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Emergency medicine is a specialty which closely reflects societal challenges and consequences of public policy decisions. The emergency department specifically deals with social injustice, health and economic disparities, violence, substance abuse, and disaster preparedness and response. This journal focuses on how emergency care affects the health of the community and population, and conversely, how these societal challenges affect the composition of the patient population who seek care in the emergency department. The development of better systems to provide emergency care, including technology solutions, is critical to enhancing population health.

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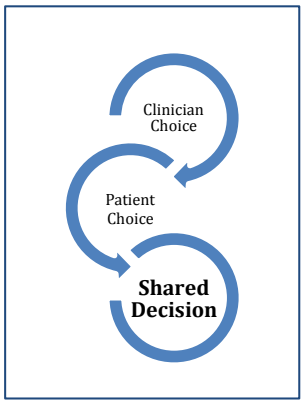

Call for Papers

2016 *Academic Emergency Medicine* Consensus Conference

Shared Decision Making in the Emergency Department: Development of a Policy-Relevant Patient-Centered Research Agenda

The 2016 *Academic Emergency Medicine* (*AEM*) consensus conference, "**Shared Decision Making in the Emergency Department: Development of a Policy-Relevant Patient-Centered Research Agenda,**" will be held on May 10, 2016, immediately preceding the SAEM Annual Meeting in New Orleans, LA. Original research papers on this topic, if accepted, will be published together with the conference proceedings in the December 2016 issue of *AEM*.

The consensus conference will convene major thought leaders and necessary stakeholders on shared decision making in acute care. Specifically, the conference will include patients, patient representatives from national advocacy organizations, emergency physicians, mid-level providers, emergency nurses, and researchers with expertise in shared decision making and patient-centered outcomes research, comparative effectiveness research, and health information technology. There will be clinicians across various disciplines such as emergency medicine, health services research, psychology, and quality improvement. Finally, the conference will include national policy makers, payer representatives, and other stakeholders with the expressed goal of developing a multidisciplinary, consensus-based, high-priority research agenda to improve and optimize shared decision making in the emergency department.

Consensus Objectives:

1. Critically examine the state of science on shared decision making in emergency medicine, and identify opportunities, limitations, and gaps in knowledge and methodology;
2. Develop a consensus statement that prioritizes opportunities for research in shared decision making that will result in practice changes, and identifies effective methodological approaches;
3. Identify and build collaborative research networks to study the use of shared decision making and patient-centered outcomes research in emergency medicine that will be competitive for federal funding.

Accepted manuscripts will present original, high-quality research in shared decision making in the ED, such as clinical decision rules, shared decision making, knowledge translation, comparative effectiveness research, and multidisciplinary collaboration. They may include work in clinical, translational, health systems, policy, or basic science research. Papers will be considered for publication in the December 2016 issue of *AEM* if received by April 17, 2016. All submissions will undergo peer review and publication cannot be guaranteed.

For queries, please contact the conference chair, Corita R. Grudzen, MD, MSHS (corita.grudzen@nyumc.org), or the co-chairs Christopher R. Carpenter, MD, MSc (carpenterc@wusm.wustl.edu) and Erik Hess, MD (Hess.Erik@mayo.edu). Information and updates will be regularly posted in *AEM* and the SAEM Newsletter, and on the journal and SAEM websites.

Intubating Ebola Patients: Technical Limitations of Extensive Personal Protective Equipment

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Shannon Toohey, MD
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As hospitals across the nation were preparing for the possibility of Ebola or Middle Eastern respiratory syndrome (MERS-CoV) cases, healthcare workers underwent intricate training in the use of personal protective equipment (PPE). An Ebola or MERS-CoV patient requiring intubation places a healthcare worker at risk for exposure to bodily secretions. The procedure must be performed only after appropriate PPE is donned.[1] Intubating while wearing PPE is yet another challenge identified in caring for these patients. Manual dexterity and free movement decreases when wearing PPE, and may increase length of time to successful intubation.

We elicited the opinion of subjects performing direct laryngoscopy versus video-assisted laryngoscopy on manikins while wearing PPE. Additionally, we recorded multiple intubation attempts by these clinicians using Google Glass. Two PPE-donned clinicians both agreed that intubation was not technically different between direct versus video-assisted techniques. However, the subjects felt that direct laryngoscopy was noticeably more labor intensive than the video-assisted technique. Subjects also felt more temperature-related discomfort during direct laryngoscopy. For one subject, contamination was more common during direct laryngoscopy, when the PPE hood contacted the patient's face or endotracheal tube. From this simulation experience, we recommend video laryngoscopy as a preferred method of intubating a patient while donning PPE.

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Video. Ebola intubation video.

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Epidemiology of Advance Directives in Extended Care Facility Patients Presenting to the Emergency Department

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Introduction: We conducted an epidemiologic evaluation of advance directives and do-not-resuscitate (DNR) prevalence among residents of extended care facilities (ECF) presenting to the emergency department (ED).

Methods: We performed a retrospective medical record review on ED patients originating from an ECF. Data were collected on age, sex, race, triage acuity, ED disposition, DNR status, power-of attorney (POA) status, and living will (LW) status. We generated descriptive statistics, and used logistic regression to evaluate predictors of DNR status.

Results: A total of 754 patients over 20 months met inclusion criteria; 533 (70.7%) were white, 351 (46.6%) were male, and the median age was 66 years (IQR 54-78). DNR orders were found in 124 (16.4%, 95% CI [13.9-19.1%]) patients. In univariate analysis, there was a significant difference in DNR by gender (10.5% female vs. 6.0% male with DNR, p=0.013), race (13.4% white vs. 3.1% non-white with DNR, p=0.005), and age (4.0% <65 years; 2.9% 65-74 years, p=0.101; 3.3% 75-84 years, p=0.001; 6.2% >84 years, p<0.001). Using multivariate logistic regression, we found that factors associated with DNR status were gender (OR 1.477, p=0.358, note interaction term), POA status (OR 6.612, p<0.001), LW (18.032, p<0.001), age (65-74 years OR 1.261, p=0.478; 75-84 years OR 1.737, p=0.091, >84 years OR 5.258, P<0.001), with interactions between POA and gender (OR 0.294, P=0.016) and between POA and LW (OR 0.227, p<0.005). Secondary analysis demonstrated that DNR orders were not significantly associated with death during admission (p=0.084).

Conclusion: Age, gender, POA, and LW use are predictors of ECF patient DNR use. Further, DNR presence is not a predictor of death in the hospital. [West J Emerg Med. 2015;16(7):966–973.]

INTRODUCTION

End-of-life medical care is responsible for a substantial portion of healthcare expenditures.[1-3] Advance directives (AD) exist to convey a patient's wishes regarding medical interventions when they no longer have capacity to express their wishes themselves. In the proper setting, they have the potential to prevent interventions not wanted by the patient at the end of life. In the emergency department (ED), the documented existence of a do-not-resuscitate (DNR) order may affect initial treatment decisions. Further, other forms of ADs, which include living wills and healthcare power of attorneys (POA), can inform the emergency physician with regards to patient preferences when the patient can no longer contribute to the decision-making process.

Patients requiring care in an extended care facility (ECF) are at high risk for both illnesses with high mortality potential as well as acute and chronic cognitive impairment.[4-6] However, a lack of ECF communication regarding patient history[7] and

ADs[8] has been demonstrated in patients transferred from ECFs to EDs. The most recent national survey of nursing homes demonstrated that 65.3% of residents had some kind of AD, of which 55.9% were do-not-resuscitate orders.[5] Factors associated with DNR status in the nursing home have been described, including age, education, living children, length of stay, ambulatory status and ethnicity.[9] However, despite the high prevalence of documentation of ADs in the ECF setting, there is a concern for the transfer and recognition of this documentation in the ED and inpatient setting, given the finding that 46.4% of transfers neglect to include information regarding ADs.[7] Further, data support that ADs are often not recognized or are misinterpreted by physicians with regards to DNR status.[10]

We performed an epidemiologic analysis of the prevalence of documentation of ADs, including do-not-resuscitate orders, living wills and healthcare POAs, among residents of ECFs presenting to the ED. We focused on the presence of DNR orders, as these are most relevant to medical care in the ED and sought to describe the prevalence of DNR orders in patients sent to the ED from extended care facilities. Secondly, we sought to identify the relationship between age and DNR status while controlling for other variables. We felt this necessary, as age has been treated variably in previous studies. For example age has been broken into greater than and less than 65 or 75,[8,11] or into decades or larger categories[9,12-14] when relating it to DNR status in the nursing home. For this secondary analysis, we hypothesized that documentation of DNR status would become more prevalent with increasing age.

METHODS

This study was conducted in the ED of a university-based, urban academic hospital in Ohio with an annual census of approximately 70,000 visits per year. We performed a retrospective, observational cohort study from our ED electronic medical record of patients originating from extended care facilities. This study was approved with a waiver of informed consent due to its retrospective nature by the Ohio State University Biomedical institutional review board. Eligible patients were identified via the "Source of Admission" data field as designated by the triage nurse upon arrival of the patient to the emergency department. Within our electronic medical record definitions, ECFs included skilled nursing facilities, long-term acute care facilities, assisted living facilities and rehabilitation facilities. For a consecutive 20-month period from October 20, 2007, to May 11, 2009, all patients designated as presenting from an ECF were identified and reviewed for inclusion in the study. We excluded return visits during the time period , as well as patients who were under the age of 18. Finally, during the data collection process the site of origin was verified via manual review of documentation of the site of origin and patients who were incorrectly coded during triage as originating from an ECF were removed from the final sample. We based our sample size calculation on the large range in prevalence of DNR orders reported in the literature and clinical experience, and we estimated 750 patients would provide an acceptable confidence interval of ±3.5% around the expected sample prevalence of DNR orders.[15]

We collected data from the ED electronic medical record (ED PulseCheck, Picis, Inc., Wakefield, MA) and the hospital electronic medical record (eResults, Lakeland HealthCare, St. Joseph, MI) via chart review. The complete electronic medical record for the identified visit and hospitalization (if applicable) as well as any information from the previous month were assessed. Variables that were collected included age, gender, race, mode of arrival, triage acuity level, disposition from the ED, in-hospital death, and advance directive status. We analyzed age both continuously and by decade. Although race was reported as White, Black or other in the medical record, we dichotomized race as White and non-White, as <1% of patients were reported as "other." Mode of arrival was reported as via private vehicle, via private ambulance or wheelchair van, or via EMS. Acuity was reported using the Emergency Severity Index (ESI),[16] which is a five-level scale that ranges from 1 – life threatening to 5 – non-urgent. At our institution the Emergency Severity Index initially is assigned at the time of triage, and then updated at the time of disposition. For the data analysis, we changed the initial and final ESI to a 1-4 scale with non-urgent (5) and semi-urgent combined (4), as only one patient was non-urgent. Disposition from the ED was reported as admission or discharge.

In Ohio, ADs consist of DNR-CC (comfort care only), DNR-CCA (full resuscitation up to the point of actual respiratory or cardiac arrest), living wills (LW) and healthcare POA. A fourth category was identified as advance directives not otherwise specified (AD-NOS) in the electronic medical record. In our institution, the documentation of a non-specified AD referred to a living will, so ADs not otherwise specified and living wills were combined for the statistical analysis. The presence of an advance directive could have been documented by physicians, nurses, or social workers.

The primary outcome was the presence of any form of DNR (DNR-CC, DNR-CCA, DNR not otherwise specified) documentation transferred with the patient from the ECF, as reported in the ED record or admission assessment. Secondary outcomes included death in hospital and disposition from the ED.

We generated descriptive statistics for all variables. Given the interest in age as related to other variables of interest, we used chi-square tests to compare age by decade to other study variables. When significant associations were noted among multilevel variables, we used adjusted standardized residuals to determine where the differences lay.

To identify independent predictors of DNR status, initial analysis was conducted using univariate logistic regression. In the logistic regression models, we examined the continuous variable age for linearity in the logit using a locally weighted smoothed scatter plot and fractional polynomial analysis.[17] Age, if treated as a continuous variable, was found to be most accurately represented as a cubed variable. The use of age

cubed in the models resulted in difficult to interpret odds ratios (e.g. 1.000003). Given the difficulty of interpretation of OR with age as a cubed variable, we divided age as a categorical variable at cut-points of <65, 65-74, 75-84, and >85 years. We used multivariate logistic regression to evaluate predictors of DNR status. An initial full model was built including all terms with a likelihood ratio with $p<0.25$ in the univariate analysis and biologic plausibility. We built a parsimonious model by removing terms in a backwards, manual, step-wise fashion, requiring a $p<0.05$ via the likelihood ratio test for retention. Interaction terms were tested for all remaining variables. We tested all models for goodness of fit using the Hosmer-Lemeshow goodness-of-fit test, and discrimination was tested using an ROC curve. We performed all statistical analyses using STATA/SE 10.1 (STATACorp, College Station, TX).

RESULTS

We identified 1,736 patients documented as originating from an ECF over a consecutive 20-month time period. Of these initial patients, 211 were excluded by repeat visit, 36 were excluded because the patient was under the age of 18, and 735 were excluded because they were incorrectly coded with ECF as the source of admission. The remaining 754 patients constituted the study population, of which 351 were male (46.6%, 95% CI [49.8-57.0%]) and 533 were White (70.7%, 95% CI [67.4-73-9%]). The age range was 19 to 102 years old, with a median age of 66 (IQR 54-78). Additional descriptive characteristics of the patient population are listed in Table 1. There were a total of 124 DNR orders identified in this cohort (16.4%, 95% CI [13.9-19.1%]), of which 44 were DNR-CC (5.8%, 95% CI [4.2-7.5%]), 74 were DNR-CCA (9.8%, 95% CI [7.7-11.9%]), and six were DNR not-otherwise-specified (0.8%, 95% CI [0.2-1.4%]). There were 504 admissions from the ED (66%, 95% CI [63.5-70.2%]), and one death in the ED (0.13%, 95% CI [-0.12-0.39%]), with a total of 27 deaths during admission (3.7%, 95% CI [2.4-5.1%]). There were 14 missing initial triage levels found in the data set, which were replaced with the final ESI recorded. No other missing data were identified.

The univariate relationships with the primary outcome of presence of DNR are shown in Table 1. Age as a continuous variable was found to lack linearity in the logit. We therefore categorized age as <65, 65-74, 75-84, and ≥85. The last triage score prior to disposition was not included in the multivariate model, though it met criteria in the univariate analysis, because this status was generally assigned after DNR status for the patient became known and there was concern for substantial collinearity with initial triage level, as the urgency level infrequently changed through the ED stay.

We further investigated age with a univariate comparison of categorical age groups with other variables as noted in Table 2. The adjusted standardized residuals were calculated for all significant univariate associations between age and related variables. First triage score was significantly associated with age. The residuals from chi-squared analysis demonstrated that the >84 year old group had lower acuity, as did the <65 year old group. DNR orders, living wills and POAs were all significantly associated with age, with residuals indicating a significantly increased prevalence with increasing age. A POA was most prevalent in all age groups compared to other forms of ADs, and DNR orders were the least prevalent form of AD.

Results of the multivariate analysis for the outcome DNR status are reported in Table 3. The initial complete model included gender, race, power-of-attorney, living will, age by decade, and mode of arrival. In the final model after removal of non-significant variables, gender, age by decade, POA status, and living will status were found to be significant predictors of DNR status. The test for interactions in this final model demonstrated a significant interaction of gender with POA and POA with living will, indicating that males with a POA had a decreased association with DNR orders (interaction OR=0.29, $p<0.016$), as did patients with both a POA and a living will (interaction OR=0.23, $p<0.005$). The Hosmer-Lemeshow goodness-of-fit demonstrated no evidence of a lack of fit ($p<0.614$) and the area under the curve indicated good discrimination (0.846). We further clarified the effect of the interaction term on gender and DNR status in the final model. Compared to females, males with POAs were less likely to have documented DNR status, while males without POAs were more likely than females to have documented DNR status.

We also generated a third, simplified model to avoid possible interactions by including only gender, living will, and age. The removal of POA and its resulting interactions did not affect the odds ratios for age by decade. There was no significant difference between males and females regarding DNR status when the interaction term was removed in the simplified model. Age and living will remained significant predictors of DNR status.

The secondary analysis yielded associations regarding the outcomes of admission and death. We performed univariate and logistic regression using ED disposition and in-hospital death as outcomes. The analysis focusing on ED disposition demonstrated that presence of a POA (OR 2.713, $p<0.001$) and the presence of an AD (OR=2.86, $p<0.001$), after adjusting for initial triage score (Urgent OR=9.81, $p<0.000$; Emergent OR=19.85, $p<0.000$; Life Threat OR=39.07, $p<0.000$) was significantly associated with increased odds of admission from the ED. The analysis further demonstrated that the presence of a POA (OR 2.62, $p=0.017$), after adjustment for male sex (OR=3.00, $p=0.009$) was significantly associated with death during admission. The initial ED triage score was not associated with the presence of a living will ($p=0.230$) but was significantly associated with POA ($p<0.002$), with more than expected powers-of-attorney in the emergent triage group and less in the semi-urgent group. Although patients with DNR orders were more likely to be admitted to the hospital (OR

Table 1. Characteristics of the population with univariate analysis for odds of do not resuscitate in patients presenting to the emergency department from extended care facilities.

	Total n (%)	With DNR (%)	Without DNR (%)	OR (5% CI)	P-value
Gender					
Male	351 (46.6)	45 (6.0)	306 (40.6)	0.60 (0.41-0.90)	0.013
Age by decade					
<65	346 (45.9)	30 (4.0)	316 (41.9)	reference	
65-74	164 (21.8)	22 (2.9)	142 (18.8)	1.63 (0.91-2.93)	0.101
75-84	128 (17.0)	25 (3.3)	103 (13.7)	2.56 (1.44-4.55)	0.001
>84	116 (15.4)	47 (6.2)	69 (9.2)	7.18 (4.24-12.15)	<0.001
Race					
White	533 (70.7)	101 (13.4)	432 (57.3)	2.01 (1.24-3.26)	0.005
Transportation					
Private vehicle	30 (4.0)	7 (0.9)	23 (3.1)	reference	
Ambulance	428 (56.8)	52 (6.9)	376 (49.9)	0.45 (0.19-1.11)	0.084
EMS	296 (39.3)	65 (8.6)	231 (30.6)	0.92 (0.38-2.23)	0.863
Initial urgency (ESI)					
Life threat	12 (1.6)	1 (0.1)	11 (1.5)	0.82 (0.08-8.75)	0.868
Emergent	277 (36.7)	53 (7.0)	224 (29.7)	2.13 (0.62-7.28)	0.228
Urgent	435 (57.7)	67 (8.9)	368 (48.8)	1.64 (0.48-5.56)	0.428
Semi-urgent	29 (3.8)	3 (0.4)	26 (3.4)	combined reference	
Non-urgent	1 (0.1)	0 (0.0)	1 (0.1)	combined reference	
Final urgency (ESI)					
Life threat	19 (2.5)	1 (0.1)	18 (2.4)	1.28 (0.08-21.86)	0.866
Emergent	300 (39.8)	66 (8.8)	234 (31.0)	6.49 (0.86-48.94)	0.070
Urgent	411 (54.5)	56 (7.4)	355 (47.1)	3.63 (0.48-27.40)	0.212
Semi-urgent	23 (3.1)	1 (0.1)	22 (2.9)	combined reference	
Non-urgent	1 (0.1)	0 (0.0)	1 (0.1)	combined reference	
Advance directive (AD)					
Power of attorney	317 (42.0)	94 (12.5)	223 (29.6)	5.72 (3.68-9.90)	<0.001
Living will (LW)	89 (11.8)	37 (4.9)	52 (6.9)	9.93 (6.46-15.25)	<0.001
Other AD	189 (25.1)	83 (11.0)	106 (14.1)	combined with LW	
Disposition					
Admit	504 (66.8)	103 (13.7)	401 (53.2)	2.80 (1.70-4.60)	<0.001

DNR, do not resuscitate; *EMS,* emergency medical services*; ESI;* emergency severity index; *OR,* odds ratio

2.8, p<0.001), DNR orders were not significantly associated with death during admission (p=0.084). Further, there was no significant association between DNR-CC orders (p=0.063) or DNR-CCA orders (p=0.870) and in-hospital death when analyzed separately.

DISCUSSION

Our study demonstrated an overall prevalence of DNR orders of 16.4% in the population presenting to the ED from ECFs overall. This number is in stark contrast to previous studies, which have demonstrated a high prevalence of DNR orders in patients transferred to the ED from skilled nursing facilities (32-64%),[5,8,9,11,12,18,19] and from ECFs (68-77%)[20]. There are three potential external correctable sources for this discrepancy, which would include a deficit in the existence of the documentation in the ECF population seen in the ED, a lack of transfer of the paperwork from facilities,[7] or a lack of documentation of these orders in the medical chart in the ED. Alternatively, given the increasing number of hospices providing care in nursing homes and the increased utilization[21] of hospice in general, it is possible that patients with DNR orders are less frequently being sent to the ED and thus not represented in this study. Regardless, given the paucity of research examining the larger ECF population and specific factors associated with DNR orders, this population demonstrates many potential avenues for further investigation

Table 2. Univariate analysis of population characteristics based on age.

	<65 (%)	65-74 (%)	75-84 (%)	>84 (%)	P-value (chi)
Gender					
Female	173 (50.0)	87 (53.1)	69 (53.9)	74 (63.8)	
Male	173 (50.0)	77 (47.0)	59 (46.1)	42 (36.2)	0.083
Race					
White	235 (67.9)	119 (72.5)	93 (72.7)	86 (25.9)	
Other	111 (32.0)	45 (27.4)	35 (27.3)	30 (74.1)	0.482
Transportation					
Private vehicle	13 (4.3)	3 (1.8)	6 (4.7)	6 (5.2)	
Ambulance or wheelchair	200 (57.8)	97 (59.2)	70 (54.7)	61 (52.6)	
EMS	131 (37.9)	64 (27.8)	52 (40.6)	49 (42.2)	0.707
Initial Urgency (ESI)					
Life Threat	5 (1.5)	1 (0.6)	6 (4.7)	0 (0.0)	
Emergent	120 (34.7)	69 (42.1)	49 (38.3)	39 (33.6)	
Urgent	208 (60.1)	84 (51.2)	70 (54.7)	73 (62.9)	
Semi/non-urgent	13 (3.8)	10 (6.1)	3 (2.3)	4 (3.5)	0.038
Final urgency (ESI)					
Life threat	8 (2.3)	5 (3.1)	6 (4.7)	0 (0.0)	
Emergent	133 (38.4)	62 (37.8)	59 (46.1)	46 (39.7)	
Urgent	195 (56.4)	89 (54.3)	60 (46.9)	67 (57.8)	
Semi/non-urgent	10 (2.9)	8 (4.9)	3 (2.3)	3 (2.6)	0.279
Advance directive					
Power of attorney	111 (32.1)	70 (42.7)	67 (52.3)	69 (59.5)	<0.001
Living will	60 (17.3)	43 (26.2)	44 (34.4)	47 (40.5)	<0.001
DNR	30 (8.7)	22 (13.4)	25 (19.5)	47 (40.5)	<0.001
Disposition					
Admit	224 (64.7)	107 (65.2)	90 (70.3)	83 (71.6)	
Discharge	122 (35.3)	57 (34.8)	38 (26.7)	33 (33.0)	0.434

DNR, do not resuscitate; *ESI;* emergency severity index

and areas of improvement in advance care planning.

Although significant in the univariate analysis, race was not significant in the multivariate analysis when controlling for age, mode of arrival, POA, and living will. Some authors have shown a relationship with race, which was not found in this study, possibly due to the inclusion of confounders in past analyses.[8,9,11,12]

In the multivariate analysis, patients of increasing age were significantly more likely to present with a DNR order. Previous studies have consistently demonstrated similar associations with age.[8,9,14,22] Age was broken out further in Table 2, and demonstrated significant associations with the presence of DNR orders, living wills, and healthcare POAs. While the oldest of the geriatric population has a high prevalence of POA (59.5%), living will (40.5%) and DNR orders (40.5%), the younger geriatric population has a significantly lower prevalence of these documents. This discrepancy, which is consistent with previous literature, demonstrates a potential for discussions in the younger geriatric ECF population regarding advance care planning, as well as instituting policies for the transfer of these documents with these patients to the ED.

The relationship between gender and DNR status in the multivariate models is less clear. Previous studies have shown either a trend towards increased DNR prevalence in women or a lack of association of gender with DNR orders.[8,9,11,12] Gender was not significant in the third simplified model. Gender was significant in the model, which included POA and living will as independent variables, but was involved in an interaction with POA. When considering this interaction, men with a POA were less likely than women to have DNR status, but men without a POA were more likely than women to have DNR status. This may indicate that, among males, discussions of medical decision-making are excluding discussions of DNR orders. Alternatively, it may be that DNR orders are felt unnecessary in cases where a POA has been appointed.

Table 3. Multivariate logistic regression of population based on do-not-resuscitate status.

	Complete model**		Final model†		Simplified model‡	
	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value
Male	0.69 (0.41-1.05)	0.078	1.48 (0.64-3.39)	0.358	0.65 (0.41-1.02)	0.063
White	1.55 (0.89-2.69)	0.120				
POA	2.01 (1.18-3.44)	0.010	6.61 (2.89-12.12)	<0.001		
Living will (LW)	6.32 (3.81-10.50)	<0.001	18.03 (7.50-43.35)	<0.001	9.03 (5.75-14.17)	<0.001
65-74	1.24 (0.65-2.36)	0.513	1.26 (0.66-2.39)	0.478	1.31 (0.70-2.46)	0.402
75-84	1.57 (0.83-2.99)	0.168	1.74 (0.92-3.30)	0.091	1.76 (0.94-3.30)	0.079
>84	4.47 (2.62-8.67)	<0.001	5.26 (2.87-9.64)	<0.001	5.38 (2.99-9.66)	<0.001
Ambulance	0.56 (0.18-1.75)	0.318				
EMS	1.02 (0.33-3.17)	0.977				
POA × male			0.29 (0.11-0.80)	0.016		
POA × LW			0.23 (0.08-0.64)	0.005		

POA, power of attorney; *EMS,* emergency medical services*; OR,* odds ratio*; CI,* confidence interval
**Goodness of fit (p<0.931), discrimination=0.84.
†Goodness of fit (p<0.614), discrimination=0.85.
‡Goodness of fit (p<0.521), discrimination=0.82.

This trend has not been reflected in the literature previously, and indicates that additional investigation is warranted to understand the nuances of this association.

The interaction between living wills and powers-of-attorney demonstrates a decreased likelihood of the presence of a DNR if both documents are in place. While this interaction could be an artifact of the high prevalence of POAs and living wills, it may indicate that patients who are able to have end-of-life discussions and sign these documents are not being approached regarding DNR orders or are not willing to enact DNR orders. Additionally, suggested by the clinical experience of the authors, another possibility is that many patients and their families assume that a living will and POA encompass DNR status. The trend of age remained consistent throughout the model, regardless of the inclusion of the interaction terms.

We examined admission rates and death in the context of the prevalence of DNR orders, as well as patient population characteristics. Although age was not significantly associated with admission, DNR status was associated with an increased odds of admission. Interestingly, POAs and living wills were significantly associated with admission, potentially demonstrating an artificial increase, as social workers at our institution are tasked with obtaining these documents from the family and ECF upon admission. An alternative explanation could be that patients with these documents are more moribund; however, when looking at the initial triage score, this trend only held true for POAs. Finally, only male gender and POA were significantly associated with death during admission.

The literature has not addressed the hazard of death in patients with DNR orders in general. Only a few studies have approached the relationship, specifically noting increased post-operative mortality in patients with pre-operative DNR orders[23] and a high prevalence of DNR orders in patients who expired in the nursing home setting.[6] However, in our secondary analysis DNR status was not associated with death in the hospital. Further, DNR orders were not associated with higher initial triage severity indexes, demonstrating that patients who presented with DNR orders were not considered more or less acute upon arrival to the ED and were not more likely to expire during admission than those without orders. These trends are counterintuitive given the association between advanced illness and DNR orders.[22] Patients with DNR orders were almost three times as likely to be admitted than those without DNR orders, a trend that was independent of age in multivariate analysis. Further research is needed to explore the causal relationship between DNR orders, admission and survival to discharge.

LIMITATIONS

This study is a retrospective chart review, which does preclude several inherent and modifiable limitations.[24] To minimize error, only one abstractor of data from the medical record was used, with a supervising principal investigator to review discrepancies within the medical record. However, this abstractor was not blinded to the purpose of the study. The data were collected using a standardized list of variables, and all chart documentation from the visit and the previous month was reviewed for every patient. As we selected cases based on a source of origin code recorded by the triage nurse, and almost half of the charts were excluded by incorrect coding, there is a large potential for patient selection error. In retrospect, there was a pattern noted among specific triage

nurses who coded all ambulance runs as originating from an ECF, which accounted for the majority of the miscoded patients. However, bias could exist due to missing patients from ECFs who were not identified via miscoding and thus not included in the study. The only missing data element within the collected data set was the 14 missing initial triage levels, which were directly imputed from the final triage levels noted at the point of disposition from the ED. With regards to in hospital death as a secondary outcome, this does not capture those patients who were discharged home on hospice to avoid in-hospital death; thus, the number of association of death and DNR orders may be underrepresented in this study.

CONCLUSION

There exists a large body of data regarding DNR orders in nursing homes; however, the transfer of these orders to the ED from extended care facilities is less well understood. Given the potential gaps in transferred data and the critical nature of these documents in patient care, it is unsettling that the prevalence of these orders in patients transferred to the ED at the time of assessment is so low. Given the trend towards advance directives and DNR orders in the older geriatric population, there exist potential windows of opportunity to discuss patients' wishes to establish advance directives at an earlier age, as well as to study further the relationship between gender, race and DNR status. Finally, the associations between DNR orders, admission and in-hospital death warrant further investigation.

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Abdominal CT Does Not Improve Outcome for Children with Suspected Acute Appendicitis

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Introduction: Acute appendicitis in children is a clinical diagnosis, which often requires preoperative confirmation with either ultrasound (US) or computed tomography (CT) studies. CTs expose children to radiation, which may increase the lifetime risk of developing malignancy. US in the pediatric population with appropriate clinical follow up and serial exam may be an effective diagnostic modality for many children without incurring the risk of radiation. The objective of the study was to compare the rate of appendiceal rupture and negative appendectomies between children with and without abdominal CTs; and to evaluate the same outcomes for children with and without USs to determine if there were any associations between imaging modalities and outcomes.

Methods: We conducted a retrospective chart review including emergency department (ED) and inpatient records from 1/1/2009–2/31/2010 and included patients with suspected acute appendicitis.

Results: 1,493 children, aged less than one year to 20 years, were identified in the ED with suspected appendicitis. These patients presented with abdominal pain who had either a surgical consult or an abdominal imaging study to evaluate for appendicitis, or were transferred from an outside hospital or primary care physician office with the stated suspicion of acute appendicitis. Of these patients, 739 were sent home following evaluation in the ED and did not return within the subsequent two weeks and were therefore presumed not to have appendicitis. A total of 754 were admitted and form the study population, of which 20% received a CT, 53% US, and 8% received both. Of these 57%, 95% CI [53.5,60.5] had pathology-proven appendicitis. Appendicitis rates were similar for children with a CT (57%, 95% CI [49.6,64.4]) compared to those without (57%, 95% CI [52.9,61.0]). Children with perforation were similar between those with a CT (18%, 95% CI [12.3,23.7]) and those without (13%, 95% CI [10.3,15.7]). The proportion of children with a negative appendectomy was similar in both groups: CT (7%, 95% CI [2.1,11.9]), US (8%, 95% CI [4.7,11.3]) and neither (12%, 95% CI [5.9,18.1]).

Conclusion: In this uncontrolled study, the accuracy of preoperative diagnosis of appendicitis and the incidence of pathology-proven perforation appendix were similar for children with suspected acute appendicitis whether they had CT, US or neither imaging, in conjunction with surgical consult. The imaging modality of CT was not associated with better outcomes for children presenting to the ED with suspected appendicitis. [West J Emerg Med. 2015;16(7):974-982.]

INTRODUCTION

Acute appendicitis in the pediatric population remains one of the most common surgical emergencies.[1] The risk of developing appendicitis over the course of a lifetime is 7% in females, and 9% in males.[2,3] In the United States, there are more than 70,000 appendectomies performed on pediatric patients 3-18 years old each year.[4] Despite its high incidence, appendicitis may be challenging to diagnose due to the overlap of symptoms with other acute abdominal conditions or atypical presenting symptoms.[5-8] Timely diagnosis and treatment of acute appendicitis is important to prevent complications such as a perforated appendix.[9] Radiographic imaging studies such as ultrasound (US) and computed tomography (CT) are frequently ordered to aid in the diagnosis of patients who present with symptoms consistent with acute appendicitis.

With the advent of the helical CT study, physicians can rapidly obtain a three-dimensional view of the appendix and abdominal region. Image capture is estimated to take less than one second, which diminishes the need to anesthetize the child before a CT.[10] The high image resolution, diagnostic accuracy, and convenience of a CT study have been contributing factors associated with its frequent use as a diagnostic tool.[11]

As the utilization of CT studies has increased over recent decades, the risks associated with varying doses of ionizing radiation have been estimated using data from atomic bomb survivors.[10-12] For children younger than 15 years, the estimated risk of dying from a radiation-induced malignancy ranges from 0.07%-0.10%, with children in the lower ages having a higher estimated risk.[13] In a recent retrospective cohort study the estimated risk for children younger than 15 developing leukemia and brain tumors tripled if a child had undergone more than two CTs.[14] Additionally, children are more susceptible to the effects of ionizing radiation because they have a higher rate of cell divisions in developing tissues. Their younger age also leaves more years of life in which a radiation-induced malignancy may develop.[15] Brenner and colleagues estimated that approximately one million children per year are unnecessarily exposed to harmful radiation from CTs.[10]

Despite the increased use of CTs, additional imaging studies may not improve the accuracy of the preoperative diagnosis of acute appendicitis.[16,17] Flum and colleagues found that the increased use of CT and US studies have not impacted the population-level rate of negative appendectomy.[18,19] In addition, a recent retrospective study found there was no increase in negative appendectomy or perforation rate following the implementation of a multi-disciplinary diagnostic protocol which used US as the initial diagnostic imaging study.[20]

The aim of this study was to determine if a correlation exists between children who received diagnostic imaging (CT and/or US) and two clinical outcomes: the rate of perforation and negative appendectomy. The hypothesis was that diagnostic imaging does not improve clinical outcomes for children with suspected acute appendicitis.

METHODS

We conducted this study at an urban, tertiary-care children's hospital with over 50,000 emergency department (ED) visits per year. Approval was obtained from the institutional review board to conduct a retrospective chart review of pediatric emergency medicine (PEM) patients. We screened ED and inpatient electronic medical records (EMR) from January 1, 2009 through December 31, 2010 to identify patients who presented to the ED with suspected acute appendicitis. The ED EMR system is PulseCheck version 5.0 Picis Inc., and the radiology EMR system is Phillips I-Site Version 3.6. Demographic data were automatically exported from the ED EMR into an excel spreadsheet. Additional data that could not be exported were hand entered onto this spreadsheet. The data from inpatient and radiology EMRs were hand entered onto the same spreadsheet. Initial screening to meet the primary inclusion criterion of suspected acute appendicitis was done by the primary author who had two years of research experience in this ED.

Inclusion criteria were all patients who met the following definition for suspected acute appendicitis, presented to the ED with acute abdominal pain who had either a surgical consult or an abdominal imaging study (ultrasound, CT) or presented to and were transferred from an outside hospital or primary care physician office with the stated suspicion of acute appendicitis. The decision to obtain imaging and the type of imaging was determined by the board-certified pediatric emergency physician, certified pediatric advanced practitioner in the ED, or the board-certified pediatric surgeon. Physicians in training did not make imaging decisions without first consulting their respective attending physicians. We included all patients aged birth to 20 years who met the pre-determined definition for suspected appendicitis (Figure 1). Patients were excluded if they eloped from the ED, left against medical advice, or if they had a previous appendectomy. Data collected from the ED EMR included the following: demographics, location of initial presentation, chief complaint, results and location of radiographic imaging (plain film, US, CT), disposition from ED, previous surgeries, chronic medical conditions, antibiotics administered, duration of pain, and inpatient length of stay. Imaging studies were classified as positive for appendicitis if the radiology report stated "enlarged or thickened appendix," "consistent with acute appendicitis" or "consider appendicitis." Imaging studies were classified as negative if the radiology report stated "appendix not visualized," or "normal appearing appendix."

Inpatient charts for children who were admitted for observation or transferred to the operating room (OR) were evaluated for surgical documentation of appendectomy. We verified diagnosis of appendicitis by review of the pathology report. Appendicitis was defined as a pathology report that stated "acute appendicitis," "gangrenous appendix," or if

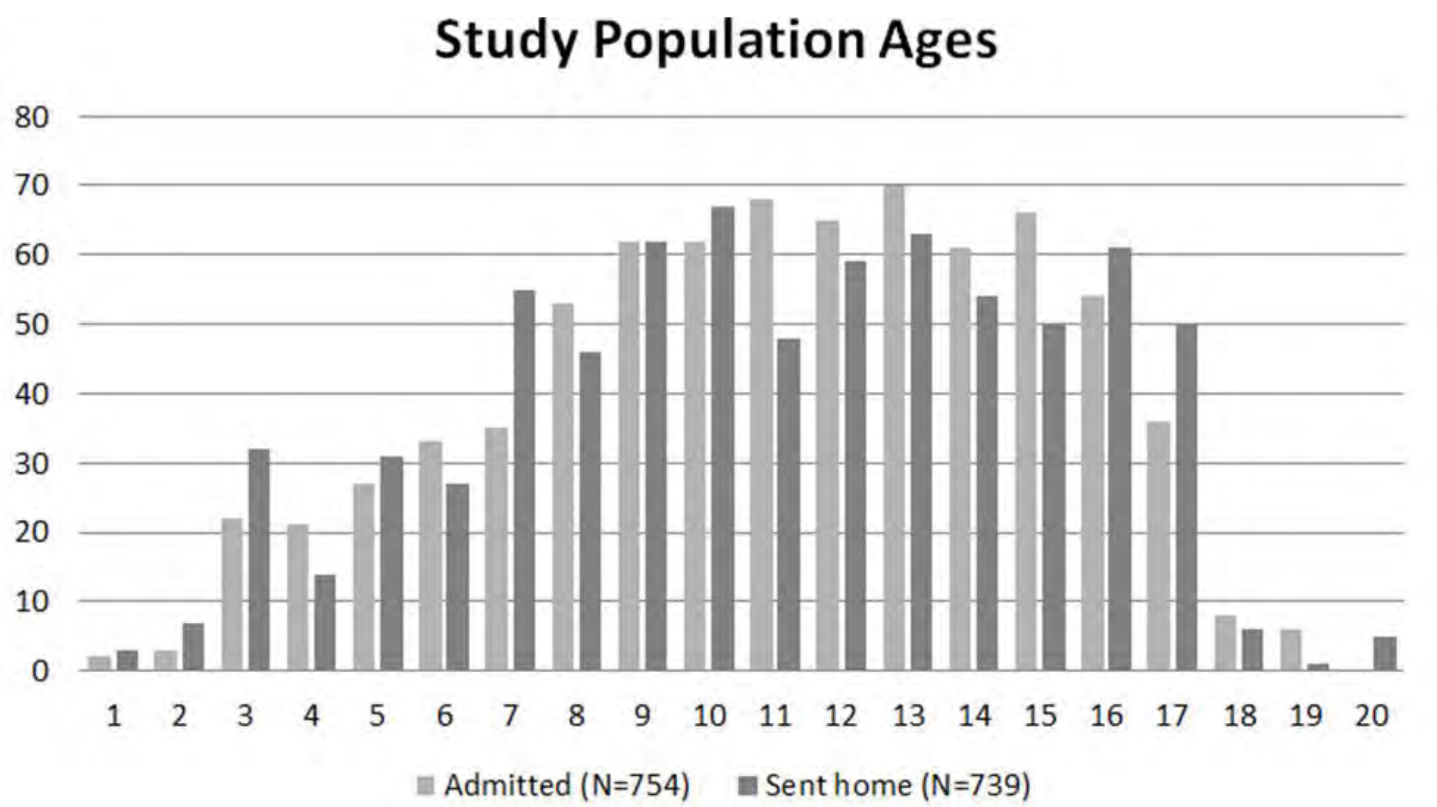

Figure 1. Histogram of study population ages (N=754) compared to population sent home (N=739).

any appendiceal inflammatory changes were documented within the report. Negative appendectomy was defined as an appendix with no inflammatory changes. Appendiceal perforation was determined by reviewing both the operative and pathology report. For purposes of analysis, we categorized patients sent home and not known to return as not having appendicitis (if true).

This retrospective chart review followed the methods outlined by Kaji and Schriger.[21] All demographic data, chief complaints, dispositions, and lengths of stay were automatically exported into an Excel spread sheet. Additional data columns were created for entry of other data and used as the data collection form. Undergraduate research assistants, trained and participating in a for-credit research course, abstracted location of original presentation (children's hospital or community hospital), location and type of all radiology studies (plain radiographs, USs, CTs), reported results of radiographic studies, if done at outside hospital, based on scanned copies of interpretation in the EMR or (if not available) reported results documented by the physician provider, antibiotic medications given, and duration of reported pain from history of present illness section. All data abstracted was reviewed for correctness and accuracy by the primary and secondary authors. Any discrepancies were reviewed by both authors and final data were determined, after they verified the accuracy of all data entered. No data analyses were done until the final, cleaned database was completed.

We compared the data in two phases. The first comparison grouped children who had a pre-operative abdominal CT and children without a CT to rate of pathology-proven diagnosis of appendicitis, rate of perforation, and rate of negative appendectomy using chi-square analyses. Patients who had an abdominal CT before surgery, regardless of any other imaging, were included in this group. Secondly, we divided the cohort into three groups of patients: children who had an abdominal CT before surgery, children who had a pre-operative abdominal US, and children who had no imaging. Chi-square analyses were used to compare rate of pathology proven appendicitis, rate of perforation, and rate of negative appendectomy among these three groups. We conducted all analyses using SPSS 17.0.

RESULTS

Between January 1, 2009 through December 31, 2010, 1,493 children presented to the pediatric ED with suspected acute appendicitis, with a mean age of 11 years (SD=4) (Figure 2). Reported ethnicities were 54% Caucasian, 25% Hispanic, 10% African-American, and 50% were female (Table 1 and 2). Of the 1,493 patients who presented with suspected acute appendicitis, 51%, 95% CI [48.5,53.5] were admitted for observation or for surgery. Of these, 62%, 95% CI [58.5,65.5] went to the OR for an appendectomy and 91%, 95% CI [88.4,93.6] were shown to have had pathology-proven appendicitis (Figure 2). None of the 739 children

Table 1. Demographic table comparing the two study groups: children who had a diagnostic computed tomography (CT), and those who did not have a CT.

	CT 16% (N=233)	No CT 84% (N=1260)
Age (years)	11.9 (SD 3.6)	10.8 (SD 4.0)
Gender (% female)	50%	50%
Race		
White	57.1%	52.9%
Hispanic	22.3%	25.3%
Black	7.7%	9.9%
Other	12.4%	11.8%
Insurance		
Private	58.7%	56.7%
Public	39.1%	37.4%
Self-pay	2.2%	3.7%

sent home returned to this hospital within the subsequent two weeks and diagnosed with acute appendicitis and were therefore presumed to not have appendicitis. Of the 430 with pathology-proven appendicitis, 23%, 95% CI [19.0,94.9] had a CT while 57%, 95% CI [52.3,61.7] had an abdominal US.

The frequency of pathology-proven appendicitis was similar for children who had a CT (57 %, 95% CI [49.6,64.4]), compared to those without a CT (57%, 95% CI [52.9,61.0]) (p=1.00) (Figure 3). The frequency of pathology-proven appendicitis was similar for children who received a CT (57%, 95% CI [52.3,61.7]), or an abdominal US (59%, 95% CI [55.0,60.1]), or those who received neither (53%, 95% CI [49.2,56.8]) (p=0.39). Of the 107 patients found to have a perforated appendix, 28%, 95% CI [19.5,36.5] of them had undergone pre-operative CT. The rate of perforation was similar for children who had a pre-operative CT (18%, 95% CI [12.2,13.8]) compared to those who did not (13%, 95% CI [10.2,15.8]) (p=0.15). No significant difference emerged when the three study groups were compared for rate of perforation; CT (31%, 95% CI [26.6,35.4]), US (20%, 95% CI [16.2,23.8]) and neither (29%, 95% CI [24.7,33.2]) (p=0.07) (Figure 4). 9%, 95% CI [6.4,11.6-2.58] of patients were determined to have a negative appendectomy and 17%, 95% CI [5.5,28.5] had a CT scan. The rate of negative appendectomy was not significantly different for children who had a pre-operative CT (7%, 95% CI [2.1,11.9]) versus those who did not (9%, 95% CI [6.0,11.9]) (p=0.56). The proportion of children who went to the OR and had a negative appendectomy was similar for those with CT (7%, 95% CI [2.1,11.9]), those with US (8%, 95% CI [4.7,11.3]) and those with neither (12%, 95% CI [5.9,18.1]) (p=0.44).

Of the 754 patients who were admitted to inpatient units, 283 did not undergo surgery; only six of those patients had abdominal CTs interpreted as positive for appendicitis by a radiologist at a community hospital that were later determined to be negative when read by a pediatric radiologist. Eleven of the patients admitted returned to the ED within seven days of their initial ED admission. Of these 11, four had abdominal CT interpretations that were negative for appendicitis and were admitted for inpatient observation. These patients had a discharge diagnosis of "RLQ Abdominal Pain" or "Abdominal Pain Site NOS," as indicated by the ICD-9 code. The remaining seven patients who returned did not have abdominal CTs during their initial ED visit; two were discharged home from the ED with a diagnosis of acute gastroenteritis; two were discharged home and one was admitted for observation with a diagnosis of abdominal pain; one was discharged home with a diagnosis of ovarian cyst; and one had a discharge diagnosis of mesenteric adenitis. Table 3 compares false positive rates (FPR) and false negative rates (FNR) for US and CT.

Community hospitals performed the majority (61%) of abdominal CTs whereas the most (89%) abdominal USs were done at a children's hospital.

Table 2. Demographic table comparing the three study groups: children who had a diagnostic computed tomography (CT), children who had a diagnostic ultrasound (US), and those who had neither.

	CT 16% (N=233)	US 51% (N=766)	Neither 33% (N=494)
Age (years)	11.9 (SD 3.63)	11.0 (SD 4.05)	10.5 (SD 4.00)
Gender (% female)	50%	54%	44%
Race			
White	57.5%	57.3%	46.0%
Hispanic	22.3%	23.4%	28.1%
Black	7.7%	7.8%	13.2%
Other	12.4%	11.3%	12.6%
Insurance			
Private	58.7%	59.5%	55.5%
Public	39.1%	37.1%	40.1%
Self-pay	2.0%	3.5%	4.3%

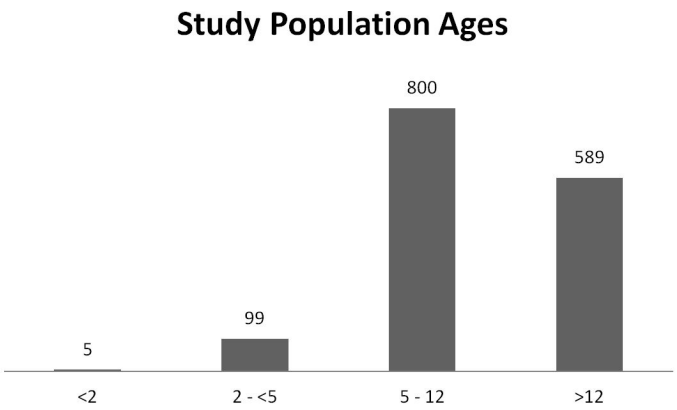

Figure 2. Histogram of study population ages (N=754).

Table 3. Comparison of false positive rate (FPR) and false negative rate (FNR) for computed tomography (CT) and ultrasound (US) for the 754 patients who were admitted.

	CT 20% (N=150)	US 53% (N=397)
FPR	12%	16%
FNR	16%	23%

DISCUSSION

The objective of this study was to determine if diagnostic imaging was associated with clinical outcomes (e.g., pathology-proven appendicitis, rate of perforation or negative appendectomy) for children who present to a pediatric ED with suspected acute appendicitis. The results of this study demonstrated that patients who underwent a pre-operative abdominal CT were equally as likely to have pathology-proven appendicitis, perforated appendices, or negative appendectomies when compared to patients who did not undergo CT pre-operatively. Additionally, negative appendectomy and perforation rates were similar for children who received either a diagnostic CT or US and children without any diagnostic imaging. Riesenman and colleagues reported no difference in perforation rates for children with and without diagnostic CT studies but an increased length of stay for children who had a CT.[22] Other authors have reported similar findings that despite an increased use of diagnostic imaging, there have not been any significant decreases in rates of negative appendectomy and perforation.[17-19, 23]

Because the use of CTs has been increasing at an approximate rate of 10% each year,[11,24] more attention has been given to the risks involved with radiation exposure from CT.[10-14,25] The amount of ionizing radiation from one CT study is approximately 100 times that of a plain radiograph, which may increase the potential to induce malignant cell divisions.[25] Staged diagnostic protocols and scoring algorithms have been explored by several investigators who report that implementation of the protocol or scoring system not only reduced radiation exposure but also was found to have a high specificity and sensitivity when used to diagnose appendicitis.[5,6,26] Moreover, Kim et al. studied the effects of lowering radiation doses involved with CTs used to diagnose appendicitis and found that negative appendectomy rates were similar in patient groups who received the low dose or standard dose CTs. Sensitivity and specificity in diagnosing appendicitis and perforated appendicitis were not found to be significantly different in Kim's study.[27]

In this study, children who had pre-operative CTs were more inclined to have a perforated appendix (31%) at the time of surgery, although this was not statistically significant. The increase in perforation rate in children who had a CT may be attributable to a delay in seeking care, or a delay in surgery or transfer as a result of having a CT.[9] Other potential factors that may have influenced the clinician to order a CT include concerning symptoms for perforated appendix, longer latency time to presenting to the ED, and/or equivocal US studies.[8, 28]

This study found that the majority (61%) of patients had abdominal CTs at community hospitals, whereas only 11% of patients had abdominal USs at a community hospital. Recent publications have reported positive correlations between the number of diagnostic CTs performed and community hospitals.[28, 29] In this study, six patients had a positive CT interpreted at a community hospital that were later determined to be negative for appendicitis when interpreted by a children's hospital radiologist. A recent study by Saito et al. reported that children evaluated for appendicitis at community hospitals were less likely to have an abdominal US and diagnostic accuracy of both CT and abdominal USs was reduced if the imaging was performed and interpreted at a community hospital.[29] A potential explanation for these observations might be due to a lack of US availability and adequately trained US technicians at community hospitals, especially at night.[30]

Using US as the primary imaging modality in children with suspected acute appendicitis has been shown to be cost effective and reduces the number of CTs ordered.[5,6,26,31] With the cost of an abdominal CT estimated to be triple the cost of an abdominal US[32] it may be appropriate to employ US initially.This approach will not only keep costs down but will prevent some children from being exposed to harmful radiation. Pediatric surgeons at our institution are willing to operate on children with suspected appendicitis who have classic history, exam and laboratory findings, but when diagnostic uncertainty exists US is used.

A prospective, multi-center study to better identify how and when to use CTs in children may decrease radiation exposure while ensuring good clinical outcomes.

Because the rate of complications is similar and CT carries the added risk of radiation, we believe that the use of CT should be reserved for children who pose diagnostic

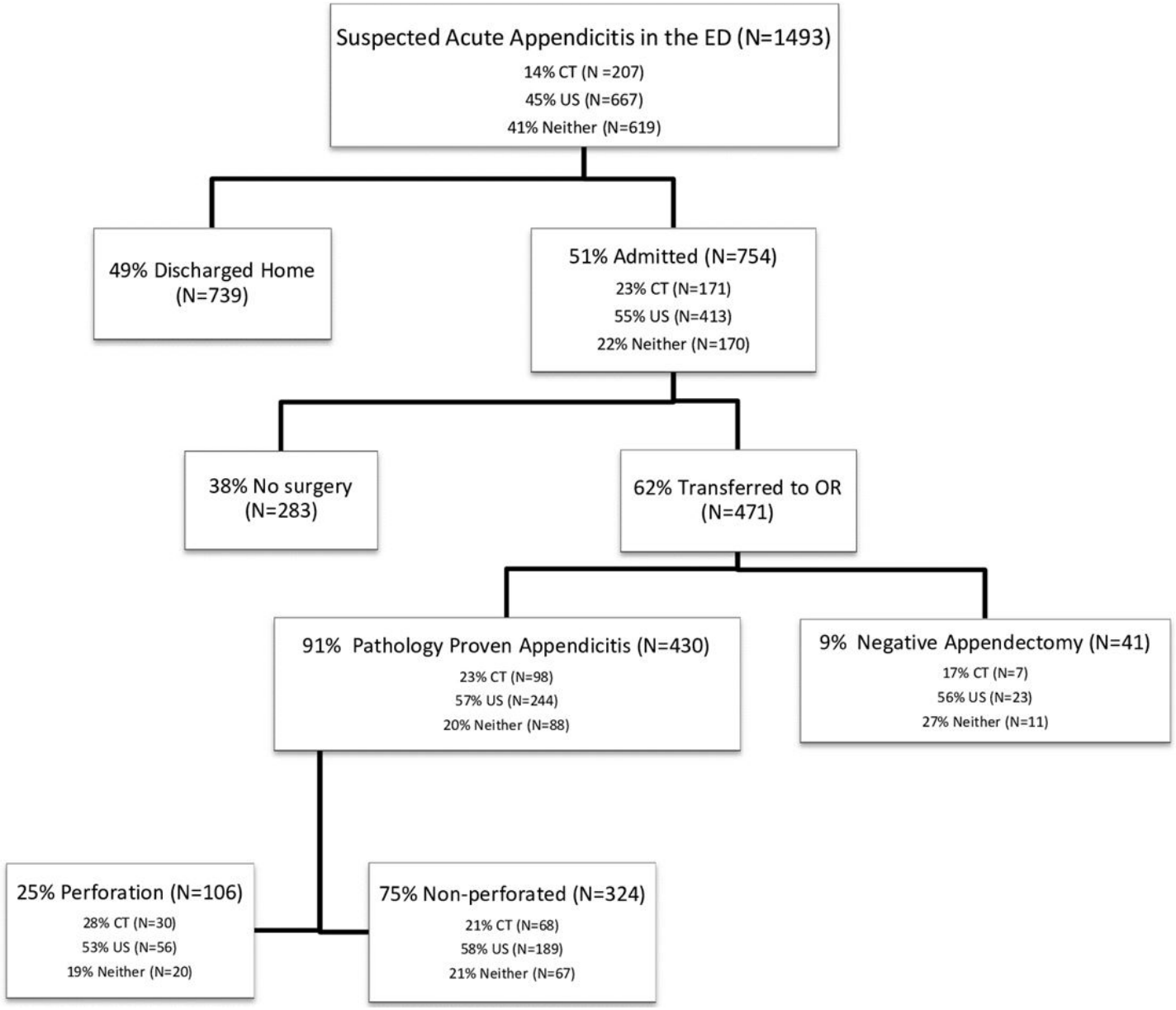

Figure 3. Flow diagram of initial ED presentation to discharge diagnosis and disposition from hospital.
ED, emergency department; *CT,* computed tomography; *US,* ultrasound; *OR,* operating room

challenges or risks of other pathologies.

LIMITATIONS

This is a retrospective, single-center non-randomized study, where imaging decisions were left to the treating physician as described in the methods section. The initial definition used to identify children who presented to the ED with suspected acute appendicitis may have limited our study population. It is possible that some children with appendicitis were missed. Additionally, follow-up contact on the 739 patients discharged from the ED was not possible, and patients who were discharged with a diagnosis other than appendicitis may have presented to another institution and ultimately been diagnosed with appendicitis. However, in our region it is rare for a community hospital to perform an appendectomy on a child. Only 11 children returned to our ED within seven days of original presentation, and none had appendicitis. Also, no children who were originally sent home returned to this study hospital within two weeks of the original visit and diagnosed with acute appendicitis. The availability of US in community hospitals may limit its use and decrease the generalizability of our results. US was available in the study hospital weekdays from 7:30am until 11:00p, and Saturday mornings. US was not available overnight or on Sundays. Propensity score analysis was not done because details regarding specific surgeon and illness severity on presentation were not available.

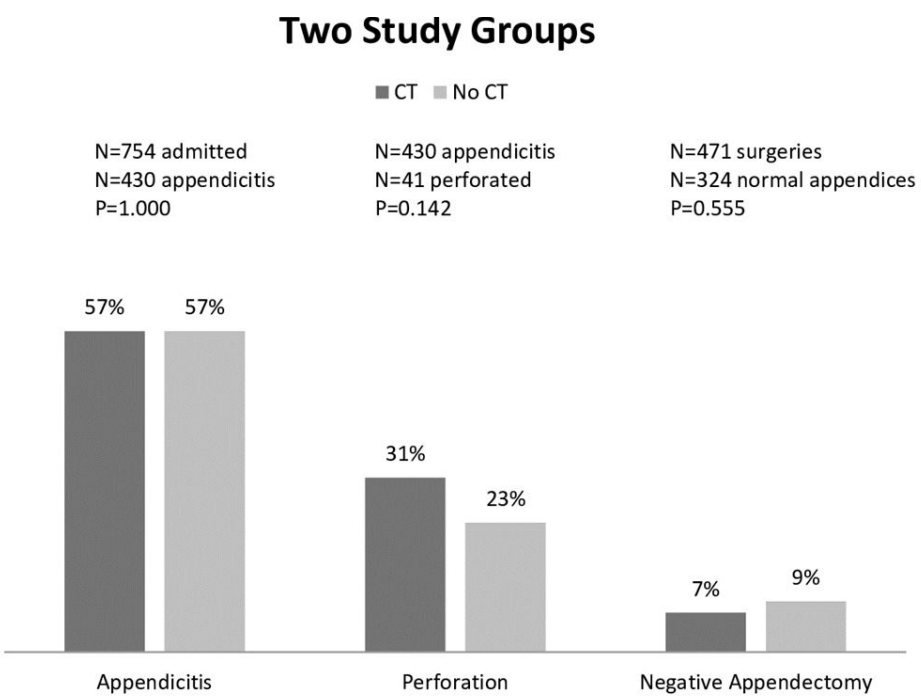

Figure 4. This figure shows the rate comparison of the two study groups and the three outcomes: pathology proven appendicitis, rupture, and negative appendectomy.
CT, computed tomography

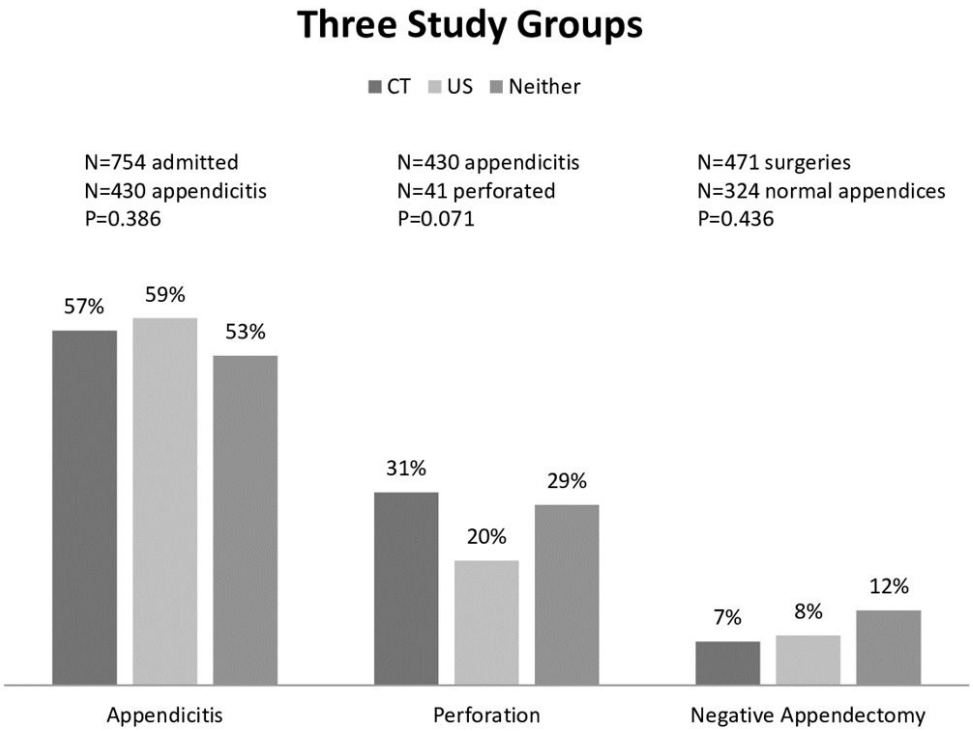

Figure 5. This figure shows the rate comparison of the three study groups and the three outcomes: pathology proven appendicitis, rupture, and negative appendectomy.
CT, computed tomography; *US,* ultrasound

CONCLUSION

The rate of complications did not vary significantly for children with suspected acute appendicitis who had CT versus US, in conjunction with surgical consult. The proportion of children with pathology-proven appendicitis, ruptured appendices, and negative appendectomy was similar for children regardless of type of imaging used.

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Conflicts of Interest: By the *West*JEM article submission agreement, all authors are required to disclose all affiliations, funding sources and financial or management relationships that could be perceived as potential sources of bias. The authors disclosed none.

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Chest Pain of Suspected Cardiac Origin: Current Evidence-based Recommendations for Prehospital Care

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Introduction: In the United States, emergency medical services (EMS) protocols vary widely across jurisdictions. We sought to develop evidence-based recommendations for the prehospital evaluation and treatment of chest pain of suspected cardiac origin and to compare these recommendations against the current protocols used by the 33 EMS agencies in the state of California.

Methods: We performed a literature review of the current evidence in the prehospital treatment of chest pain and augmented this review with guidelines from various national and international societies to create our evidence-based recommendations. We then compared the chest pain protocols of each of the 33 EMS agencies for consistency with these recommendations. The specific protocol components that we analyzed were use of supplemental oxygen, aspirin, nitrates, opiates, 12-lead electrocardiogram (ECG), ST segment elevation myocardial infarction (STEMI) regionalization systems, prehospital fibrinolysis and β-blockers.

Results: The protocols varied widely in terms of medication and dosing choices, as well as listed contraindications to treatments. Every agency uses oxygen with 54% recommending titrated dosing. All agencies use aspirin (64% recommending 325mg, 24% recommending 162mg and 15% recommending either), as well as nitroglycerin and opiates (58% choosing morphine). Prehospital 12-Lead ECGs are used in 97% of agencies, and all but one agency has some form of regionalized care for their STEMI patients. No agency is currently employing prehospital fibrinolysis or β-blocker use.

Conclusion: Protocols for chest pain of suspected cardiac origin vary widely across California. The evidence-based recommendations that we present for the prehospital diagnosis and treatment of this condition may be useful for EMS medical directors tasked with creating and revising these protocols. [West J Emerg Med. 2015;16(7):983-995.]

INTRODUCTION

The care provided by emergency medical services (EMS) varies widely in the United States. The Institute of Medicine report, "EMS at the Crossroads," notes that an area of improvement for EMS is the need for more uniform quality care and the need to develop measures for EMS quality.[1] A major area of EMS quality that is difficult to measure is the prehospital protocols that EMS personnel follow while taking care of patients. These protocols vary widely between jurisdictions. In the state of California, EMS care is divided

into 33 separate local EMS agencies (LEMSAs). These government agencies are a countywide or region-wide system of first responders and ambulance transporters that operate under one set of medical control policies.

The EMS Medical Directors Association of California (EMDAC) is a professional organization whose members include the directors of these agencies along with other interested EMS medical directors. The function of EMDAC is to provide support and guidance to the various agencies as well as to make recommendations to the California EMS Authority about policy, legislation and scope of practice issues. In an effort to improve the quality of EMS care in our state, EMDAC has endeavored to create evidence-based recommendations for EMS protocols. These recommendations are intended to assist medical directors of the various LEMSAs in developing protocols that are of high quality and evidence based. We hope to provide a summary of the evidence for the prehospital treatment of chest pain of suspected cardiac origin and to measure the consistency of current California protocols.

METHODS

A subcommittee of EMDAC endeavored to create a narrative review of the existing evidence for prehospital treatment of chest pain. The subcommittee chose by consensus the elements that should be included in any protocol for chest pain of suspected cardiac origin.

Clinical questions regarding these interventions were developed in the population, intervention, control group and outcome format. Our population was those patients in the prehospital setting with chest pain of suspected cardiac origin. The intervention varied by clinical question. The control group consisted of patients who were not receiving the specific intervention, and outcomes were defined by resolution of electrocardiographic (12-lead ECG) findings, chest pain resolution, infarct size and mortality. The outcomes varied considerably depending on the individual study design. These commonly included cardiac events, rate of myocardial infarction (MI), arrhythmias, shock, death, length of stay, infarct size, need for percutaneous intervention (PCI) and/or ejection fraction.

We relied heavily on recommendations made by various organizations that have performed systematic reviews and meta-analyses regarding these treatment interventions including the American Heart Association (AHA), the Cochrane Group and the International Liaison Committee on Resuscitation (ILCOR). We supplemented the recommendations from these organizations with additional literature searches through PubMed for each specific question.

The process used for assigning levels of evidence (LOE) and grading our recommendations was taken from the American College of Emergency Physicians (ACEP) process of creating their clinical policies with slight modification to better fit our objectives. A committee of EMDAC reviewed studies and assigned LOE based on the study design, including features such as data collection methods, randomization, blinding, outcome measures and generalizability.[2] A brief summary of the reviewed studies is available in an electronic appendix. LOE I consisted of randomized, controlled trials, prospective cohort studies, meta-analysis of randomized trials or prospective studies, or clinical guidelines/comprehensive review. LOE II consisted of nonrandomized trials and retrospective studies. LOE III consisted of case series, case reports, and expert consensus. After assigning LOE to the studies, these were translated to clinical grades of our recommendations using the following standards:

Level A recommendations

Prehospital recommendations with a strong degree of certainty based on one or more LOE I studies or multiple LOE II studies.

Level B recommendations

Prehospital recommendations with a moderate degree of certainty based on one or more LOE II studies or multiple LOE III studies.

Level C recommendations

Prehospital recommendations that are based on only poor quality or minimal LOE III studies or based on consensus.

No recommendation

No recommendation will be given in those cases where only preliminary data or no published evidence exists and we have no expert consensus. We may also withhold recommendation when studies, no matter their LOE, currently show conflicting data.

After answering the clinical question and providing recommendations for diagnostic and treatment interventions, each current chest pain protocol for the 33 agencies were reviewed for consistency with the recommendations. The clinical protocols were reviewed during the month of July 2015. Institutional review board approval was deemed to not be necessary for this review of publicly available research and clinical protocols.

Supplemental Oxygen

Clinical Question

Does the prehospital administration of oxygen to patients with chest pain and normal oxygen saturations improve outcomes in cases of suspected acute coronary syndrome (ACS)?

Summary of Current Evidence

There have been few randomized controlled studies that have attempted to answer this question. A study in 1976 by Rawles et al. randomized patients to oxygen or air and found

more deaths in the oxygen group, although not clinically significant.[3] A more recent trial addressing this question was in 2012 by Ranchord et al. showing no difference in mortality between a titrated oxygen group and a high-flow oxygen group, but with a very small sample size.[4] The ILCOR ACS guidelines in 2010 do not find sufficient evidence to support the use of oxygen in suspected ACS, but do not find evidence of harm.[5] A meta-analysis by Cochrane review (updated in 2013) showed no evidence of benefit and, in fact, showed possible harm with routine oxygen administration in suspected ACS, but noted that the analysis lacked the power to substantiate or refute the use of oxygen in these cases.[6] A recent multicenter, prospective, randomized, controlled trial compared prehospital oxygen (8L/min) with no supplemental oxygen in patients with ST segment myocardial infarction (STEMI) and oxygen saturation of 94% or greater.[7] The authors demonstrated that supplemental oxygen in this group increased early myocardial injury and was associated with larger myocardial infarct size and a higher rate of re-infarction. The DETO2X-AMI trial is ongoing and will examine this question among patients with suspected ACS and should be adequately powered to address this question.[8]

Current Prehospital Treatment Recommendation

There is no evidence that the routine use of oxygen to patients with normal oxygen saturations provides any benefit, but may cause harm.

Level A Recommendation

We recommend against routine oxygen supplementation in normoxic patients (oxygen saturation of 94% or greater) with suspected ACS.[9] We recommend using supplemental oxygen for those patients with suspected ACS and signs of heart failure or shock.[9]

Level B Recommendation

None given.

Level C Recommendation

Oxygen saturations should be titrated between 94%-98% (consensus).

Aspirin

Clinical Question

Does the prehospital administration of aspirin to patients with suspected ACS improve outcomes with an acceptable rate of adverse events?

Summary of Current Evidence

There is high-quality evidence demonstrating benefit of aspirin administration (162.5mg) in improving mortality among patients with an acute myocardial infarction (MI).[5-11] This reduction in long-term mortality is greatest when the aspirin is administered early.[12,13]

Current Prehospital Treatment Recommendation

Level A Recommendation

We recommend the administration of aspirin to adults with chest pain due to suspected ACS. In making this recommendation, we place a higher value on the benefits of aspirin (decreased mortality and decreased complications of MI), which outweigh the risks of adverse effects (gastrointestinal bleeding). Aspirin is contraindicated in the setting of known aspirin allergy.

Level B Recommendation

None given.

Level C Recommendation

None given.

Nitrates

Clinical Question

Does the administration of nitroglycerin in the prehospital setting to patients with suspected ACS improve outcomes when compared to not using nitrates?

Summary of Current Evidence

There have been no trials to specifically evaluate the usefulness of nitrates in the field or in the emergency department (ED) among patients with chest pain of suspected ACS.[5] A reduction in infarct size (using creatinine kinase as a surrogate measure) was noted in those treated within three hours of symptoms in three studies of intensive care unit patients.[14-16] There have been two trials showing that combined treatment with nitroglycerin and fibrinolytics may have a detrimental effect on reperfusion.[17,18] There is currently not enough evidence to suggest clinical benefit or harm of nitroglycerin use in the prehospital setting.

Current Prehospital Treatment Recommendation

Level A Recommendation

None given.

Level B Recommendation

None given.

Level C Recommendation

If nitroglycerin is used, then the following contraindications should be part of the protocol (expert consensus):

- Contraindications with hypotension, defined as a systolic blood pressure less than 90mmHg, by expert consensus.
- Contraindications with suspected right side/inferior infarct.
- Contraindication with the recent use of

phosphodiesterase-5 inhibitors for erectile dysfunction or pulmonary hypertension.

No recommendation

Although it is reasonable to consider the early administration of nitroglycerin in selected patients without contraindications, insufficient evidence exists to support or refute the routine administration of nitroglycerin in the ED or prehospital setting in patients with suspected ACS.[5]

Opiates

Clinical Question

Does the administration of opiates to patients with suspected ACS improve outcomes when compared to not using opiates?

Summary of Current Evidence

Clear benefit to opiate administration is unclear. There is a single study that suggested mortality and rates of infarction are more prevalent in patients who receive morphine with Non STEMI.[5,19] No studies have been done with fentanyl among patients with chest pain of suspected cardiac etiology.

Current Prehospital Treatment Recommendation

Level A Recommendation

None given.

Level B Recommendation

None given.

Level C Recommendation

If opiates are used, they should be administered intravenously and titrated to pain relief (consensus). Contraindications with hypotension, defined as a systolic blood pressure less than 90mmHg.

No Recommendation

Although it is reasonable to consider the early administration of opiates in selected patients without contraindications, insufficient evidence exists to support or refute its routine administration in the ED or prehospital setting in patients with chest pain of suspected ACS. There is only one poor quality study that demonstrated harm.

12-lead ECG

Clinical Question

Does the prehospital use of a 12-lead ECG increase the diagnostic sensitivity and specificity of STEMI among patients with chest pain of suspected ACS when compared to not using a prehospital 12-lead ECG?[5]

Summary of Current Evidence

Several studies have demonstrated that prehospital 12-lead ECGs can improve the recognition of STEMI with reasonable sensitivity and specificity.[20-26] Repeat prehospital or ED 12-lead ECGs may be helpful.[21,27] The timely notification of the STEMI center is helpful in reducing door-to-intervention times.[28] The research on computer-interpreted electrocardiography has been mixed but seems to be generally accurate and had a greater influence on non-expert performance.[5,29] There has been limited research in the effectiveness of transmission of the 12-lead ECG.[30]

Current Prehospital Treatment Recommendation

Level A Recommendation

In patients with suspected ACS, a 12-lead ECG should be acquired and interpreted by prehospital or emergency providers as soon as possible after first patient contact. The interpretation should be used in conjunction with the clinical signs and presentation for diagnosis and triage, including destination decisions.

Level B Recommendation

Repeated prehospital 12-lead ECGs may improve diagnostic accuracy of STEMI. Transmitted 12-lead ECGs may be useful in decreasing door-to-intervention times. The timely notification of the STEMI-receiving center is helpful in decreasing door-to-intervention times. Prehospital activation of the catheterization lab may also help to decrease door-to-intervention times. Computer interpretation of 12-lead ECGs may help to increase the specificity of the diagnosis, especially with less experienced paramedics.

Level C Recommendation

None given.

Regionalization of STEMI Care

Clinical Question

Does the regionalization of STEMI care lead to decreased door-to-intervention times and improved patient outcomes in prehospital patients with STEMI when compared to a non-regionalized program?

Summary of Current Evidence

It has been shown in multiple studies that primary PCI is the ideal method of reperfusion in patients presenting with STEMI.[31] Timely PCI leads to decreased morbidity and mortality in this patient population.[32,33] Current AHA recommendations call for a first medical contact to intervention time of less than 90 minutes and additionally note that the EMS system can play a large role in decreasing not only D2B time, but "total ischemic time," as well.[11,34,35] The AHA also recognizes that PCI is not always available and in these cases thrombolytics may be required.[11] Regionalization of STEMI care does lead to decreased door-to-intervention times.[36,37] The evidence for improvements in mortality and other clinical outcomes among STEMI patients

are less well studied.

Rapid inter-facility transfers of patients with STEMI presenting to a non-PCI hospital can reduce time to treatment. STEMI systems should include an organized inter-facility transfer process that includes inter-hospital agreements and ambulance dispatch protocols designed to minimize transfer time.

Current Prehospital Treatment Recommendation

Level A Recommendation

There is a large body of evidence suggesting that primary PCI is superior to thrombolytics.There is also evidence suggesting benefit of STEMI regionalization programs in decreasing door-to-intervention times. We recommend EMS systems employ a regionalization program for STEMI patients that provide direct transport to PCI capable centers. In cases where timely transport to a PCI center is not possible (>90min), transport to a facility that can provide thrombolytic therapy is reasonable.

Level B Recommendation

None given.

Level C Recommendation

None given.

Fibrinolytics

Clinical Question

In patients with STEMI and a prolonged time to primary PCI, does the use of prehospital fibrinolytics improve outcomes?

Summary of Current Evidence

There is a significant body of high-quality evidence describing the benefit of fibrinolytic therapy given to patients with STEMI when it is anticipated that primary PCI cannot be performed within 120 minutes of first medical contact.[10,11,38,39] If prehospital fibrinolysis is chosen as the reperfusion strategy, there should be well-established protocols with a competency training program, performance improvement, and robust medical oversight. This is not currently in the scope of practice for paramedics in the state of California.

Current Prehospital Treatment Recommendation

Level A Recommendation

None given.

Level B Recommendation

None given.

Level C Recommendation

For those patients with a STEMI, onset of ischemic symptoms within the previous 12 hours and primary PCI cannot be accomplished within 120 minutes of first medical contact, prehospital fibrinolytics can be considered. There should be considerable oversight for any prehospital thrombolytic program. Because it is not in the current scope of practice for paramedics in California, this could only be done as a pilot study with approval from the EMS Authority.

β-Blockers

Clinical Question

Does the prehospital administration of a β-blocker to patients with an acute STEMI improve outcomes?

Summary of Current Evidence

Current recommendations by the AHA are that a β-blocker be administered in the first 24 hours after an acute MI.[40] There is evidence to show that early β-blocker administration may improve infarct size and left ventricular ejection fraction.[41] There has been one study comparing prehospital metoprolol administration to patients with STEMI to those receiving metoprolol 12 to 24 hours later. The prehospital patients, in this study, showed smaller infarct sizes and improved ejection fractions.[42]

Current Prehospital Treatment Recommendation

Level A Recommendation

None given.

Level B Recommendation

None given.

Level C Recommendation

None given.

No Recommendation

While the prehospital administration of β-blockers does seem to show promise, there are insufficient studies at this time to make a prehospital treatment recommendation regarding their use in the field.

RESULTS

All 33 agencies protocols were identified and reviewed for consistency with the recommendations made by EMDAC for chest pain of suspected cardiac origin. Every agency has a protocol relating to the treatment of chest pain, though these protocols vary significantly in content and organization. Examples of suggested language for protocol development that the committee felt was most consistent with the recommendations were taken from the agency protocols.

Supplemental Oxygen Administration

Every agency has a component of oxygen administration in their protocol for chest pain. Routine use of oxygen, regardless of the patient's oxygen saturation is recommended in 39% of agencies, with 54% percent of agencies advising

Table 1. Oxygen use in patients with chest pain.

LEMSA	Routine use regardless of SpO_2%	Oxygen titration	Titration range	Advise against use with normal SpO_2%	Advise use in shock or dyspnea
Alameda County	No	Yes	94-99%	No	Yes
Central California	Yes	No	N/A	No	Yes
San Francisco	No	Yes	94-95%	No	Yes
Coastal Valleys	No	Yes	94-98%	No	Yes
Contra Costa County	No	Yes	>94%	No	Yes
El Dorado County	Yes	No	N/A	No	Yes
Imperial County	No	Yes	94%	No	Yes
Inland Counties	No	No	N/A	No	Yes
Kern County	Yes	No	N/A	No	Yes
Los Angeles County	No	Yes	94-98%	No	Yes
Marin County	No	Yes	94-99%	No	Yes
Merced County	Yes	No	N/A	No	Yes
Monterey County	No	No	N/A	No	Yes
Mountain Valley	Yes	No	N/A	No	Yes
Napa County	Yes	Yes	>94%	No	Yes
Northern California	Yes	No	N/A	No	Yes
North Coast	No	Yes	>94%	Yes	Yes
Orange County	No	Yes	>94%	No	Yes
Riverside County	No	Yes	>94%	No	Yes
Sacramento County	No	Yes	95%	Yes	Yes
San Benito County	No	Yes	95%	Yes	Yes
San Diego County	No	No	N/A	No	Yes
San Joaquin County	Yes	No	N/A	No	Yes
San Luis Obispo County	Yes	No	N/A	No	Yes
San Mateo County	Yes	No	N/A	No	Yes
Santa Barbara County	No	Yes	94%	No	Yes
Santa Clara County	Yes	No	N/A	No	Yes
Santa Cruz County	No	Yes	94-95%	Yes	Yes
Sierra-Sacramento	Yes	Yes	>94%	No	Yes
Solano County	Yes	No	N/A	No	Yes
Tuolumne County	No	No	N/A	No	Yes
Ventura County	No	Yes	94%	No	Yes
Yolo County	No	Yes	94-99	No	Yes

LEMSA, local emergency medical services angencies

a titrated dose to their providers (Table 1). Only four of the agencies had language specifically advising against the use of supplemental oxygen if the patient had normal oxygen saturation. All agencies advise the use of supplemental oxygen in cases of shock or respiratory distress, even if the patient has normal oxygen saturations.

Aspirin Administration

The use of aspirin for chest pain of suspected cardiac etiology is universal among our agencies (Table 2). There is no consensus on the dose of aspirin to be used. Sixty-four percent of agencies recommend a 324mg dose, 24% recommend a 162mg dose and 15% recommend either 162mg or 325mg dosing.

There is also great variability in what are considered contraindications to aspirin use. Aspirin allergy is specifically noted as a contraindication in 58% of agencies and recent gastrointestinal bleeding is noted in 30% of agencies. Two agencies noted peptic ulcer disease as a contraindication and one noted asthma, chest pain

Table 2. Aspirin use in patients with chest pain.

LEMSA	Used	Dose (mg)	Hold if allergy	Hold if recent GI bleed
Alameda County	Yes	162-324	No	No
Central California	Yes	162	Yes	Yes
San Francisco	Yes	324	Yes	Yes
Coastal Valleys	Yes	324	Yes	Yes
Contra Costa County	Yes	325	Yes	Yes
El Dorado County	Yes	162	Yes	No
Imperial County	Yes	162	No	No
Inland Counties	Yes	324/325	No	No
Kern County	Yes	325	Yes	Yes
Los Angeles County	Yes	162-325	Yes	Yes
Marin County	Yes	162-325	No	No
Merced County	Yes	324	Yes	Yes
Monterey County	Yes	162	No	No
Mountain Valley	Yes	324	Yes	No
Napa County	Yes	162	Yes	Yes
Northern California	Yes	324/325	Yes	Yes
North Coast	Yes	324	Yes	No
Orange County	Yes	324	Yes	No
Riverside County	Yes	324	No	No
Sacramento County	Yes	325	Yes	No
San Benito County	Yes	162	Yes	No
San Diego County	Yes	324	No	No
San Joaquin County	Yes	325	Yes	Yes
San Luis Obispo County	Yes	162	Yes	Yes
San Mateo County	Yes	324	Yes	No
Santa Barbara County	Yes	324	No	No
Santa Clara County	Yes	324	No	No
Santa Cruz County	Yes	162	Yes	No
Sierra-Sacramento	Yes	325	No	No
Solano County	Yes	325	No	No
Tuolumne County	Yes	325	No	No
Ventura County	Yes	324	No	No
Yolo County	Yes	162-325	Yes	No

LEMSA, local emergency medical services agency; *GI*, gastrointestinal

radiating to the mid back and chronic anticoagulant use as contraindications. Some protocols clarify that aspirin is indicated in the setting of the use of other anticoagulants (e.g. warfarin) or of gastrointestinal disease without a recent bleeding episode.

Nitroglycerin Administration

All agencies include sublingual nitroglycerin, either tablets or spray, in the treatment of chest pain (Table 3). One agency does not allow the use of nitroglycerin for patients with STEMI. Topical nitroglycerin paste is present in 36% of the protocols. Hypotension is noted as a contraindication to nitroglycerin use in 100% of the protocols; however, the definition of hypotension varies. A systolic blood pressure as less than 90mmHg is the definition of hypotension in 36% of agencies while less than 100mm Hg is the definition in 52% of agencies. One agency (2%) uses less than 110mmHg as the cut off and three agencies (9%) do not define hypotension. Right-sided or inferior MI is a contraindication in 21% of agencies and phosphodiesterase 5 (PDE5) inhibitor use is noted as a contraindication in 91% of protocols.

Table 3. Nitroglycerin use in patients with chest pain.

LEMSA	Used	Route	Hold if hypotension	Hold if right or inferior MI	Hold if PDE5 inhibitor
Alameda County	Yes	SL	Yes (90/30)	Yes	Yes
Central California	Yes	SL, Paste	Yes (<100sys)	No	No
San Francisco	Yes	SL	Yes (<90sys)	Yes	Yes
Coastal Valleys	Yes	SL, Paste	Yes (<100sys)	No	Yes
Contra Costa County	Yes	SL	Yes (<90sys)	All STEMI	Yes
El Dorado County	Yes	SL, Paste	Yes (<100sys)	No	Yes
Imperial County	Yes	SL	Yes (<100sys)	No	Yes
Inland Counties	Yes	SL	Yes	Yes	Yes
Kern County	Yes	SL	Yes (<90sys)	No	Yes
Los Angeles County	Yes	SL	Yes (<100sys)	No	Yes
Marin County	Yes	SL	Yes (<100sys)	Yes	Yes
Merced County	Yes	SL, Paste	Yes (<100sys)	No	Yes
Monterey County	Yes	SL, Paste	Yes (<110sys)	No	Yes
Mountain Valley	Yes	SL	Yes (<100sys)	No	Yes
Napa County	Yes	SL, Paste	Yes (<100sys)	No	Yes
Northern California	Yes	SL	Yes (<90sys)	No	Yes
North Coast	Yes	SL	Yes (<90sys)	Yes	No
Orange County	Yes	SL	Yes (<90sys)	No	Yes
Riverside County	Yes	SL, Paste	Yes (<90sys)	No	Yes
Sacramento County	Yes	SL	Yes (<90sys)	No	Yes
San Benito County	Yes	SL, Paste	Yes	No	Yes
San Diego County	Yes	SL, Paste	Yes (<100sys)	No	Yes
San Joaquin County	Yes	SL	Yes (<90sys)	No	Yes
San Luis Obispo County	Yes	SL, Paste	Yes (<100sys)	Yes	Yes
San Mateo County	Yes	SL	Yes (<90sys)	No	Yes
Santa Barbara County	Yes	SL	Yes (<100sys)	No	Yes
Santa Clara County	Yes	SL	Yes (<100sys)	No	Yes
Santa Cruz County	Yes	SL, Paste	Yes	No	Yes
Sierra-Sacramento	Yes	SL	Yes (<100sys)	No	Yes
Solano County	Yes	SL	Yes (<100sys)	No	Yes
Tuolumne County	Yes	SL	Yes (<90sys)	No	Yes
Ventura County	Yes	SL	Yes (<100sys)	No	Yes
Yolo County	Yes	SL, Paste	Yes (<100sys)	Yes	Yes

LEMSA, local emergency medical services angencies; *MI*, myocardial infarction, *STEMI,* ST segment elevation myocardial infarction; *SL*, sublingual; *sys*, systolic

Opiate Administration

Opiate use for chest pain is recommended in all protocols. Morphine sulfate is the opiate used in 58% of agencies, while fentanyl is the opiate of choice in 15% of agencies (Table 4). Both medications are available in 27% of the agencies' protocols. Hypotension is noted as a contraindication for 88% of the protocols. Of those that mention hypotension as a contraindication for opiate administration, 41% define it as a systolic blood pressure of less than 90mmHg and 45% define it as less than 100mmHg. One agency (3%) defines it as less than 110mmHg, and three agencies (10%) do not define hypotension.

Prehospital 12-lead ECGs

Prehospital 12-lead ECGs are used in all but one of the 33 agency (97%) (Table 5). Transmission of the ECG to a receiving facility is advised in 61% of the protocols. Computer interpretation of the ECG is mentioned in 82% of the protocols and some form of medic interpretation (whether by noting morphology or contacting the base hospital) is

Table 4. Opiate use in patients with chest pain.

LEMSA	Used	Opiate	Route	Hold if hypotension
Alameda County	Yes	Fentanyl	IV/IO/IM/IN	Yes (<90sys)
Central California	Yes	Fentanyl	IV/IN	Yes (<100sys)
San Francisco	Yes	Morphine	IV/IO/IM	Yes (<90sys)
Coastal Valleys	Yes	Fentanyl	IV	Yes (<100sys)
Contra Costa County	Yes	Fentanyl	IV	Yes (<90sys)
El Dorado County	Yes	Fentanyl/MS	IV/IO/IM/IN	Yes (<90sys)
Imperial County	Yes	Morphine	IV	Not mentioned
Inland Counties	Yes	Fentanyl/MS	IV/IO/IM/IN	Not mentioned
Kern County	Yes	Morphine	IV	Yes (<90sys)
Los Angeles County	Yes	Fentanyl/MS	IV/IO	Yes
Marin County	Yes	Morphine	IV	Not mentioned
Merced County	Yes	Morphine	IV	Yes (<100sys)
Monterey County	Yes	Morphine	IV	Yes (<110sys)
Mountain Valley	Yes	Morphine	IV/IO/IM	Yes (<100sys)
Napa County	Yes	Fentanyl	IV/IN	Yes (<100sys)
Northern California	Yes	Morphine	IV	Not mentioned
North Coast	Yes	Morphine	IV/IM	Yes (<90sys)
Orange County	Yes	Fentanyl/MS	IV	Yes (<90sys)
Riverside County	Yes	Morphine	IV/IO/IM	Yes (<90sys)
Sacramento County	Yes	Fentanyl/MS	IV/IO	Yes (<90sys)
San Benito County	Yes	Morphine	IV/IO	Yes
San Diego County	Yes	Morphine	IV	Yes (<100sys)
San Joaquin County	Yes	Morphine	IV	Yes (<90sys)
San Luis Obispo County	Yes	Morphine	IV	Yes (<100sys)
San Mateo County	Yes	Morphine	IV/IM	Yes (<90sys)
Santa Barbara County	Yes	Morphine	IV/IM	Yes (<100sys)
Santa Clara County	Yes	Morphine	IV	Yes (<100sys)
Santa Cruz County	Yes	Morphine	IV/IO	Yes
Sierra-Sacramento	Yes	Fentanyl/MS	IV/IO	Yes (<100sys)
Solano County	Yes	Fentanyl/MS	IV	Yes (<100sys)
Tuolumne County	Yes	Fentanyl/MS	IV	Yes (<90sys)
Ventura County	Yes	Morphine	IV/IM	Yes (<100sys)
Yolo County	Yes	Fentanyl/MS	IV/IO/IM	Yes (<100sys)

LEMSA, local emergency medical services angencies; *IV*, intravenous; *IM*, intramuscular; *IO*, intraosseous; *sys*, systolic; *MS*, morphine sulfate

mentioned in 42% of protocols. Timely receiving center notification of STEMI is mandated in 94% of protocols. Serial 12-lead ECGs during transport of a patient with chest pain is practiced by 55% of agencies.

STEMI Regionalization

All but one (97%) of the agencies has some form of regionalization of STEMI care. These systems are not uniform in design and the capabilities of the systems vary widely based on geography and access to PCI capable receiving centers.

Prehospital Fibrinolytics

There are currently no agencies that employ fibrinolytics in the field. One agency received approval in the past for a trial study of prehospital fibrinolytics for STEMI patients but enrolled no patients during the trial study period.

DISCUSSION

The chest pain protocols reviewed varied greatly in content and structure between LEMSAs in California. These government agencies consist of either a county or region that develops a system of care that include first responders,

Table 5. 12-lead ECG in patients with chest pain.

LEMSA	Used	Transmit	Computer interprets	Medic interprets	Notify STEMI center	Serial ECGs
Alameda County	Yes	Yes	Yes	Yes	Yes	Yes
Central California	Yes	No	Yes	No	Yes	No
San Francisco	Yes	Yes	No	Yes	Yes	Yes
Coastal Valleys	Yes	Yes	Yes	Yes	Yes	Yes
Contra Costa County	Yes	Yes	Yes	No	Yes	Yes
El Dorado County	Yes	Yes	Yes	No	Yes	No
Imperial County	Yes	No	Unclear	Unclear	Yes	No
Inland Counties	Yes	No	No	Yes	Yes	Yes
Kern County	Yes	Yes	Yes	No	Yes	No
Los Angeles County	Yes	Yes	Yes	No	Yes	No
Marin County	Yes	Yes	Yes	Yes	Yes	No
Merced County	Yes	No	Yes	No	Yes	No
Monterey County	Yes	Yes	Yes	Yes	Yes	Yes
Mountain Valley	Yes	No	Yes	No	Yes	Yes
Napa County	Yes	Yes	Yes	Yes	Yes	Yes
Northern California	Yes	Yes	Unclear	Yes	Yes	No
North Coast	Yes	No	Yes	Yes	Yes	Yes
Orange County	Yes	No	Yes	No	Yes	No
Riverside County	Yes	Yes	Yes	Yes	Yes	No
Sacramento County	Yes	No	Yes	No	Yes	No
San Benito County	No	No	No	No	No	No
San Diego County	Yes	No	Yes	No	No	Yes
San Joaquin County	Yes	Yes	Yes	No	Yes	No
San Luis Obispo County	Yes	No	Yes	Yes	Yes	Yes
San Mateo County	Yes	Yes	Yes	Yes	Yes	Yes
Santa Barbara County	Yes	No	Yes	No	Yes	Yes
Santa Clara County	Yes	Yes	Yes	Yes	Yes	No
Santa Cruz County	Yes	Yes	No	Yes	Yes	No
Sierra-Sacramento	Yes	Yes	Yes	No	Yes	No
Solano County	Yes	Yes	Yes	No	Yes	Yes
Tuolumne County	Yes	Yes	Yes	No	Yes	No
Ventura County	Yes	No	Yes	No	Yes	Yes
Yolo County	Yes	Yes	Yes	Yes	Yes	No

LEMSA, local emergency medical services angencies; *ECG*, electrocardiogram; *STEMI,* ST segment elevation myocardial infarction

ambulance transporters, and specialty receiving facilities. These systems reflect the needs and demographics of that county or region and operate under one set of medical control policies.

A similar variation among protocols was seen in a recent study on state wide EMS protocols.[43] The National Association of EMS Officials recently published model EMS guidelines that could be used to decrease this variability.[44]

Many agencies use some sort of titration language for oxygen use but only four restricted use with normal saturations. The current evidence seems to point towards more restrictive language for our protocols. Aspirin use, while universal, varied considerably in dosing and many agencies did not have contraindications clearly noted in their protocols. Local training could address these issues, even if not explicitly stated in the protocols themselves. Recent studies have demonstrated low rates of prehospital aspirin administration despite being almost universal in our protocols.[45]

Nitroglycerin is used by every agency with a wide variability noted in delivery route. Few agencies noted a contraindication with right-sided infarcts, with one agency

not allowing nitrates in any patient with STEMI to avoid this potential contraindication. Most agencies did caution use with PDE5 Inhibitors. Holding nitroglycerin for hypotension was universal, but the systolic blood pressure cut-off varied. Our recommended cut-off is a systolic blood pressure of 90mmHg.

Opiates were also found to be used in all protocols with many agencies preferring fentanyl over morphine. It should be noted that studies with fentanyl for ischemic chest pain are not available to specifically recommend this agent for suspected ACS.

Twelve-lead ECGs were used in all but one agency. The technique used to interpret STEMI varied between agencies with some using computer interpretation, medic interpretation or both. Most agencies notified receiving centers of their potential STEMI and many have transmission capabilities.

Prehospital fibrinolytics, while not employed at any agency, may still have a place for some rural systems without timely access to regionalized STEMI centers. Currently, paramedics in California do not have this in their scope of practice. If such a system were to be put in place it would require a trial study and substantial medical oversight.

While many states have mandatory protocols in place for their providers, California has allowed the individual agencies to develop and implement their own protocols. While this has allowed for flexibility among regions with different populations and financial and geographic restrictions, it may also contribute to health outcome disparities among the agencies. A study by Kupas et al. coined the term "model" protocols, which were found to be present in 17 states.[43] In contrast with mandatory protocols, which require local agencies to adopt the state protocols, model protocols are in place as an option for local use, but not required. This respects the local agencies' autonomy, but also provides a standard that can be adopted should a local agency need to create or change its protocols.

CONCLUSION

Protocols for chest pain of suspected cardiac origin vary widely across the state of California. The evidence-based recommendations that we present for the prehospital diagnosis and treatment of this condition may be useful for EMS medical directors tasked with creating and revising these protocols.

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Impact of Burnout on Self-Reported Patient Care Among Emergency Physicians

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Introduction: Burnout is a syndrome of depersonalization, emotional exhaustion and sense of low personal accomplishment. Emergency physicians (EPs) experience the highest levels of burnout among all physicians. Burnout is associated with greater rates of self-reported suboptimal care among surgeons and internists. The association between burnout and suboptimal care among EPs is unknown. The objective of the study was to evaluate burnout rates among attending and resident EPs and examine their relationship with self-reported patient care practices.

Methods: In this cross-sectional study burnout was measured at two university-based emergency medicine residency programs with the Maslach Burnout Inventory. We also measured depression, quality of life (QOL) and career satisfaction using validated questionnaires. Six items assessed suboptimal care and the frequency with which they were performed.

Results: We included 77 out of 155 (49.7%) responses. The EP burnout rate was 57.1%, with no difference between attending and resident physicians. Residents were more likely to screen positive for depression (47.8% vs 18.5%, p=0.012) and report lower QOL scores (6.7 vs 7.4 out of 10, p=0.036) than attendings. Attendings and residents reported similar rates of career satisfaction (85.2% vs 87.0%, p=0.744). Burnout was associated with a positive screen for depression (38.6% vs 12.1%, p=0.011) and lower career satisfaction (77.3% vs 97.0%, p=0.02). EPs with high burnout were significantly more likely to report performing all six acts of suboptimal care.

Conclusion: A majority of EPs demonstrated high burnout. EP burnout was significantly associated with higher frequencies of self-reported suboptimal care. Future efforts to determine if provider burnout is associated with negative changes in actual patient care are necessary. [West J Emerg Med. 2015;16(7):996-1001.]

INTRODUCTION

Burnout is a triad of emotional exhaustion, depersonalization and reduced sense of personal accomplishment that produces decreased effectiveness at work.[1] Physician burnout is widespread, with almost half of all physicians reporting high levels of burnout.[2] Among all specialties, emergency medicine (EM) experiences the highest levels of physician burnout at over 60%.[2,3]

High levels of burnout may negatively impact the quality of care physicians provide to patients. Prior work in select medical specialties suggests that burnout is associated with self-reported medical error (e.g., medication errors) and suboptimal care (e.g., failure to adhere to practice standards, lower patient satisfaction).[4-14] Burnout may also contribute to job turnover, absenteeism, low morale, and deterioration of provider health.[3,15-26] Although emergency physicians (EPs) report some of

the highest levels of burnout, to our knowledge the relationship between EP burnout and patient care has not been studied. Our study evaluated rates of burnout among attending and resident EPs and examined the relationship between their levels of burnout and self-reported patient care practices.

METHODS

Study Design

A cross-sectional survey of EPs measured provider levels of burnout and self-reported rates of suboptimal care.

Study Setting and Population

All attending and post-graduate year (PGY) 2-4 resident EPs, except the study authors, at two university-based PGY 1-4 training programs were eligible for this study conducted in September 2013. PGY-1 residents were excluded from the study because the survey asked respondents to rate their perception of patient care over the past year, and PGY-1 residents at the time of the study had only been in their positions for three months.

Study Protocol

An anonymous electronic survey was emailed to all eligible subjects. The invitation did not mention burnout, depression, or suboptimal care and subjects were blinded to any specific hypothesis of the study. Subjects consented to the voluntary study by completing the anonymous survey on an online and secure platform (REDCap). Up to two reminder emails were sent to non-responders. The human subjects review boards at both institutions approved the study.

Measurements

The survey included 39 items taken from previously described instruments on provider burnout, depression, and suboptimal care. Burnout was measured through the Maslach Burnout Inventory (MBI), a 22-item questionnaire that is a standard tool for measuring burnout.[1,27] The MBI evaluates the three dimensions of burnout: depersonalization, emotional exhaustion, and sense of low personal accomplishment. Consistent with prior work, burnout was defined by high scores in the depersonalization or emotional exhaustion subscales of the inventory.[27] In addition to burnout and depression, we evaluated quality of life (QOL) and career satisfaction. Provider depression was screened using the first two items of the Primary Care Evaluation of Mental Disorders instrument.[28] A "yes" response to either question was considered a positive screen for depression. We measured QOL by a single-item linear analog scale assessment: "How would you rate your overall quality of life over the past week?"[29] We assessed career satisfaction by a single-question: "If given the opportunity to revisit your career choice, would you choose to become a physician again?"[30] Responses of "likely" and "very likely" on a 5-point Likert scale were categorized as positive for career satisfaction.

We measured suboptimal care with a series of six statements adapted from prior work that investigated self-reported patient care among internal medicine resident physicians.[8] A group of board-certified EPs modified the statements to present EM-focused patient care practices that are common, relevant and important to a practicing EP. The six statements were (1) "I admitted or discharged patients to make the emergency department (ED) more manageable;" (2) "I did not fully discuss treatment options or answer a patient's questions;" (3) "I ordered more laboratory or radiology tests because I was so busy;" (4) "I did not treat a patient's pain in a timely manner;" (5) "I did not communicate important information during handoff to an ED colleague or admitting service;" and (6) "I did not discuss a patient's treatment plan with the patient's appropriate nursing or ancillary staff." EPs were asked if they performed these acts of suboptimal care rarely, monthly or weekly over the past year.

To encourage study participation and honest reporting, we collected limited demographic information (Table 1) so that subject responses could not be easily identified. We did not obtain information regarding the subject's work or training institution.

Data Analysis

We categorized burnout data as described above, and burnout was dichotomized and defined as meeting the MBI criteria of high emotional exhaustion or high depersonalization.[27] Burnout, depression, career satisfaction, QOL, and rates of self-reported suboptimal care were compared to career stage (resident versus attending). We then compared burnout to depression, career satisfaction, and self-reported suboptimal care. Comparisons were made using Fischer's exact test for categorical variables, and Student's t-test was used for continuous variables. We performed data analysis using STATA version 13 (College Station, TX).

RESULTS

A total of 91 out of 155 (58.7%) subjects responded to the survey with 77 completed responses included in the analyses (49.7%). Respondents were primarily attending EPs at a university hospital (61.0%), followed by residents (29.9%), and attending EPs at a community hospital (9.1%) (Table 1). EPs reported a burnout rate of 57.1%, with no statistically significant difference between attending and resident physicians. Residents, however, were more likely to report higher scores on the depersonalization subscale than attendings (73.9% vs 38.9%, p=0.011). There were no associations between burnout and gender and year in practice or training. Residents were more likely to screen positive for depression (47.8% vs 18.5%, p=0.012) and report lower QOL scores (6.7 vs 7.4 out of 10, p=0.036) than attendings (Table 2). Attendings and residents reported similar rates of career satisfaction (85.2% vs 87.0%, p=0.744). EP burnout was significantly associated with a positive screen for depression (38.6% vs 12.1%, p=0.011) and lower career satisfaction (77.3% vs 97.0%, p=0.02) (Table 3).

Table 1. Demographics of participants in study examining rates of burnout among emergency physicians.

	N (77)	%
Female	29	37.7
Attendings	54	70.1
Years in practice		
<1 yr	8	10.4
1-4 yr	13	16.8
5-10 yr	17	22.1
11-20 yr	8	10.4
21+ yr	8	10.4
Residents	23	29.9
Post-graduate year		
2	7	9.1
3	7	9.1
4	9	11.7
% effort to clinical practice (attendings)		
0-25%	0	0
26-50%	12	22.2
51-75%	19	35.2
76-100%	23	42.6
Primary practice site setting (attendings)		
Academic	47	87.0
Community	7	13.0
Primary practice site annual patient volume		
<25,000	0	0
25,001-50,000	8	10.4
50,001-75,000	24	31.1
75,001-100,000	35	45.5
>100,000	10	13.0

Table 2. Rates of provider distress.

	Attending (%)	Resident (%)	Total (%)
Burnout	27 (50.0)	17 (73.9)	44 (57.1)
EE Median (IQR)	20 (12-26)	20 (13-24)	20 (13-26)
Low	21 (38.9)	7 (30.4)	28 (36.3)
Intermediate	21 (38.9)	12 (52.2)	33 (42.9)
High	12 (22.2)	4 (17.4)	16 (20.8)
DP Median (IQR)	10 (7-14)	17 (12-21)	12 (7-19)
Low	13 (24.1)	4 (17.4)	17 (22.1)
Intermediate	20 (37.0)	2 (8.7)	22 (28.5)
High	21 (38.9)*	17 (73.9)*	38 (49.4)
PA Median (IQR)	41 (37-44)	43 (41-44)	42 (38-44)
Low	6 (11.1)	0 (0)	6 (7.8)
Intermediate	13 (24.1)	4 (17.4)	17 (22.1)
High	35 (64.8)	19 (82.6)	54 (70.1)
Depression	10 (18.5)^	11 (47.8)^	21 (27.3)
Career satisfaction	46 (85.2)	20 (87.0)	66 (85.7)
Quality of life (median, IQR)	7.4 (6.4-8.1)#	6.7 (5.8-7.3)#	7.2 (6.1-8.0)

Maslach Burnout Inventory subscales: *EE*, emotional exhaustion; *DP*, depersonalization; *PA,* personal accomplishment
*p=0.011.
^p=0.012.
#p=0.036.

Table 3. Relationship between burnout and depression, career satisfaction.

	Depression	Career satisfaction
Burnout		
Yes (%)	17 (38.6)	34 (77.3)
No (%)	4 (12.1)	32 (97.0)
	p=0.011	p=0.020

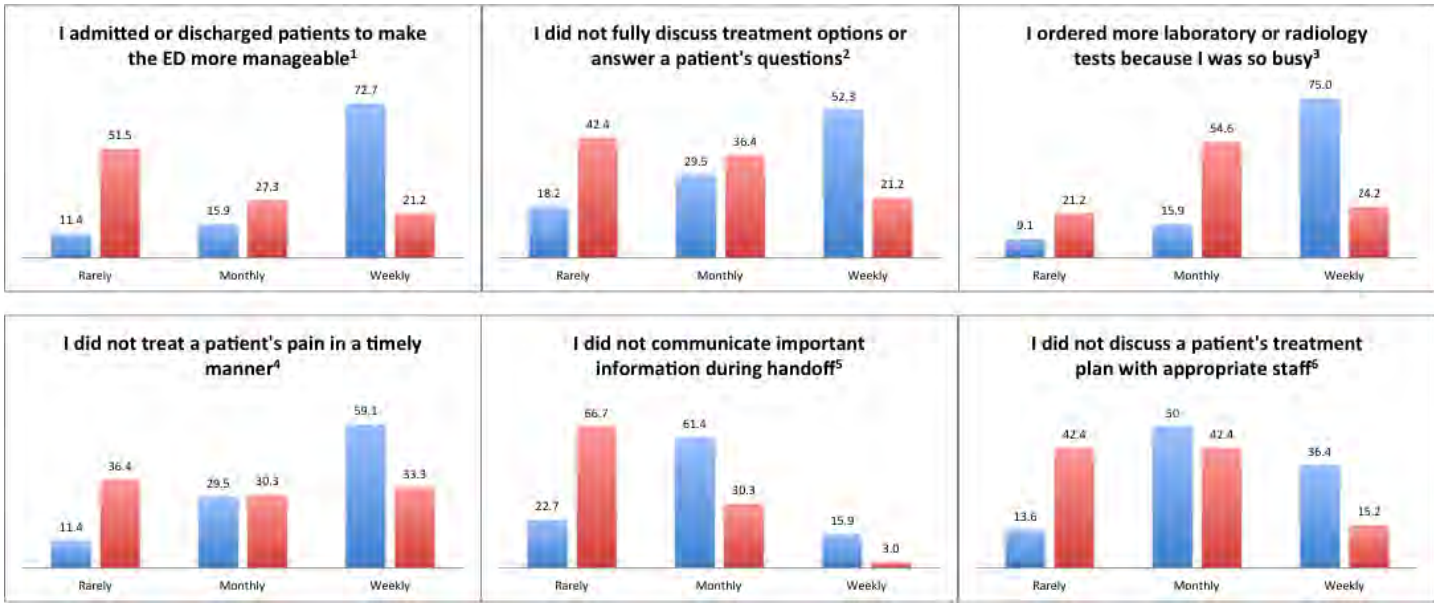
EPs with high levels of burnout were significantly more likely to report performing suboptimal care practices with greater frequency in all six domains (Figure 1): (1) admitting or discharging patients early (p<0.001); (2) not discussing options or answering questions (p=0.012); (3) ordering more tests (p<0.001); (4) not treating patients' pain (p=0.019); (5) not communicating important handoffs (p<0.001); and (6) not discussing plans with staff (p=0.009). There were no significant associations between rates of suboptimal care and depression, QOL or career satisfaction.

DISCUSSION

To our knowledge this is the first study to examine the relationship between physician burnout and patient care practices in emergency medicine. Burned-out EPs were more likely to report performing on a more frequent basis all of our queried suboptimal patient care practices. Most prior studies on improving patient safety and quality in emergency medicine have focused on system-level issues rather than individual-level factors.[31,32] Our results suggest that addressing physician factors such as emotional distress and burnout may be important in efforts to improve patient care.

Burnout was common among EPs, with 57% of attending and resident physicians experiencing burnout, a figure that is consistent with studies dating back to 1996.[3,24,33] Our study showed no significant difference in levels of burnout between attending and resident EPs. This is similar to a prior study of EPs, which demonstrated that PGY 2-4 residents exhibited burnout rates comparable to those of attending physicians (49-64% vs 60%).[3] Our findings demonstrate that at least half of EPs suffer from burnout in as early as the second year of residency training. We did not expect burnout rates among attending EPs to be significantly different than those noted in prior studies, since

Figure 1. Percentage of emergency physicians and their self-reported frequencies of suboptimal care by burnout. Blue=Burnout; Red=No burnout.



[1]p<0.001; [2]p=0.012; [3]p<0.001; [4]p=0.019; [5]p<0.001; [6]p=0.009.

to our knowledge no large organized effort has been made to improve the working conditions of practicing EPs. However, despite efforts to improve resident working conditions, including work hour restrictions, resident burnout has not changed over the last two decades.[33,34]

Although our study did not investigate specific causes of EP burnout, previous studies may provide insights into possible explanations for the high rate of EP burnout. Emergency medicine is challenging physically and emotionally.[35] An unpredictable workload, frequent disruptions to circadian rhythms, and caring for high acuity and high complexity patients in a high stakes environment all potentially contribute to burnout. A national survey of physicians across all specialties found that burnout was highest not just in EM but also in other "front line" disciplines such as general internal medicine and family medicine.[2] Our results suggest that resident physicians in as early as the PGY-2 level may suffer high levels of burnout similar to those of attending physicians. This may be the result of their socialization in the "hidden curriculum," a phenomenon in which physicians in training acquire and model the attitudes and habits of other physicians.[36,37] In this sense direct interaction and long hours spent with burned-out EPs may lead to a "contagious" spread of burnout to trainees.

Resident physicians in our study were significantly more likely to report high scores in the depersonalization subscale of the MBI than attending physicians. This is consistent with prior work among residents and attendings across multiple specialties.[38] Depersonalization is characterized by negative, cynical and dehumanized attitudes and feelings about patients.[39] We suspect EM residents may experience higher rates of depersonalization due to the fact they on average work more clinical hours than EM attendings at the two sampled academic training sites. In addition resident physicians at these sites are charged with the role of interfacing primarily with admitting services, consultants and ancillary staff to a greater extent than attending physicians. As such resident physicians may experience greater exposure to negative, cynical or dehumanized attitudes about patients.

Our results showed that a positive screen for depression was significantly associated with higher rates of burnout. Burnout is related to depression, although the two are not synonymous.[40,41] Whereas depression affects an individual globally, burnout is specifically related to one's work. While research on rates of depression among EM residents is limited, our rates of depression among attending physicians are comparable to those in prior studies of EPs.[42-44] Our rates of career satisfaction among EPs were also similar to those reported in previous work,[45,46] as was our study's demonstrated significant association between burnout and low career satisfaction.[3,33] Interestingly, we did not find significant relationships between suboptimal care and EP rates of depression, QOL or career satisfaction. Although related studies showed associations between various aspects of provider wellness (e.g. burnout, depression, QOL) and physician self-reported medical error,[4-6] only burnout demonstrated a significant relationship with suboptimal care in a similar study of internal medicine trainees.[8] We theorize that burnout may be a unique and pervasive condition that not only adversely impacts the occurrence of discrete and perhaps more salient medical errors but also the less apparent aspects of quality care (e.g. empathy, professionalism) that physicians provide to patients.

LIMITATIONS

Our subject population was a convenience sample of EM attending and resident physicians at two academic programs. As such, our results may not be generalizable to EPs in non-academic settings. Approximately 50% of eligible subjects were included in the final analysis, which could allow for response bias. We were unable to compare characteristics of respondents with non-respondents due to the anonymous nature of the survey methodology. Specifically we do not know if non-respondents suffered higher levels of burnout, for example, and therefore did not choose to participate in the study. Still, our rates of burnout are consistent with those reported in prior studies of both academic and non-academic EPs.[2,3,24,33] Although our questions measuring self-reported suboptimal care were modeled after prior work[8] and have face validity, their criterion and construct validity as well as reliability have not been examined. In addition we are unable to ascertain if these self-reported frequencies of suboptimal care translate into actual practice. It also remains unclear if burned-out EPs report higher rates of suboptimal care as a result of their higher levels of burnout.[5,6] Despite these limitations, our results are consistent with prior work in other specialties demonstrating that provider wellness, one aspect of which is professional burnout, may significantly impact the quality of care received by patients.[4-8,12,13,47-50]

CONCLUSION

A majority of EPs reported high levels of burnout. EP burnout was also significantly associated with higher frequencies of self-reported suboptimal care. Future efforts to determine if provider burnout is associated with negative changes in actual patient care are necessary.

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Outcomes of Patients Requiring Blood Pressure Control Before Thrombolysis with tPA for Acute Ischemic Stroke

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Introduction: The purpose of this study was to assess safety and efficacy of thrombolysis in the setting of aggressive blood pressure (BP) control as it compares to standard BP control or no BP control prior to thrombolysis.

Methods: We performed a retrospective review of patients treated with tissue plasminogen activator (tPA) for acute ischemic stroke (AIS) between 2004-2011. We compared the outcomes of patients treated with tPA for AIS who required aggressive BP control prior to thrombolysis to those requiring standard or no BP control prior to thrombolysis. The primary outcome of interest was safety, defined by all grades of hemorrhagic transformation and neurologic deterioration. The secondary outcome was efficacy, determined by functional status at discharge, and in-hospital deaths.

Results: Of 427 patients included in the analysis, 89 received aggressive BP control prior to thrombolysis, 65 received standard BP control, and 273 required no BP control prior to thrombolysis. Patients requiring BP control had more severe strokes, with median arrival National Institutes of Health Stroke Scale of 10 (IQR [6-17]) in patients not requiring BP control versus 11 (IQR [5-16]) and 13 (IQR [7-20]) in patients requiring standard and aggressive BP lowering therapies, respectively (p=0.048). In a multiple logistic regression model adjusting for baseline differences, there were no statistically significant differences in adverse events between the three groups (P>0.10).

Conclusion: We observed no association between BP control and adverse outcomes in ischemic stroke patients undergoing thrombolysis. However, additional study is necessary to confirm or refute the safety of aggressive BP control prior to thrombolysis. [West J Emerg Med. 2015;16(7):1002-1006.]

INTRODUCTION

Acute ischemic stroke (AIS) is a major cause of morbidity and mortality. AIS affects over 15 million patients yearly worldwide, and represents the fifth-leading cause of death and leading cause of disability in the United States.[1] Currently, the only FDA-approved medical therapy for treatment of AIS is thrombolysis with recombinant tissue plasminogen activator (tPA) within three hours of symptom onset. However, despite this being the only approved medical therapy, the majority of eligible patients remain untreated. One of the reasons for this under-treatment stems from exclusion of patients who present with elevated blood pressure (BP).[2-4] Prior literature has found that patient BPs in excess of the pre-thrombolytic goal of 185/110 is associated with delayed[5] and non-treatment with thrombolytics.[6] and that active management of BP in these patients is associated with an increased proportion receiving thrombolytic therapy.[7]

The original National Institute for Neurologic Disorders

and Stroke rt-PA Stroke Study (NINDS) excluded patients with BP>185/110, as well as those requiring aggressive BP lowering prior to thrombolysis. The rationale was an observed association between this level of hypertension and increased risk of intracranial hemorrhage after thrombolysis, largely extrapolated from the cardiac literature and the NINDS tPA pilot study.[8-10] What constituted aggressive treatment was not specifically defined in the NINDS protocol but has generally been considered to include continuous infusion of antihypertensive medication or repeated doses of antihypertensive medications, such as labetalol, enalapril, nicardipine, or nifedipine.[7]

Since the original NINDS trial, many versions of guidelines and protocols have excluded these patients from eligibility for treatment with tPA.[11,12] However, current evidence does not consistently observe an association between elevated BP and adverse outcomes in patients treated with thrombolytics.[2,13,14] While the latest guidelines from the American Heart Association regarding the treatment of stroke allow for use of intravenous (IV) anti-hypertensive therapy previously considered aggressive, this is largely based on expert opinion due to a paucity of evidence regarding the treatment of arterial hypertension in the setting of stroke.[15] A recent post hoc analysis of two large randomized controlled trials found 21% of 1,657 AIS patients who were otherwise eligible for IV thrombolysis had elevated pretreatment BP above 185/110mmHg,[7] a figure consistent with previous retrospective studies.[3] It is clear that further evidence is needed to determine the optimal management of these patients.

In this study, we aim to further assess the safety and efficacy of thrombolysis in the setting of aggressive BP control as it compares to standard BP control or no BP control prior to thrombolysis.

METHODS

This was a retrospective analysis of registry data from the University of Texas Health Science Center at Houston, collected between 2004 and 2011.[16] We reviewed all patients who were treated with IV tPA for AIS within 4.5 hours of symptom onset. Patients treated with anti-hypertensive medications other than labetalol or nicardipine, treated beyond 4.5 hours, or who were enrolled in clinical trials were excluded.

Data collected included time of symptom onset and patient arrival, all recorded vital signs, clinical findings, baseline computed tomographic findings, comorbidities, medication history, dosage and time of administration of antihypertensive agents in the emergency department, and time of tPA administration. BP and the type and dosage of anti-hypertensive medications used were abstracted with an additional chart review by two independent abstractors. Long-term outcome data, such as pre-stroke functional status and 90-day clinical outcome measures, were available only for a limited number of patients and therefore were not included as part of the analysis.

Aggressive BP control was defined as continuous nicardipine infusion or greater than two doses of IV labetalol, whereas standard BP control was defined as requiring two or less doses of IV labetolol prior to thrombolysis. The primary outcome was safety as measured by all grades of hemorrhagic transformation, symptomatic intracranial hemorrhage, and neurologic deterioration. The secondary outcome was efficacy as measured by good functional status at hospital discharge, hospital inpatient length of stay, and in-hospital deaths. Symptomatic intracerebral hemorrhage was defined as parenchymal hematoma likely to be the cause of neurologic deterioration. Good functional status at hospital discharge was defined as a score of 0 to 2 on the modified Rankin Scale (mRS).

Demographic variables and baseline characteristics are described by the median and interquartile range (IQR) or count and percentage for continuous and categorical variables, respectively. We carried out comparisons between groups using the Kruskall-Wallis test for continuous variables and the chi-square test for categorical variables. To compare outcomes between groups, multiple logistic regression models were fit adjusting for certain demographic and/or baseline characteristic variables (see Table 2 for details). Expressing hospital length of stay (HLOS) as time to discharge, we applied a Cox proportional hazards (PH) model with right censoring to account for death during hospital stay. The number of variables included in the models was restricted by to the limited sample size and thus variables deemed clinically meaningful were included. We reported adjusted odds ratios (OR) and the adjusted hazard ratio (HR) with corresponding 95% confidence interval (CI) for the multiple logistic regression models and the Cox PH model, respectively. Statistical significance was assessed at the 5% significance level. We analyzed the data using the SAS 9.4 statistical software (SAS Institute, Inc., Cary, NC).

This study was approved by the institutional review board of the University of Texas, which granted a waiver of informed consent for this retrospective review.

RESULTS

Of the 427 patients included in the analysis, 273 patients did not require BP control prior to thrombolysis with tPA, while 65 required standard BP treatment and the remaining 89 required aggressive BP control prior to thrombolysis. The median age in the no BP and standard BP treatment groups were 67 and 68 years, respectively while those in the aggressive BP treatment group had a median age of 72. There were more males in the no BP (57%) and standard BP (54%) treatment groups in comparison to 43% males in the aggressive BP treatment group. Overall, the patients were similar in demographic and baseline characteristics, with the exception of National Institutes of Health Stroke Scale (NIHSS) where the group requiring aggressive BP control had a greater median arrival NIHSS of 13 (IQR [7-20]) as compared to the no BP and standard BP treatment groups

(see details in Table 1). Also noteworthy was that patients not requiring BP control received thrombolytic therapy in similar timeframes to patients requiring BP control.

In patients receiving aggressive BP control 8% had hemorrhagic complications and 23% had neurologic complications during their hospitalization. However, when adjusting for other covariates, these differences were not statistically significant for both neurologic deterioration (p=0.554) and hemorrhagic transformation (p=0.156).

After adjusting for arrival NIHSS, age, and gender, the odds of in-hospital mortality were not different in patients requiring either type of BP control prior to thrombolysis when compared to patients not requiring BP control (OR 0.70, 95% CI [0.22-2.29] for standard therapy, OR 1.27, 95% CI [0.56-2.89] for aggressive therapy, p=0.649).

Regarding discharge functional status for survivors as measured by a mRS of 0-2, after adjustment for differences in baseline characteristics, no significant differences were observed between patients requiring either BP-lowering strategies as compared to patients not requiring BP control prior to thrombolysis (OR 1.14, 95% CI [0.60-2.15] for standard therapy, OR 0.56, 95% CI [0.29-1.07] for aggressive therapy, p=0.157). Detailed outcomes are reported in Table 2.

In comparing HLOS between the three groups, after adjusting for age, gender, glucose, and arrival NIHSS, there were no significant differences in HLOS between these groups (HR 0.67, 95% CI [0.22.-2.02], for standard therapy, HR 0.82, 95% CI [0.37-1.84], for aggressive therapy, p=0.732; see Table 3)

DISCUSSION

Our study represents a large data set comparing patients requiring BP control prior to thrombolysis to those who did not. There were a few important findings of note. The primary finding of our study is that patients presenting with very elevated BPs in the setting of AIS generally have more severe strokes and are older, and after correcting for these baseline differences, treatment with thrombolysis does not seem to add additional risk of hemorrhage in patients requiring BP control as compared to patients not requiring BP control prior to thrombolysis.

Previous literature supports our finding that patients presenting with AIS who have an extremely elevated BP have worse outcomes, which is likely due to the baseline increased severity in stroke symptoms.[17,18] Because there is a very limited amount of literature addressing this question, our study represents the largest experience with pre-treatment BP control in the setting of thrombolysis in AIS. Since in our study, we could not detect a statistically significant difference in adverse events between patients requiring any method of BP control prior to thrombolysis versus those who did not, when adjusting for the baseline severity of the stroke, it is possible that patients presenting with elevated BP in the setting of AIS who may otherwise be eligible for thrombolysis could be considered for thrombolysis after optimization of BP.

The second important finding of our study is that the management of elevated BP prior to thrombolysis did not significantly increase door-to-tPA time. This is an improvement over the temporal impact of antihypertensive treatment described in previous literature.[5] This underlines how, with an appropriate process in place, door-to-tPA time may yet be optimized even in those patients requiring further interventions prior to initiation of therapy. As has been the case with other performance improvement strategies used for decreasing the door-to-tPA time in AIS, such as pre-hospital notification[19], direct transport to computed tomography,[20] tPA availability in the emergency department and systemized activation of treatment teams,[21] the utility of antihypertensive agents to achieve desired BP control prior to thrombolysis

Table 1. Summary of demographic variables and baseline characteristics between groups.

Variable	No BP treatment before tPA (n=273)	Standard BP treatment before tPA (n=65)	Aggressive treatment before tPA (n=89)	P-value
Age, median (IQR)	67 (55-80)	68 (57-80)	72 (59-82)	0.227
Male gender, n (%)	156 (57.1)	35 (53.9)	38 (42.7)	0.060
White race, n (%)	175 (64.1)	41 (63.1)	52 (58.4)	0.629
Latino ethnicity, n (%)	44 (16.2)	8 (12.5)	8 (9.0)	0.218
Arrival NIHSS score, median (IQR)	10 (6-17)	11 (5-16)	13 (7-20)	0.048
Glucose, median (IQR)	122 (106-154)	118 (99-146)	126 (108-155)	0.234
Initial systolic BP, median (IQR)	152 (137-168)	175 (155-185)	180 (165-194)	-
Initial diastolic BP, median (IQR)	80 (71-89)	89 (79-98)	89 (81-99)	-
Time from door to tPA (min), median (IQR)	69 (51-88)	68 (53-82)	76 (58-95)	0.146
Time from onset to tPA (min), median (IQR)	149 (121-175)	150 (122-175)	157 (130-182)	0.407
History of hypertension, n (%)	192 (70.3)	50 (76.9)	73 (82.0)	0.077
Patients receiving long-term BP medication, n (%)	155 (65.1)	35 (71.4)	53 (67.1)	0.689

BP, blood pressure; *tPA,* tissue plasminogen activator; *IQR,* interquartile range; *NIHSS,* National Institutes of Health Stroke Scale

Table 2. Analysis of outcome variables and group via multiple logistic regression.

Outcome variable	Comparison to baseline*	AOR (95% CI)	P-value
Neurologic deterioration†	Standard BP treatment before tPA	0.71 (0.33, 1.54)	0.554
	Aggressive treatment before tPA	1.15 (0.63, 2.11)	
Hemorrhagic transformation	Standard BP treatment before tPA	1.04 (0.22, 5.04)	0.156
	Aggressive treatment before tPA	2.71 (0.95, 7.76)	
Symptomatic hemorrhage‡	Standard BP treatment before tPA	0.69 (0.15, 3.15)	0.889
	Aggressive treatment before tPA	0.97 (0.30, 3.10)	
Good outcome§	Standard BP treatment before tPA	1.14 (0.60, 2.15)	0.157
	Aggressive treatment before tPA	0.56 (0.29, 1.07)	
Death‖	Standard BP treatment before tPA	0.70 (0.22, 2.29)	0.649
	Aggressive treatment before tPA	1.27 (0.56, 2.89)	

AOR, adjusted odds ratio
*Baseline set as no blood pressure (BP) treatment before tissue plasminogen activator (tPA).
†Adjusted for age, gender, glucose, arrival National Institutes of Health Stroke Scale (NIHSS) score, time from onset to tPA (min).
‡Adjusted for arrival NIHSS score.
§Adjusted for age, gender, glucose, arrival NIHSS score, time from onset to tPA (min).
‖Adjusted for age, gender, arrival NIHSS score.

Table 3. Hazard ratios (HR) for length of hospital stay (time to discharge) via Cox PH model.

Outcome variable	Comparison to baseline	HR* (95% CI)	P-value
Length of hospital stay	Standard BP treatment before tPA	0.67 (0.22, 2.02)	0.732
	Aggressive treatment before tPA	0.82 (0.37, 1.84)	

BP, blood pressure; *tPA,* tissue plasminogen activator; *PH,* proportional hazards
*Adjusted for age, gender, glucose, and arrival National Institutes of Health Stroke Scale score.

can be incorporated in routine stroke care. An example of such a process using rapidly acting agents to achieve pre-treatment goals in patients with AIS was recently described in the literature by Bowry et al.[22]

LIMITATIONS

There are several limitations to this study. This is a retrospective review of prospectively collected data, which may be useful for hypothesis generation but is not well-suited for evaluating the safety or efficacy of a clinical intervention. Additional, unmeasured, prognostic variables may confound our adjusted statistics. Our registry does not provide details regarding the selection criteria by which patients were chosen for treatment with thrombolysis after BP control, nor do we report data regarding patients presenting with hypertension in the setting of AIS who did not receive treatment with tPA. In addition, it does not provide details of the amounts and types of medications used for BP optimization. Functional outcomes are also available only at hospital discharge, rather than the three- to six-month follow up typical to stroke research. Lastly, the results of this study represent the experience of a single, high-volume academic stroke center over a seven-year time period, and may not be generalizable to other institutions.

Given the totality of evidence, the limitations of our study preclude a declaration of safety associated with BP control prior to thrombolysis; however, it does underline the need for further study to allow for up to 25% of otherwise-eligible patients to be considered for the only approved therapy for AIS.

CONCLUSION

This study represents the largest data set to date evaluating the outcomes experienced by patients requiring BP control prior to receiving treatment for ischemic stroke with tPA in the emergency department. In the context of prior research suggesting harms associated with BP treatment prior to thrombolysis, these data suggest it may be reasonable to further investigate subgroups of patients for whom BP pretreatment does not confer additional risk. In addition, these data also show, with integrated efforts, the treatment of elevated arterial BP need not be associated with significantly longer door-to-tPA time, as has been previously reported.[5,15]

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Troponin Marker for Acute Coronary Occlusion and Patient Outcome Following Cardiac Arrest

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Introduction: The utility of troponin as a marker for acute coronary occlusion and patient outcome after out-of-hospital cardiac arrest (OHCA) is unclear. We sought to determine whether initial or peak troponin was associated with percutaneous coronary intervention (PCI), OHCA survival or neurological outcome.

Methods: Single-center retrospective-cohort study of OHCA patients treated in a comprehensive clinical pathway from November 2007 to October 2012. Troponin I levels were acquired at presentation, four and eight hours after arrest, and then per physician discretion. Cardiac catheterization was at the cardiologist's discretion. Survival and outcome were determined at hospital discharge, with cerebral performance category score 1-2 defined as a good neurological outcome.

Results: We enrolled 277 patients; 58% had a shockable rhythm, 44% survived, 41% good neurological outcome. Of the 107 (38%) patients who underwent cardiac catheterization, 30 (28%) had PCI. Initial ED troponin (median, ng/mL) was not different in patients requiring PCI vs no PCI (0.32 vs 0.09, p=0.06), although peak troponin was higher (4.19 versus 1.57, p=0.02). Of the 85 patients who underwent cardiac catheterization without STEMI (n=85), there was no difference in those who received PCI vs no PCI in initial troponin (0.22 vs 0.06, p=0.40) or peak troponin (2.58 vs 1.43, p=0.27). Regarding outcomes, there was no difference in initial troponin in survivors versus non-survivors (0.09 vs 0.22, p=0.11), or those with a good versus poor neurological outcome (0.09 vs 0.20, p=0.11). Likewise, there was no difference in peak troponin in survivors versus non-survivors (1.64 vs 1.23, p=0.07), or in those with a good versus poor neurological outcome (1.57 vs 1.26, p=0.14).

Conclusion: In our single-center patient cohort, peak troponin, but not initial troponin, was associated with higher likelihood of PCI, while neither initial nor peak troponin were associated with survival or neurological outcome in OHCA patients. [West J Emerg Med. 2015;16(7):1007-1013.]

INTRODUCTION

More than 359,000 out-of-hospital cardiac arrests (OHCAs) occur each year in the U.S.[1] For more than a decade, therapeutic hypothermia (TH) has been shown to improve survival with good neurological outcome.[2-4] Beyond TH, early identification of the arrest etiology is another resuscitative priority, with acute coronary occlusion remaining a common cause.[5] Clinical features and electrocardiogram (EKG) are

poorly predictive of acute coronary occlusion in comatose patients after OHCA. Additionally, little is known about cardiac troponin as a marker for acute coronary occlusion and patient outcome in OHCA patients undergoing TH.

Current guidelines recommend immediate coronary angiography for suspected acute myocardial infarction (AMI) in patients successfully resuscitated after cardiac arrest.[6] More specifically, guidelines encourage immediate angiography for OHCA patients with initial EKGs showing ST-elevation myocardial infarction (STEMI)[6]. A dilemma occurs, however, in that many patients resuscitated from cardiac arrest do not have ST-elevations on initial EKG, despite the possibility of a coronary occlusion.[7] Thus, the challenge is identifying which non-STEMI patients have likely suffered cardiac arrest due to an acute coronary occlusion.

Troponin has been identified as a potential marker for acute coronary occlusion in the setting of cardiac arrest, as well as a potential marker for patient outcomes following cardiac arrest. Studies investigating various troponin assays, including newer high-sensitivity troponin T assays have shown mixed results.[8,9] Additionally, few studies have investigated troponin's association with survival, neurological outcome, and percutaneous coronary intervention (PCI), in the setting of TH.[10] While previous studies have been conflicting on whether external defibrillation results in troponin elevation, recent studies using the high-sensitivity troponin T assay show external defibrillation can lead to an increased troponin.[11,12]

We sought to determine whether initial or peak cardiac troponin was associated with acute coronary occlusion, survival, or neurologic outcome in OHCA patients.

METHODS

This was a retrospective cohort analysis on a prospectively collected post-cardiac arrest QI database. Patients were included for analysis if they were treated with TH in a comprehensive post-cardiac arrest clinical pathway known as Code Cool™, and were enrolled from November 2007 through October 2012. We enrolled all patients following admission to Carolinas Medical Center (CMC), an urban, 900-bed teaching hospital. Our center is a cardiac arrest receiving hospital with a network of 25 transferring hospitals in the region, as well as an STEMI receiving hospital. CMC is designated by the American Heart Association Mission: Lifeline® regional systems of care program, and is accredited by the Society of Chest Pain Centers. Sixty percent of our resuscitated cardiac arrest patients are brought directly to our cardiac arrest receiving hospital, while 40% are transferred, after initial resuscitation at a transferring hospital ED.

Patient inclusion and exclusion into our Code Cool™ protocol has been previously described.[13] Briefly, resuscitated victims of out-of-hospital, non-traumatic cardiac arrest, with persistent coma (Glasgow Coma Scale [GCS] ≤8 and/or unable to follow verbal commands 15 minutes following ROSC) were eligible. All non-traumatic patients were eligible for the clinical TH pathway, at the discretion of the attending physician, regardless of initial arrest rhythm. Post-arrest care is standardized via protocol with patients cooled to 33ºC for 24 hours then controlled rewarming at <0.5ºC per hour, maintenance of mean arterial pressures >70mmHg via norepinephrine as needed, and avoidance of hyperventilation and hyperoxia. The Carolinas HealthCare System Institutional Review Board approved the study protocol.

We prospectively collected clinical data, including arrest type, treatment variables, and outcome, on consecutive patients with the use of a preformatted standard data collection tool using Utstein criteria. Survival and neurological outcomes were determined at the time of hospital discharge, with neurologic outcome being measured by the Pittsburgh cerebral performance category (CPC) scale. A "good neurological outcome" was defined as a CPC of 1 or 2.[14] CPC 1 is defined as good cerebral performance and equates to patients that are conscious, alert, able to work, and might have mild neurologic or psychologic deficit. CPC 2 is defined as moderate cerebral disability and equates to patients that are conscious with sufficient cerebral function for independent activities of daily life and ability to work in a sheltered environment.

The primary outcome was the association of the initial or peak troponin with PCI. Acknowledging the time-sensitive nature of an acute coronary occlusion, the initial ED troponin was chosen as a potential marker for an acute coronary occlusion and the need for emergent coronary catheterization. However, as troponin elevations may go undetected if drawn less than six hours from an acute coronary occlusion, we chose to analyze peak hospitalization troponin as well. According to our standard clinical pathway, troponin I levels were acquired upon ED presentation, at four hours and eight hours after OHCA, and thereafter at physician discretion. Troponin I assays were performed using either the iSTAT platform or Abbott Architect Clinical Chemistry Analyzer (Abbott Diagnostics, Lake Forest, IL, USA), depending on standard laboratory practices of each institution. The decision to proceed to cardiac catheterization was made at the discretion of the cardiologist in accordance with predetermined institutional guidelines, which recommend emergent cardiac catheterization for survivors of OHCA with EKG findings of ST-elevations, age less than 75 years, and collapse to ROSC time less than 20 minutes. Patients not meeting these criteria were rapidly evaluated on a case-by-case basis by the cardiology team.

Secondary outcomes studied were the association between the initial and peak troponin levels with survival and good neurological outcome. We performed additional subgroup analysis on patients without STEMI to assess the association of initial and peak troponin with PCI, survival, and neurologic outcome.

For the statistical analysis, we assessed categorical variables with the chi-square or Fisher's exact tests for small

counts. T-tests and Wilcoxon rank-sum tests were used for continuous data, depending upon the distribution of the data. P-values less than 0.05 were considered statistically significant. We conducted all analyses using SAS statistical software version 9.2 (SAS Institute, Cary, NC).

RESULTS

We screened 279 patients in our post-arrest TH database, excluded two patients with missing or unattainable data for witnessed arrest, initial rhythm, survival, neurological outcome, and cardiac catheterization, and analyzed the remaining 277 patients. Of the 277 patient studied, they had a median age 58 years (SD 14 years), 62% male, median time of arrest to ROSC of 21 minutes (SD 53 minutes), and initial shockable rhythm present in 58%. Demographics, arrest characteristics, EKG with STEMI, and troponins in all patients, as well as those with and without cardiac catheterization, are shown in Table 1. One hundred twenty-two patients (44%) survived to hospital discharge, 115 (41%) with good neurologic outcome. A total of 107 patients underwent cardiac catheterization with 22 STEMIs, 85 without STEMI, and 38 (36%) going emergent to cardiac catheterization.

We performed a primary analysis to assess whether initial or peak troponin level was associated with PCI. Of the 107 (38%) patients undergoing cardiac catheterization, the initial arrest rhythm in 91 (85%) was VT/VF versus 16 (15%) with asystole or PEA. Thirty out 107 patients (28%) had PCI and 15 of the 30 (50%) had a STEMI. Fifty-nine (55%) patients had their peak troponin before cardiac catheterization with a median time from ED arrival to peak troponin of 649 minutes. Forty-six (43%) patients had a cardiac catheterization within six hours, with the median time from hospital arrival to cardiac catheterization of 68 minutes. Although median initial troponin (IQR) was not significantly different in patients requiring PCI versus patients who did not, (0.32 [0.09-1.18] vs 0.09 [0.04-0.71)], p=0.06); median peak troponin (IQR) was higher in those patients who received PCI therapy (4.19 [1.56-7.53] vs 1.57 [0.52-5.44], p=0.02) (Table 2).

We performed further subgroup analysis on patients without STEMI. Eight-five patients out of 107 who underwent cardiac catheterization were without STEMI on ECG. There was no statistical difference in median initial or peak troponins in patients requiring PCI, survival, or neurological outcome (Table 3).

A secondary analysis was performed to assess whether initial ED troponin or peak hospitalization troponin were associated with survival and neurological outcome.

There was no difference in median (IQR) initial troponin in survivors versus non-survivors (0.09 [0.04-0.78] vs 0.22 [0.06-0.58], p=0.11). Likewise, there was no difference in median (IQR) peak troponin in survivors versus non-survivors (1.64 [0.54-6.39] vs 1.23 [0.29-4.85], p=0.07) (Table 4). With regards to neurologic outcome, there was no difference in median (IQR) initial ED troponin (ng/mL) in patients with a good versus poor neurological outcome (0.09 [0.04-0.78] vs 0.20 [0.06-0.61], p=0.11) and no difference in median (IQR) peak troponin (ng/mL) in patients with a good versus poor neurological outcome (1.57 [0.54-6.18] vs 1.26 [0.29-5.17], p=0.14) (Table 5).

DISCUSSION

In our study population, peak troponin but not initial troponin levels were associated with PCI in our OHCA cohort who underwent a TH clinical pathway. However, in patients without STEMI, neither initial nor peak troponins were associated with patients receiving PCI. Additionally, initial and peak troponin levels were not associated with survival or neurological outcome.

Troponin elevation after cardiac arrest may be caused by several mechanisms including ischemic insult of arrest, direct effect of defibrillation, and coronary occlusion.[15] The extent of ischemic insult following cardiac arrest is highly variable. Prior work has demonstrated higher troponin levels in patients with longer durations of resuscitation, and in patients with cardiogenic shock following ROSC.[16]

While previous studies have been conflicting on whether external defibrillation results in troponin elevation, newer studies using the high-sensitivity troponin T assays show that external defibrillation can lead to an increased troponin[8,9] In another study, troponin elevation in implanted defibrillator discharges was an independent risk factor for mortality, but did not reliably differentiate those patients with AMI or acute coronary occlusion from those without.[17] In studies using older troponin assays, elevated troponin levels did not reliably predict short-term outcome.[18] Our study showed no significant difference in initial or peak troponin level among OHCA survivors versus non-survivors. Thus, based on our results, troponin does not appear to be useful for survival or neurologic prognostication.

The latest AHA guidelines encourage immediate coronary angiography for those with suspected AMI.[6] Current STEMI guidelines recommend cardiac arrest patients with STEMI undergo emergent cardiac catheterization for potential PCI. Resuscitated patients after cardiac arrest without STEMI pose a challenge, as it is unclear which subgroup of these patients might benefit from cardiac catheterization.

Thus, the potential role of troponin as a biomarker to detect a recent coronary occlusion in OHCA has stirred interest. However, in a recent study, nearly all resuscitated OHCA patients, regardless of initial arrest rhythm, had a detectable troponin I, and most met biomarker guideline criteria for MI.[19] Using standard normal troponin ranges in post-cardiac arrest to identify coronary occlusion appears to be of limited utility. With this in mind, researchers have attempted to determine if there was an optimal troponin threshold to detect a recent coronary occlusion in out-of-hospital arrest.[10,20,21] From this work, a single initial ED troponin appears to have minimal utility in diagnosing or excluding MI after cardiac arrest. Even using the optimal

Table 1. Demographic, arrest characteristics, initial ECG, and troponins, and outcomes for overall cohort and in patients with and without cardiac catheterization.

	All patients (N=277)	Patients with cardiac catheterization (N=107)	Patients without catheterization (N=170)	p-value
	N (%)	N (%)	N (%)	
Age (Median, years)	58 (14)	58 (12)	58 (16)	0.96
Sex: Male	174 (62%)	76 (71%)	96 (56%)	0.02
Arrest interval (median (SD), minutes)	21 (53)	15 (13)	24 (68)	0.04
Initial rhythm				<0.0001
Shockable (VT/VF)	163 (58%)	91 (85%)	72 (43%)	
Non-shockable (PEA/asystole)	110 (39%)	16 (15%)	94 (55%)	
Unknown	4 (3%)	0 (0%)	4 (2%)	
Bystander CPR				0.10
Yes	178 (64%)	75 (70%)	103 (61%)	
No	77 (27%)	24 (22%)	53 (31%)	
Missing	24 (9%)	8 (8%)	14 (8%)	
Witnessed arrest*	233 (84%)	98 (92%)	135 (79%)	0.007
EKG findings				<0.0001
Without STEMI		254 (91%)	85 (79%)	169 (99%)
STEMI		23 (8%)	22 (21%)	1 (1%)
Initial troponin, mean (ng/mL)	0.18	0.18	0.15	0.44
Peak troponin, mean (ng/mL)	1.71	2.02	0.97	0.01
Survival*	122 (44%)	86 (80%)	36 (21%)	<0.0001
Neurologic outcome (CPC)*				<0.0001
CPC 1–2 (Good neuro outcome)	115 (41%)	23 (22%)	31 (18%)	
3–5 (Poor neuro outcome)	162 (58%)	84 (78%)	139 (82%)	

VT, ventricular tachycardia; *VF,* ventricular fibrillation; *PEA,* pulseless electrical activity; *CPR,* cardiopulmonary resuscitation; *EKG,* electrocardiogram; *STEMI,* ST segment elevation myocardial infarction; *CPC,* cerebral performance category

Table 2. Association with initial and peak troponin with percutaneous coronary intervention (PCI).

	PCI	No PCI	p-value
Patients	n=30 (28%)	n=77 (72%)	
Initial troponin, ng/mL (mean, SD)	0.32 (0.09-1.18)	0.09 (0.04-0.71)	0.06
Peak troponin, ng/mL (mean, SD)	4.19 (1.56-7.53)	1.57 (0.52-5.44)	0.02

cardiac troponin I threshold of 4.66 ng/mL to identify a recent coronary occlusion at admission, the sensitivity and specificity of this lab value is only 67% and 66% respectively.[10] Another study in post-arrest patients revealed the optimal troponin cutoff of 2.5 ng/mL achieved a sensitivity and specificity of 72% and 75%, respectively, for the detection of a recent coronary occlusion.[20]

Given the uncertainty of troponin level relevance in OHCA, we sought to explore if troponin levels could be used as a marker for coronary occlusion in our population of patients undergoing TH. More specifically, we investigated the potential for initial ED troponin to predict which patients might benefit from emergent cardiac catheterization, as well as the utility of peak hospitalization troponin, to guide which patients might benefit from urgent cardiac catheterization.

Our study showed that peak troponin, but not initial troponin, was associated with PCI. Unfortunately, this has limited clinical utility because the myocardial damage is likely extensive when the peak troponin value is used to determine cardiac catheterization candidacy. Of the 107 patients who underwent cardiac catheterization, only 28% received PCI, of which 15 (50% of those receiving PCI) were patients with STEMI. Interestingly, excluding the STEMI patients among those chosen for cardiac

Table 3. Subgroup analysis of patients with cardiac catheterization and without ST segment elevation myocardial infarction (n=85).

	Initial troponin, median (IQR)	p-value	Peak troponin, median (IQR)	p-value
Survive		0.14		0.86
Yes	0.06 (0.03 - 0.55)		1.57 (0.58 - 6.39)	
No	0.29 (0.19 - 0.68)		1.86 (0.69 - 4.60)	
Neurologic outcome (CPC)		0.07		0.76
Good (CPC 1-2)	0.06 (0.03 - 0.53)		1.57 (0.55 - 6.29)	
Bad (CPC 3-5)	0.30 (0.21 - 0.71)		2.02 (0.75 - 4.68)	
PCI				
Yes	0.22 (0.06 - 0.5)	0.40	2.58 (1.30 - 6.39)	0.27
No	0.06 (0.03 - 0.71)		1.43 (0.52 - 5.06)	

CPC, cerebral performance category; *PCI,* percutaneous coronary intervention

Table 4. Association of initial and peak troponin with survival.

	Survivors	Non-survivors	p-value
Patients	n=122 (44%)	n=155 (55%)	
Initial troponin, ng/mL (mean, SD)	0.09 (0.04-0.78)	0.22 (0.06-0.58)	0.11
Peak troponin, ng/mL (mean, SD)	1.64 (0.54-6.39)	1.23 (0.29-4.85)	0.07

Table 5. Association of initial and peak troponin with neurologic outcome.

	CPC 1/2	CPC 3/4/5	p-value
Patients	n=115 (41%)	n=162 (58%)	
Initial troponin, ng/mL (mean, SD)	0.09 (0.04-0.78)	0.20 (0.06-0.61)	0.11
Peak troponin, ng/mL (mean, SD)	1.57 (0.54-6.18)	1.26 (0.29-5.17)	0.14

CPC, cerebral performance category

catheterization, only 15 out of 85 (18%) received PCI. This suggests that in our cohort of patients without STEMI, either current strategies are suboptimal at determining who needs a cardiac catheterization, or that aggressively cardiac catheterizing OHCA patients may be of low yield. Unfortunately, initial ED troponin was not useful to identify those patients without STEMI that might benefit from emergent cardiac catheterization in our study. Given this finding, future work should explore if early serial troponins, such as the delta increase in troponin level, can be used as markers for acute coronary occlusion amendable to emergency coronary intervention.

Limitations of our study include a sample size that limits our ability to statistically discriminate small but potentially important outcome differences. The potential for unrecognized bias is also present given the non-randomized study design, and the fact that the inclusion of patients with non-shockable rhythms into the clinical pathway was at the discretion of the treating physician. Additionally, while all but one STEMI patient underwent emergent cardiac catheterization, patients without STEMI were evaluated on a case-by-case basis by our cardiology team to determine cardiac catheterization candidacy, with only 16 of 85 (19%) of patients without STEMI who underwent emergent cardiac catheterization. One major limitation in our study is that cardiologist were not blinded to the initial troponin levels and thus likely considered troponin level, in conjunction with age, demographic, and arrest characteristics, in their decision to perform angiography. Thus, selection bias is possible in the patient cohort that underwent angiography; however, this is less likely given the mean initial troponin were similar in patients undergoing versus those not undergoing cardiac catheterization (0.18 ng/mL vs 0.15 ng/mL, p=0.44). We also do not have data on the extent of the coronary lesions (i.e., findings of acute thrombus on cardiac catheterization) requiring PCI and thus we cannot draw any conclusions regarding acute coronary occlusion as the cause of the arrest based on PCI performance. Elevation of troponin levels can vary based on baseline patient characteristics, renal function, and presence of prior coronary artery disease, yet our database did not capture these baseline characteristics. We did not obtain the pre-PCI peak troponin nor post-PCI troponins during data extraction, which may have been more useful measurements over peak hospitalization troponin in retrospect, especially since PCI itself may cause troponin elevation.

Regardless, our study showed that in the non-STEMI population where it is very challenging to identify those that might benefit by cardiac catheterization, we found no difference in peak troponins despite not further analyzing the sub-groups of pre- and post-PCI, and thus do not believe this analysis would provide additional clinically useful information. Our study was performed in an urban metropolitan hospital with relatively short transport times and may not be generalizable to regions with longer transport intervals. Our study population includes those selected as good candidates for an aggressive post-cardiac arrest resuscitative pathway, rather than the mandatory inclusion of all patients initially resuscitated from OHCA. This flexibility in the protocol potentially introduces selection bias, as the intervention is already being provided at the time of enrollment, and this may influence physicians to continue the TH protocol on the in-patient side, thereby including the patient in the data analysis. We believe this method is generalizable; however, as accrual is more reflective of clinical medicine outside of the research setting. The troponin I assays were performed on two different machines, namely the iSTAT and Abbott Architect platforms, which risks variability in the results obtained. Finally, although a logistic regression analysis could be performed to control for the multiple demographic and arrest variables, the authors felt this was of limited utility given the relatively small number of patients who underwent cardiac catheterization, and thus limits the strength on the association between troponin with PCI, survival, and neurological outcome.

CONCLUSION

In our cohort of OHCA patients, peak troponin, though not initial troponin, was associated with need for PCI. When excluding STEMI patients, neither peak nor initial troponin was associated with need for PCI. Initial and peak troponin were also not associated with survival or neurological outcome. Future work should explore if early serial troponins can be used to detect acute coronary occlusion amendable to emergency coronary intervention.

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Written Informed Consent for Computed Tomography of the Abdomen/Pelvis is Associated with Decreased CT Utilization in Low-Risk Emergency Department Patients

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Introduction: The increasing rate of patient exposure to radiation from computerized tomography (CT) raises questions about appropriateness of utilization. There is no current standard to employ informed consent for CT (ICCT). Our study assessed the relationship between informed consent and CT utilization in emergency department (ED) patients.

Methods: An observational multiphase before-after cohort study was completed from 4/2010-5/2011. We assessed CT utilization before and after (Time I/ Time II) the implementation of an informed consent protocol. Adult patients were included if they presented with symptoms of abdominal/pelvic pathology or completed ED CT. We excluded patients with pregnancy, trauma, or altered mental status. Data on history, exam, diagnostics, and disposition were collected via standard abstraction tool. We generated a multivariate logistic model via stepwise regression, to assess CT utilization across risk groups. Logistic models, stratified by risk, were generated to include study phase and a propensity score that controlled for potential confounders of CT utilization.

Results: 7,684 patients met inclusion criteria. In PHASE 2, there was a 24% (95% CI [10-36%]) reduction in CT utilization in the low-risk patient group ($p<0.002$). ICCT did not affect CT utilization in the high-risk group ($p=0.16$). In low-risk patients, the propensity score was significant ($p<0.001$). There were no adverse events reported during the study period.

Conclusion: The implementation of ICCT was associated with reduced CT utilization in low-risk ED patients. ICCT has the potential to increase informed, shared decision making with patients, as well as to reduce the risks and cost associated with CT. [West J Emerg Med. 2015;16(7):1014-1024.]

INTRODUCTION

Computed tomography (CT) accounts for a significant amount of patient exposure to medical ionizing radiation. Ionizing radiation has been listed by the World Health Organization and the United States Department of Health and Human Services as a carcinogen at low doses.[1,2] Over

the last 30 years, the rate of CT use in medical imaging has increased exponentially in the U.S.[3,4] In 1981, approximately 2.3 million CTs were performed in the U.S., and by the year 2006 this number had risen to greater than 60 million.[5–7] CT utilization is estimated to now exceed 80 million per year. Despite the known risk of cancer associated with ionizing radiation, there has been no national standard to educate patients about the risks, benefits, and alternatives to CT imaging, or to obtain patient informed consent for this diagnostic procedure.

In the early 1980s, U.S. citizens were exposed to an estimated 3.6 milliSieverts (mSv) of ionizing radiation per year, 15% of which was attributed to medical sources.[8,9] Less than 25 years later, ionizing radiation exposure has doubled in the U.S., largely attributed to CT and cardiac nuclear medicine imaging. In one large study, Smith-Bindman et al. documented a 7.8% increase in CT utilization annually between 1996 and 2010.[4] The rapid rise in CT utilization has led to higher patient exposures to radiation, and therefore an increased risk of subsequent cancer development.[10]

A similar acceleration in CT utilization has been documented in U.S. emergency departments (ED), with over a four-fold increase in ED CT utilization documented between 2000-2006.[11] There is no doubt that CT saves lives and it is often the imaging modality of choice in EDs.[12,13] However, the dramatic increase in CT utilization has raised concerns about the appropriateness of use, cost, and the potential long-term consequences of patient exposure to ionizing radiation.

The practice of informed consent has been uniformly adapted in the U.S. for surgical procedures, lumbar punctures, and even for the administration of intravenous (IV) medications, such as CT contrast.[14–18] However, there is currently no national standard to encourage or require patient informed consent prior to CT imaging.

In a multiphase quality improvement initiative, our research team developed a one-page written informed consent for CT (ICCT) to describe the risks, benefits, and alternatives to CT imaging (Appendix I). The consent protocol was studied at a university hospital over an 18 month period, in an observational multiphase before-after cohort analysis. These data represent the first U.S. study of written informed consent for CT in a large cohort of ED patients.[18]

METHODS

Investigators developed, piloted, and implemented ICCT during a multiphase before-after cohort study to assess the effect of informed consent on CT utilization. Following the development of the informed consent,[18] the study was comprised of the following phases:

1. PHASE 1: Characterization of baseline CT utilization in high- and low-risk populations of ED patients presenting for evaluation of abdominal or pelvic pain. Clinical and historical patient risk factors were identified in an a priori fashion; all potential confounders of risk were included in the propensity score model, which was then included in the adjusted, stratified regression model.
2. PHASE 2: Implementation of ICCT, with comparative study of the pre-implementation patient cohort was completed; all study participants were stratified into high and low clinical risk categories. High-risk patients were defined a priori as those demonstrating focal tenderness, rebound tenderness, and/or a rigid abdomen on examination.

The study was completed at a university hospital ED with 37,000 high acuity visits per year. (The hospital serves a quaternary care population consisting of organ transplant, chemotherapy, high-risk neurology and cardiac patients, with a 38% ED hospital admission rate.) The ED serves the local and extended communities, providing emergency care to a culturally and ethnically diverse patient population: in 2013, patient demographics were composed of 50.12 % Black/African American, 48.49% White, and 1.39% other; while 2.38% of patients identified as Hispanic or Latino. ED visits were comprised of a 60:40% female/male patient ratio. The adult hospital provides primary and tertiary care, multiple organ transplant services, and oncological subspecialty care. The study protocol was reviewed and exempted by the university institutional review board, as a quality improvement initiative.

ED patients presenting with abdominal/pelvic pain were selected due to specific characteristics of this patient population: these patients are often alert and able to provide consent; there are accepted alternative imaging modalities to assess abdominal/pelvic pain; and CT leads to ionizing radiation exposure.

PHASE 1. Demographics, Predictors of CT Utilization, and Predictors of Positive CT Findings

Between April and September 2010, we completed a retrospective chart review to assess baseline utilization of CT and identify criteria associated with significant risk of intra-abdominal or intra-pelvic pathology. Adult patients who presented to the ED with a chief complaint related to abdominal/pelvic pathology and/or who received abdomen/pelvis CT were included. We excluded patients with pregnancy, trauma, or altered mental status.

Research assistants abstracted data from the electronic medical record (EMR) using a standardized tool. Data included demographics; history of immunocompromising illness, cancer, surgery, nausea, vomiting, diarrhea, or vaginal bleeding; physical exam findings of vital signs, abdominal/pelvic tenderness, peritoneal signs, abdominal/pelvic mass, distention; laboratory / imaging diagnostic results; and patient disposition, including observation status, admission,

discharge, surgery, and/or intensive care unit admission. We calculated returns to the ED within 30 days, and quantified utilization patterns of ultrasound (US), magnetic resonance imaging (MRI), and inpatient CT. Automated and manually extracted data were matched for accuracy.

PHASE 2. The Effect of Informed Consent on CT Utilization in High and Low-Risk Patients

In PHASE 2, we conducted an observational cohort study of written informed consent for all eligible ED visits. Adult ED patients with a chief complaint related to abdominal/pelvic pathology or who completed ED CT of abdomen or pelvis were eligible for the study. We excluded patients with pregnancy, trauma, or altered mental status.

An example of the written informed consent is attached in Appendix I. Summary data on patient preferences, the development of the consent, and the quantified educational value of the consent process were published previously. The attached one-page consent form is written at an eighth-grade level and takes approximately one minute to review. Consents are completed with patients by the ordering provider (MD or mid-level provider) and then reviewed by the radiology technician prior to imaging, along with screens for pregnancy, and written consent for IV contrast as appropriate per local standard CT acquisition protocol. The informed consent for CT protocol was active 24 hours a day, seven days a week. Data were abstracted using the methodology outlined in PHASE 1.

Data Analysis

PHASE 1. Demographics, Predictors of CT Utilization, and Predictors of Positive CT Findings

Descriptive statistics were stratified by abdominal/pelvic CT use in ED (Yes/No); univariate analyses (t-test, chi-square) were completed (α=0.05). All distributions of variables were examined and assumptions were met. We constructed a multivariate logistic model to assess CT utilization upon presentation in the ED. Demographics, clinical history, physical exam, and lab results were considered possible predictors. We identified clinically relevant historical, clinical, laboratory, and radiographic variables, a priori (based on past research and clinical acumen) and then applied them to the model. The remainder of the potential predictors were evaluated in the model for statistical significance using stepwise regression and overall model fit using Akaike's Information Criterion (AIC). All relevant diagnostics were examined and no severe violations were found. This model was validated on random sample patients presenting to the ED at a later time, using both deviance statistics and goodness of fit statistics.

In the cohort of patients who received a CT, additional analyses assessed the predictors of positive CT findings. CT findings were defined as no acute pathological process/negative CT; diverticular disease; appendicitis; obstruction; renal stone; mass; perforation; colitis/inflammation; fluid collection; post-operative changes; biliary tract disease; hernia; other (fibroids, constipation, vascular abnormalities, and/or extra-abdominal findings ie pneumonia). We calculated descriptive statistics and completed univariate analyses (t-test and chi-square). A multivariate logistic model was constructed to define predictors of positive CT (CTP) and negative CT (CTN) using the same methodology described above. This procedure also examined predictors associated with acute versus chronic/negative CT findings. For all analyses, $p < 0.05$ denotes statistical significance. All analyses were completed using SAS software version 9.3.

PHASE 2. The Effect of Informed Consent on CT Utilization in High and Low-Risk Patients

We stratified descriptive statistics by CT use in ED. Univariate analyses were completed. Using the multivariate logistic regression model generated from the baseline data, we assessed patterns of ED CT utilization for one year (April 2010 - May 2011).

In the analysis, study participants were stratified into high and low clinical risk categories. High-risk patients were defined as those demonstrating focal tenderness, rebound tenderness, and/or a rigid abdomen on examination. We created logistic regression models examining the relationship of ED CT use and the use of informed consent, stratifying by high- or low-risk status. The following independent potential confounders were chosen for the models based on statistical significance (p-value <0.05) and/or clinical relevance: age, sex, initial pain score, immunocompromised state; history of nausea, vomiting, and/or cancer; presence of mass, distention, bowel sounds, and/or vaginal bleeding; laboratory data including white blood cell count and urine nitrites, as well as temperature and systolic blood pressure. We used these variables to create a propensity score for inclusion in the final model. When included in the regression model, the propensity score is a measure of the relationship between receiving an ED CT, clinical and radiographic findings, and the intervention of informed consent. The propensity score controls for potential confounders, without the inflated standard errors that often arise from controlling for a large number of individual confounders and helps to balance the differences that may exist between groups in an observational study, providing estimates closer to the true treatment effect. The logistic regression represents overall CT utilization after adjustment for all clinically relevant confounding variables via the propensity score. This is distinct from the unadjusted values. We examined all relevant diagnostics and found no severe violations.[19,20]

A sensitivity analysis of the missing data was completed for this model, comparing the complete case analysis to an

analysis using multiple imputation to control for missing data. No significant differences were found.[19,20] We completed all analyses using SAS software version 9.3.

RESULTS

PHASE 1. Demographics, Predictors of CT Utilization, and Predictors of Positive CT Findings

CT Utilization

We identified 4,702 patients as presenting to the ED with a chief complaint of abdominal or pelvic pathology; 4,108 met eligibility criteria. Thirty-two percent of these patients (n=1,333) received CT (CTED). The CTED group demonstrated several significant differences from patients who did not receive CT (nCTED). CTED patients had higher initial pain scores (6.9 vs 5.5, p<0.001) and were older (50.4 years vs 48.5 years, p=0.003) than nCTED patients. CTED patients were more likely to endorse history of nausea (p<0.001) or vomiting (p=0.006). Patients with history of cancer, compromised immune systems, or vaginal bleeding were less likely to receive CTED (p<0.001). While patients with history of cancer or immunocompromise received fewer CT studies, this subset demonstrated more frequent total positive CT findings (p<0.001). Patients who received ED US or MRI were less likely to receive ED CT (p<0.001). Significant physical exam and laboratory findings are further reported in Table 1.

In summary, factors associated with CT utilization in PHASE I included age and immune competence; symptoms of nausea, vomiting, and pain; elevation in serum alanine aminotransferase (ALT), hematocrit, and white blood cells (WBC); and physical exam findings of focal or rebound tenderness (Table 2). Patients undergoing active chemotherapy therapy were noted to more frequently receive medical management in the ED independent of CT imaging. The use of MRI and US were inversely correlated with ED CT utilization.

CT Findings

Thirty-two percent of participants (1,333/4,108) received CT, and 74% (n=985) were noted to have positive CT imaging (CTP). All CT-specific chart data were complete. CTP patients were more likely than CT negative (CTN) patients to be older or to report nausea, history of immunocompromise, cancer, palpable mass, distention, elevated serum lipase, bilirubin, WBC, and/or prior surgery (p<0.025). In the multivariate model, CTP patients more frequently demonstrated history of cancer, immunocompromised state, and/or prior surgery (p<0.025).

CT results were stratified into two groups, those with acute pathology (CTPA, 45% n=594) and those with chronic pathology and/or negative findings (CTPC, 55% n=739). CTPA patients were more likely to have a history of nausea or recent surgery, and to demonstrate abnormal lab values for lipase, bilirubin, and WBC (p<0.05). Statistically significant physical exam predictors for CTPA in an adjusted model included sex and the laboratory finding of elevated white blood count.

PHASE 2. The Effect of Informed Consent on CT Utilization in High and Low-Risk Patients

There were 7,684 patients who met inclusion criteria for analyses in the study of CT utilization before and after implementation of ICCT. Of these, 4,108 were included before implementing the informed consent (PHASE 1) and 3,576 patients were included after implementing informed consent (PHASE 2). There were no significant differences in patient demographics for sex or ethnicity between the two study phases. All patients from PHASE 1 and PHASE 2 were treated as independent. Unadjusted data illustrate that 32% of patients in PHASE 2 received CTED, 21% of the low-risk group received CTED and 47% of the high-risk group. This compares to 32% of patients in PHASE 1 receiving CTED, 22% of the low-risk group and 48% of the high-risk group.

Of the 3,576 patients studied after implementing informed consent, those who received CT in the ED were noted to be older (<0.001) and reported higher pain scores (<0.001) than nCTED patients. CTED patients were more likely to present with focal tenderness, rebound tenderness, mass, distention, decreased bowel sounds and nausea (p<0.05). History of immunocompromise and/or presentation with fever, diarrhea, or vaginal bleeding were negatively correlated with CTED. MRI and US use were negatively correlated with CTED (Table 3).

Patients seen during PHASE 1 were older than patients seen during PHASE 2 (49.1 v. 47.3, p-value<0.001). Race and sex were similar between PHASE 1 and PHASE 2 (Table 4). Participants who received a CT after ICCT, were more likely to present with peritoneal signs, focal tenderness, history of vomiting, decreased bowel sounds, mass, and/or history of cancer than those who received a CT before ICCT (p<0.05).

There were 3,130 patients in the high-risk group and 4,554 patients in the low-risk group. Of those in the high-risk group, 1,497 (47.8%) had a CT performed and 1,113 (74.3%) of these patients had a positive CT result. CTs completed in these high-risk patients made up 35.6% of the total positive CTs performed. Of those in the low-risk group, 1,004 (22.0%) had a CT performed and 740 (73.7%) had a positive result; positive CT scans in the low-risk group represent a value of 16.2% of the total CTs performed.

After implementation of the ICCT protocol there was a 24% (95% CI [10-36%]) reduction in CT utilization in the low-risk patient population (p=0.002) after controlling for clinical confounders via the propensity score. The ICCT protocol did not affect utilization in the high-risk population (p=0.16) after controlling for the propensity score. The propensity score was statistically significant for the low-risk group (p=0.002), indicating the set of variables included

Table 1. Demographics and clinical characteristics of patients prior to implementation of informed consent protocol, stratified by ED prescription of CT imaging (n=4,108).

	Overall[a](n=4,108)	ED CT(n=1,333)	No ED CT(n=2,775)	p-value[b]
Demographics				
Average age[†]	49.14 (19.00)	50.42 (18.70)	48.53 (19.11)	0.003
Sex[†‡]				
Male	1,610 (39.19%)	506 (37.96%)	1,104 (39.78%)	0.26
Female	2,498 (60.81%)	827 (62.04%)	1,671 (60.22%)	
Ethnicity				0.005
Black	1,640 (40.22%)	488 (36.86%)	1,152 (41.83%)	
White	2,135 (52.35%)	741 (55.97%)	1,394 (50.62%)	
Other	303 (7.43%)	95 (7.18%)	208 (7.56%)	
Labs				
ALT (n=3,538)	33.00 (71.02)	35.42 (96.18)	31.64 (51.74)	0.19
AST (n=3,546)	40.38 (80.22)	43.48 (120.00)	38.66 (44.14)	0.17
Creatinine (n=3,730)	1.26 (1.57)	1.25 (1.56)	1.26 (1.57)	0.83
Hematocrit (n=3,735)[†]	36.85 (5.98)	37.71 (5.74)	36.38 (6.06)	<0.001
Lactic acid (n=308)	2.07 (1.73)	2.07 (1.70)	2.08 (1.77)	0.99
Lipase (n=1,752)[†‡]	42.48 (148.59)	37.59 (90.41)	46.20 (180.60)	0.19
Total bilirubin (n=3,539)[†‡]	1.03 (2.23)	1.03 (2.24)	1.03 (2.23)	0.93
WBC (n=3,731)[†‡]				
>11.1	904 (22.0%)	379 (28.45)	525 (18.9%)	<0.001
<3.6	199 (4.8%)	44 (3.3%)	155 (5.6%)	
Vital signs				
Systolic blood pressure (n=4,104)[†]				
<100 or >160mmHg	675 (16.5%)	265 (19.9%)	410 (14.8%)	<0.001
Diastolic blood pressure (n=4,108)	76.96 (13.79)	78.05 (14.71)	76.44 (13.29)	<0.001
Heart rate (n=4,100)	88.03 (18.56)	86.83 (18.37)	88.61 (18.62)	0.004
Body temperature (n=4,106)	36.84 (0.70)	36.78 (0.61)	36.87 (0.74)	<0.001
Signs and symptoms				
Initial pain score (n=4,107)	5.93 (3.60)	6.86 (3.19)	5.48 (3.70)	<0.001
Focal tenderness[‡]	1,570 (38.22%)	762 (57.16%)	808 (29.12%)	<0.001
Abdomen soft	4,094 (99.66%)	1,323 (99.25%)	2,771 (99.86%)	0.003[c]
Rebound tenderness[‡]	71 (1.73%)	48 (3.60%)	23 (0.83%)	<0.001
Bowel sounds	4012 (97.66%)	1,276 (95.72%)	2,736 (98.59%)	<0.001
Mass (n=3,988)[†]	59 (1.48%)	31 (2.38%)	28 (1.04%)	0.001
Distention (n=4,004)[†]	219 (5.47%)	99 (7.59%)	120 (4.44%)	<0.001

ED, emergency department; *CT*, computerized tomography; *ALT*, alanine aminotransferase; *AST*, aspartate transaminase; *WBC*, white blood cell

[†]These variables were also significantly related to positive CT findings (CTP).

[‡]These variables were also significantly related to acute CT findings (CTPA).

[a]Statistics provided are mean (std dev) for continuous and discrete variables and n (%) for categorical variables.

[b]p-values are results of t-tests or chi-square tests.

[c]Used Fisher's exact test due to small cell counts.

Table 1. Continued.

	Overall[a] (n=4,108)	ED CT (n=1,333)	No ED CT (n=2,775)	p-value[b]
Medical history				
Immunocompromise[d†]	614 (14.95%)	142 (10.65%)	472 (17.01%)	<0.001
Cancer[†]	670 (16.31%)	179 (13.43%)	491 (17.69%)	<0.001
Blood in urine (n=3,303)[†]	1,233 (37.33%)	435 (36.52%)	798 (37.78%)	0.47
Leukocytes in urine (n=4,102)	1,364 (41.30%)	470 (39.46%)	894 (42.33%)	0.11
Nitrites in urine (n=4,101)	206 (6.24%)	71 (5.96%)	135 (6.39%)	0.62
Fever (n=4,102)[e]	730 (17.80%)	192 (14.44%)	538 (19.41%)	<0.001
Nausea (n=4,101)[†‡]	2,149 (52.40%)	814 (61.20%)	1,335 (48.18%)	<0.001
Vomiting (n=4,102)	1,443 (35.18%)	507 (38.12%)	936 (33.77%)	0.006
Diarrhea (n=4,102)	628 (15.31%)	191 (14.360%)	437 (15.76%)	0.24
Vaginal bleeding[a] (n=4,102)	96 (2.34%)	9 (0.68%)	87 (3.14%)	<0.001
Surgery 1-30 days ago[†‡]	266 (6.48%)	105 (7.88%)	161 (5.80%)	0.011
Surgery 31-60 days ago	91 (2.22%)	36 (2.70%)	55 (1.98%)	0.14
Surgery 61-90 days ago	77 (1.87%)	20 (1.50%)	57 (2.05%)	0.22
Surgery 91-365 days ago[†]	343 (8.35%)	122 (9.15%)	221 (7.96%)	0.20

ED, emergency department; *CT*, computerized tomography
[†]These variables were also significantly related to positive CT findings (CTP).
[‡]These variables were also significantly related to acute CT findings (CTPA).
[a]Categorized as yes, no, n/a.
[d]Patients with active chemotherapy or immunomodulatory therapy were included in this cohort.
[e]Patients with symptoms of gastroenteritis (fever + symptoms of vomiting / diarrhea) were included in this cohort.

Table 2. Predictors of ED prescription of CT imaging prior to implementation of informed consent in multivariable logistic model.

	Beta	Std error	p-value	Adjusted odds ratio	Adjusted OR 95% CI
Intercept	2.44	2.43	n/a	n/a	n/a
Presence of bowel sounds	-0.44	0.14	0.0012	0.41	(0.24, 0.70)
Focal tenderness	0.492	0.04	<0.0001	2.67	(2.25, 3.18)
Immune compromised	-0.274	0.06	<0.0001	0.58	(0.45, 0.74)
Nausea	0.148	0.06	0.0085	1.34	(1.08, 1.67)
Rebound tenderness	0.436	0.16	0.0076	2.39	(1.26, 4.55)
Soft abdomen	-1.07	0.48	0.0255	0.12	(0.02, 0.77)
History of vaginal bleeding	-0.61	0.23	0.0072	0.30	(0.12, 0.71)
History of vomiting	-0.20	0.06	0.0004	0.68	(0.54, 0.83)
ED MRI	-0.95	0.41	<0.0001	0.39	(0.17, 0.87)
ED ultrasound	-0.57	0.14	<0.0001	0.55	(0.43, 0.74)
ALT	0.01	0.001	0.0229	1.001	(1.000, 1.003)
Hematocrit	0.03	0.01	<0.001	1.02	(1.01, 1.05)
White blood cell count	0.05	0.01	<0.0001	1.05	(1.03, 1.07)
Temperature	-0.13	0.06	0.0437	0.88	(0.78, 0.99)
Age on arrival	0.02	0.002	<0.0001	1.02	(1.01, 1.02)
Initial pain score	0.09	0.01	<0.0001	1.10	(1.07, 1.12)

ED, emergency department; *CT*, computerized tomography; *OR*, odds ratio; *CI*, confidence interval; *MRI*, magnetic resonance imaging; *ALT*, alanine aminotransferase

Table 3. Demographics and clinical characteristics of patients after implementation of informed consent protocol, stratified by ED prescription of CT imaging (n=3,576).

	Overall[a] (n=3,576)	ED CT (n=1,168)	No ED CT (n=2,404)	p-value[b]
Demographics				
Age	47.28 (18.68)	49.81 (18.02)	46.06 (18.87)	<0.001
Sex				
Male	1,442 (40.32%)	482 (41.27%)	960 (39.87%)	0.42
Female	2,134 (59.68%)	686 (58.73%)	1,448 (60.13%)	
Ethnicity				0.06
Black	1,471 (41.53%)	451 (39.12%)	1,020 (42.70%)	
White	1,803 (50.90%)	620 (53.77%)	1,183 (49.52%)	
Other	268 (7.49%)	82 (7.02%)	186 (7.73%)	
Labs				
ALT (n=3,211)	31.42 (53.84)	30.85 (46.93)	31.73 (57.23)	0.64
AST (n=3,212)	39.67 (67.74)	41.21 (84.63)	38.83 (60.21)	0.40
Creatinine (n=3,333)	1.25 (1.60)	1.18 (1.24)	1.28 (1.76)	0.06
Hematocrit (n=3,325)	37.48 (6.20)	38.31 (5.61)	37.04 (6.45)	<0.001
Lactic acid (n=315)	1.91 (1.67)	2.02 (1.96)	1.79 (1.30)	0.22
Lipase (n=1,933)	42.11 (119.9)	44.12 (118.2)	40.77 (120.9)	0.55
Total bilirubin (n=3,212)	0.99 (1.63)	0.99 (1.41)	0.99 (1.74)	0.97
WBC (n=3,324)				
High	849 (25.5%)	372 (32.2%)	477 (22.0%)	<0.001
Low	130 (3.9%)	27 (2.3%)	103 (4.8%)	
Vital signs				
Systolic blood pressure (n=3,574)				
Abnormal	144 (4.0%)	44 (3.8%)	100 (4.2%)	0.5798
Diastolic blood pressure (n=3,573)	69.60 (17.78)	69.04 (18.39)	69.88 (17.47)	0.20
Heart rate (n=3,574)	83.33 (19.57)	81.84 (20.29)	84.05 (19.17)	0.002
Body temperature (n=3,572)	36.34 (0.75)	36.17 (0.77)	36.42 (0.73)	<0.001
Signs and symptoms				
Initial pain score (n=3,575)	6.11 (3.53)	6.99 (3.05)	5.67 (3.66)	<0.001
Focal tenderness	1,526 (42.67%)	720 (61.64%)	806 (33.47%)	<0.001
Soft abdomen	3,559 (99.52%)	1,160 (99.32%)	2,399 (99.63%)	0.205
Rebound tenderness	81 (2.27%)	58 (4.97%)	23 (0.96%)	<0.001
Bowel sounds	3,408 (95.30%)	1059 (90.67%)	2349 (97.55%)	<0.001
Mass (n=3,988)	91 (2.54%)	61 (5.22%)	30 (1.25%)	<0.001
Distention (n=4,004)	188 (5.26%)	89 (7.62%)	99 (4.11%)	<0.001

ED, emergency department; *CT*, computerized tomography; *ALT*, alanine aminotransferase; *AST*, aspartate transaminase; *WBC*, white blood cell

[a]Statistics provided are mean (std dev) for continuous and discrete variables and n (%) for categorical variables.

[b]p-values are results of t-tests or chi-square tests.

Table 3. Continued.

	Overall[a] (n=3,576)	ED CT (n=1,168)	No ED CT (n=2,404)	p-value[b]
Medical history				
Immunocompromised	551 (15.41%)	150 (12.84%)	401 (16.66%)	0.003
Cancer	632 (17.67%)	208 (17.81%)	424 (17.61%)	0.88
Blood in urine (n=2,981)[c]	1,075 (36.06%)	361 (33.64%)	714 (37.42%)	0.04
Leukocytes in urine (n=2,981)	1,229 (41.235)	386 (35.97%)	843 (44.18%)	<0.001
Nitrites in urine (n=2,981)	157 (5.27%)	33 (3.08%)	124 (6.50%)	<0.001
Fever	513 (14.35%)	148 (12.67%)	365 (15.16%)	0.05
Nausea	2,059 (57.58%)	734 (62.84%)	1,325 (55.02%)	<0.001
Vomiting	1,452 (40.60%)	491 (42.04%)	961 (39.91%)	0.22
Diarrhea	595 (16.64%)	153 (13.10%)	442 (18.36%)	<0.001
Vaginal bleeding[d]	94 (2.63%)	7 (0.60%)	87 (3.61%)	<0.001

ED, emergency department; *CT*, computerized tomography
[a]Statistics provided are mean (std dev) for continuous and discrete variables and n (%) for categorical variables.
[b]p-values are results of t-tests or chi-square tests.
[c]Patients with nephrolithiasis and/or UTI are included in this cohort.
[d]Categorized as yes, no, n/a.

Table 4. Model results of effect of informed consent on ED prescription of CT imaging stratified by risk status.

	Low risk (n=3783)			High risk (n=2877)		
	Adjusted OR	95% CI	P-value	Adjusted OR	95% CI	P-value
Intercept	--	--	--	--	--	--
Time 2	0.76	(0.64, 0.90)	0.002	0.89	(0.76, 1.05)	0.17
Propensity score	1.74	(1.23, 2.45)	0.002	0.89	(0.62, 1.29)	0.54

ED, emergency department; *CT*, computerized tomography; *OR*, odds ratio; *CI*, confidence interval

in the propensity score were statistically related to the performance of ED CT.

There were no adverse events reported or identified during the study period. Returns to the ED within 30 days of the initial visit were not different between risk groups, before or after implementation of ICCT (p=0.87). CT utilization in the clinically high-risk population did not change during the study period. Multiple imputation analyses were performed and did not differ from the complete data analysis; no bias was identified. Patients who received CT in the ED were more likely to receive CT during their inpatient stay in the hospital, when compared to patients who did not receive ED CT. Results of the stratified regression models are available in Table 4.

DISCUSSION

In this novel, multiphase study, investigators developed the ICCT tool and demonstrated its feasibility, acceptability, and ability to improve patient knowledge about the risks of ionizing radiation from CT.[18] Researchers identified factors that placed patients at high and low risk for clinically important findings on CT. ICCT implementation was associated with reduced CT use in low-risk patients, and did not affect CT utilization in the high-risk patient population.

In this cohort study, the derived propensity score adjusts for clinically relevant covariates, such as laboratory, historical, and physical exam findings related to patient course and evaluation. Such variables are present in the cohorts, but are not presumed to be balanced between groups. The unadjusted data do not account for such covariates and do not illustrate statistically significant differences between groups. However, the propensity model controls for the clinically relevant confounders, and illustrates a significant difference between PHASE 1 and PHASE 2 in CT utilization, within the low-risk patient population.

The ICCT protocol is intended to engage patients in shared medical decision-making. This approach has the potential to help physicians achieve national goals to reduce unnecessary medical imaging and resource use, as supported by the 24% (95% CI [10-36%]) reduction we found in CT utilization among low-risk patients after implementation of the protocol.[21]

Although our study is limited by secular trends in CT utilization and physician education via the informed consent tool; it is essential to note that reduction in CT utilization was

only noted in the low-risk patient population of our cohort; no significant change in utilization occurred in high-risk patients. This relationship supports future application of informed consent as an educational and shared decision-making tool.

Much of the data on carcinogenesis from ionizing radiation have been derived from animal models or retrospective studies of nuclear workers / atomic bomb survivors. In 2012, Pearce et al. published the first longitudinal cohort study to identify a linear dose response curve between CT exposure and cancer development.[10]Pearce et al. call for action to decrease radiation exposure related to CT to the lowest possible dose (ALARA, "as low as reasonably achievable"), and to perform scans only when clearly justified. Using the linear no threshold model, routine abdominal-pelvic CT is conservatively estimated to induce fatal cancer in 1 per 5,000-10,000 patients exposed.[22,34–37]

Despite the known risks of ionizing radiation exposure, it is neither standard care nor routine practice to obtain informed consent for CT.[17,18] This may be due to the fact that ionizing radiation from CT causes no immediately tangible effect or visible scar and the resulting development of cancer may not occur for decades. However, like surgery, ionizing radiation leaves a biological mark on the patient. Furthermore, the calculated risk of cancer induction from CT is surprisingly greater than the risk associated with other medical interventions (e.g. blood transfusion) that routinely require hospital regulated informed consent.[18] As blood transfusion carries an estimated 1 in 250,000 risk of infection with hepatitis C virus, and a 1 in 1.3 million risk of acquiring HIV,[38] it appears we have failed to proportionally perform due diligence with regard to informed consent for CT.

Whether communication with the patient about the benefits and risks of CT should be through informed consent or via a shared decision-making process has been an ongoing debate.[18,39,40] Yet, without informed consent, there is no evidence that information is being shared with patients with any frequency or in a standardized fashion.

The study's ICCT process is a rapid, practical, and effective method to educate patients about the risks, benefits, and alternatives to CT imaging. Over the extended cohort, ICCT was associated with a reduction of CT utilization in low-risk ED patients who presented with abdominal/pelvic pain. Future analyses will assess the effect of a video educational module/written informed consent on the utilization patterns of CT, MRI, and US in the ED population.

LIMITATIONS

Investigators were not able to control for institutional and secular trends within the longitudinal cohort that may have affected CT utilization. However, the effect of informed consent was observed to be limited to the low-risk patients within the cohort, and not observed in all ED patients.

Our study cannot discriminate between the effect of provider versus patient education on utilization, as these occurred simultaneously. The overall act of instituting ICCT was significantly associated with reduced utilization, increased patient understanding, and positive patient preferences.

Additional limitations include the fact that chart data were collected via retrospective review of the EMR within a single center. It is unknown whether or not a patient visited the ED multiple times within or between the phases, all patient visits were treated as independent interactions for statistical purposes. However, several features strengthen the likelihood that our findings are relevant to a range of ED settings. As a collaborative, multidisciplinary effort, the protocol was validated by a variety of stakeholders, including physician/nursing colleagues, radiation physicists, technicians, medical ethicists, and patient consultants. Furthermore, the study's ED population was racially, ethnically, and socioeconomically diverse, making the study likely to be relevant to many different practice settings. Finally, with a brief, <1-minute script, the protocol was designed to be minimally disruptive to the practice setting.

While the use of the propensity score adjusted for potential unbalanced characteristics between groups and controlled inflated standard errors, propensity scores, by their nature, are unable to control for unmeasured potential confounders.

CONCLUSION

The implementation of informed consent for CT was associated with reduced CT utilization, after controlling for clinical confounders, in this large prospective cohort study of ED patients. No significant adverse events or complications were reported throughout the study. ICCT has the potential to increase informed, shared decision-making for patients, as well as to reduce the risks and costs associated with the CT procedure.

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Inpatient Readmissions and Emergency Department Visits within 30 Days of a Hospital Admission

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Introduction: Inpatient hospital readmissions have become a focus for healthcare reform and cost-containment efforts. Initiatives targeting unanticipated readmissions have included care coordination for specific high readmission diseases and patients and health coaching during the post-discharge transition period. However, little research has focused on emergency department (ED) visits following an inpatient admission. The objective of this study was to assess 30-day ED utilization and all-cause readmissions following a hospital admission.

Methods: This was a retrospective study using inpatient and ED utilization data from two hospitals with a shared patient population in 2011. We assessed the 30-day ED visit rate and 30-day readmission rate and compared patient characteristics among individuals with 30-day inpatient readmissions, 30-day ED discharges, and no 30-day visits.

Results: There were 13,449 patients who met the criteria of an index visit. Overall, 2,453 (18.2%) patients had an ED visit within 30 days of an inpatient stay. However, only 55.6% (n=1,363) of these patients were admitted at one of these 30-day visits, resulting in a 30-day all-cause readmission rate of 10.1%.

Conclusion: Approximately one in five patients presented to the ED within 30 days of an inpatient hospitalization and over half of these patients were readmitted. Readmission measures that incorporate ED visits following an inpatient stay might better inform interventions to reduce avoidable readmissions. [West J Emerg Med. 2015;16(7):1025-1029.]

INTRODUCTION

Hospital readmissions continue to pose challenges for the nation's healthcare system. The odds of a Medicare patient being readmitted within 30 days may be as high as one in five,[1] and closer to one in four for patients 65 years and older with common chronic conditions such as congestive heart failure.[2,3] In recent years, there has been an increased effort to decrease hospital readmissions to reduce associated costs and as a purported measure of care quality. These efforts have included care coordination for high readmission conditions and patients, enhanced discharge planning, and self-management and education during the post-discharge transition period.[4-9]

However, little research has focused on emergency department (ED) visits following an inpatient admission. ED visits have increased dramatically in the last decade – roughly 23% from 1997 to 2007 by one national estimate.[10] The ED not only plays an important role for returning patients after an inpatient discharge, but can also prevent the need for a longer inpatient stay for well-timed visits. However, current hospital readmission measures focus only on repeat inpatient care episodes, overlooking patients who return for care to the ED, but were not actually admitted. Prior studies suggest that nearly half of all 30-day return visits from an inpatient stay might be

missed by focusing only on patients who are readmitted.[11]

The purpose of this study was to assess 30-day ED utilization and all-cause readmissions following an inpatient stay.

METHODS

Study design

This was a retrospective study using inpatient and ED utilization data. This study was approved by the institutional review board.

Study setting and population

We obtained utilization data from two hospitals with a shared patient population and electronic medical record. One hospital is an urban academic teaching hospital (Level 1 trauma center) with an annual census of approximately 40,000 visits. The second hospital is a suburban community hospital with an annual census of approximately 24,000 visits.

Measures

We obtained data from electronic hospital discharge records for all ED and inpatient admissions during 2011. Measures included patient demographic information, service date, primary payer, discharge disposition, and up to 25 International Classification of Disease 9th Revision Clinical Modification diagnoses codes. Primary diagnoses codes were used to describe the clinical classification of patient visits based on Clinical Classification Software.[12]

Outcomes

The primary outcome was 30-day ED utilization and defined as any ED visit within 30 days of an inpatient discharge, regardless of discharge disposition. We defined a 30-day ED discharge as any ED visit within 30 days of an inpatient discharge in which the patient was not admitted. The secondary outcome was 30-day all-cause readmission, defined as the number of patients with at least one hospital readmission within 30 days of an inpatient discharge. The following exclusions were applied: 1) invalid patient identifier; 2) age <14 days; 3) primary diagnosis of maternity; and, 4) psychiatric care admission. Readmission was not evaluated immediately following visits in which the patient 1) left against medical advice, 2) expired, or 3) was discharged in last month of study period. Readmission was discounted if the visit was a scheduled admission.

Analysis

We classified patients into three groups based on the type of 30-day visit: patients with 1) a 30-day inpatient readmission (from the ED); 2) a 30-day ED discharge only; and, 3) no 30-day visits. Descriptive analyses of patient characteristics were conducted for each group. We used non-parametric Mann-Whitney U tests to compare length of the index inpatient stay between patients in each group. A Mann-Whitney U test was conducted to compare time to 30-day visit between patients with 30-day inpatient readmissions and patients with only 30-day ED discharges. The top two clinical classifications by type of 30-day visit were also reported. We conducted all analyses using the IBM SPSS Statistics 19.0 software package (SPSS, Inc., Chicago, IL).

RESULTS

There were 21,311 patients who were discharged from inpatient care during the study period, accounting for 27,620 total inpatient discharges. Of these patients, 13,449 patients (63.1%) had at least one inpatient discharge meeting the criteria for an index visit. Overall, 2,453 patients (18.2%) had an ED visit within 30-days of index inpatient stay, for a combined total of 4,423 30-day ED visits (Table 1). However, only 1,363 (55.6%) of these patients were admitted at one or more of these 30-day ED visits. This corresponds to a modest 30-day all-cause readmission rate of 10.1%. Thus, by assessing all 30-day ED visits rather than only those ED visits which resulted in an admission, an additional 1,090 patients and 1,430 30-day acute care visits were identified.

Demographic characteristics are described for each group in Table 2. The proportion of patients who had private insurance (35.7%) was highest among patients with no 30-day visits. Medicare coverage was highest among patients with a 30-day inpatient readmission (41.3%); whereas, the lack of medical coverage (self-pay/indigent) was highest among patients with only a 30-day ED discharge (21.4%).

The median length of stay at index inpatient visits was longer for patients with 30-day inpatient readmissions (4 days; inter-quartile range [IQR]=2 to 7 days) compared to patients with only 30-day ED discharges (3 days; IQR=2 to 6 days) and patients with no 30-day visits (3 days; IQR=1 to 5 days) (p's<0.001). The median length of time to 30-day visits was similar for patients with 30-day inpatient readmissions (10

Table 1. Frequency and percentage of patients with 30-day visits.

Characteristic	Frequency (N)	Frequency (%)
Patients with at least one index inpatient admission	13,449	--
Patients with a 30-day ED visit	2,453	18.2
Total number of 30-day ED visits	4,423	--
Patients with a 30-day inpatient readmission	1,363	10.1
Number of 30-day inpatient readmissions	2,040	--
Number of 30-day ED visits	2,993	--
Patients with only a 30-day ED discharge	1,090	8.1
Number of 30-day ED discharges	1,430	--
Patients without a 30-day ED visit	10,996	81.8

ED, emergency department

Table 2. Patient demographic characteristics by type of 30-day visit.

	Patients without a 30-day visit (n=10,996)	Patients with a 30-day inpatient readmission (n=1,363)	Patients with a 30-day ED discharge only (n=1,090)
Characteristic	n(%)	n(%)	n(%)
Age in years			
Less than 25	1,009 (9.2)	55 (4.0)	59 (5.4)
25 to 44	2,400 (21.8)	257 (18.9)	259 (23.8)
45 to 64	4,374 (39.8)	615 (45.1)	472 (43.3)
65 or older	3,213 (29.2)	436 (32.0)	300 (27.5)
Male gender	6,122 (55.7)	731 (53.6)	634 (58.2)
Ethnicity/Race			
Non-Hispanic White	6,206 (56.4)	759 (55.7)	662 (60.7)
Hispanic/Latino	2,703 (24.6)	313 (23.0)	204 (18.7)
Non-Hispanic Black	882 (8.0)	137 (10.1)	123 (11.3)
Non-Hispanic Other	1,205 (11.0)	154 (11.3)	101 (9.3)
Payer			
Private	3,923 (35.7)	297 (21.8)	243 (22.3)
Medicare	3,638 (33.1)	563 (41.3)	362 (33.2)
Medi-Cal	1,736 (15.8)	327 (24.0)	252 (23.1)
Self-pay/indigent	1,699 (15.5)	176 (12.9)	233 (21.4)

days; IQR=4 to 18 days) compared to patients with only 30-day ED discharges (9 days; IQR=4 to 18 days) (p=0.884).

The top clinical classifications for all 30-day inpatient readmissions were septicemia (8.7%) and complications of surgical procedures or medical care (6.5%); whereas, the top clinical classifications for all 30-day ED visits were abdominal pain (8.8%) and nonspecific chest pain (6.3%). The top clinical classifications at inpatient stays preceding a 30-day readmission were septicemia (7.0%) and complication of device, implant or graft (4.9%); and, were identical at inpatient stays preceding a 30-day ED discharge (5.5% and 3.7%, respectively).

DISCUSSION

Numerous studies have investigated hospital readmissions among specific populations traditionally at higher risk for readmission, including patients with Medicare,[1,13] older adults,[9,14] and patients with chronic conditions such as congestive heart failure[6,7] and COPD.[15] While this approach is important, a global understanding about ED and inpatient utilization can provide new insights into how providers and medical centers approach reducing short-term re-evaluations. This approach has also been endorsed by the National Quality Forum and is increasingly becoming the standard approach after the implementation of the Affordable Care Act and ongoing evolution of payment reform in the United States.

Examining ED visits in tandem with readmissions can provide unique insight into the post-discharge period. For example, in this study the proportion of patients with an ED visit within 30 days of an inpatient stay that were not admitted (8.1%) was very similar to the proportion of patients who were admitted at least once (11.1%). In addition, the total number of ED visits within 30 days of an inpatient stay accounted for roughly 7.6% of all non-obstetric-related ED visits during the entire study period. Thus, an opportunity exists here to identify gaps in care for all patients who seek emergency care following an inpatient stay, rather than only those who require admission.

Interestingly, many of these patients had more than one 30-day visit in the study period. Over one-third (37%) of patients with at least one 30-day return visit to the ED (admitted or discharged) had multiple 30-day visits, and 16% had more than one 30-day readmission. Patients with multiple visits to the ED, often described as frequent users of ED resources, are admitted at higher rates, have medical insurance, and are often burdened by multiple chronic diseases, substance abuse issues and mental illness.[16-18] Similar findings have been reported for frequently admitted patients as well.[19] This specific group of patients with multiple return visits may be an ideal target for interventions to reduce readmissions given the potential return on investment.

There are multiple interventions after an inpatient discharge that can assist with decreasing hospital readmissions. Comprehensive discharge planning that focuses on care transitions is a pivotal step toward preventing a hospital readmission,[20,21] including timely follow up with a healthcare provider.[15,22,23] Similarly, home monitoring is a promising approach with high-risk patients to identify poor disease management that may result in a hospital readmission.[24,25] The

better utilization of community resources to address recidivism issues can also play an important role in improving care for hard-to-reach populations.[26] Finally, when acute exacerbations do occur, patients can often be stabilized in an ED and either discharged or admitted to an observation unit rather than being admitted to an inpatient service. All of these resources can be used across the continuum of care, including the ED, to maintain the patients' health and potentially prevent an otherwise avoidable readmission. Further research should focus on specific healthcare utilization trends related to both the readmission and ED revisit process, the relationship between specific diagnoses and potential interventions, and how these can be impacted by acute care providers.

LIMITATIONS

Our findings should be interpreted in the context of study design and setting. First, the retrospective methodology provides limitations on these specific data. Second, only inpatient and ED utilization at two facilities were available. Although it is expected that established patients of these two facilities continued to seek care there, data on the utilization of hospitals and EDs elsewhere in the community were not available. However, given that there are other EDs located in the general proximity of the study EDs (a trauma center, a community hospital, and a Veterans Affairs facility), 30-day readmissions and ED visits may be underestimated. Lastly, these results may not be generalizable to other communities and healthcare systems. Nevertheless, these results provide context of ED visits after an inpatient discharge.

CONCLUSION

Approximately one in five patients presented to the ED within 30 days of an inpatient hospitalization and over half of these patients were readmitted. Interventions targeting 30-day hospital readmissions need to consider the entire continuum of care admission, including the ED.

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Achieving the Triple Aim Through Informed Consent for Computed Tomography

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At the end of a particularly busy shift, you meet Mary, a 24 year-old female with no past medical history, who presents with six hours of crampy, intermittent, periumbilical abdominal pain but no associated fever, nausea, vomiting, diarrhea or anorexia. Her vital signs are normal and her abdominal and gynecological exams are notable only for mild, diffuse abdominal tenderness without rebound or guarding. Her lab results and urinalysis are unremarkable, and her pain improves somewhat with intravenous pain medications. You explain to the patient that you have a low suspicion for an intraabdominal emergency, but cannot be certain without a computed tomography (CT) scan. "I'll do whatever you recommend," she replies. The patient ultimately gets a CT, which is normal, and she is discharged 30 minutes later with a diagnosis of nonspecific abdominal pain.

Emergency department (ED) clinicians see patients like Mary every day- patients for whom our experience and clinical suspicion of a truly emergent condition is low, albeit not negligible, and for whom there are no consensus, evidence-based guidelines or algorithms to guide the use of advanced imaging. The decision to image is, at times, dictated by systems-factors, such as difficulties arranging for adequate follow-up. Fear of litigation has been cited as a common driver of excessive diagnostic testing.[1] Ultimately, diagnostic CT use in the ED is on a steep rise, which, combined with unchanging prevalence of disease, results in greater exposure to CT risks and costs with lower corresponding diagnostic yield.[2-5]

The risks (and costs) of CT are undeniably real and should not be ignored or minimized. Extrapolating from data from atomic bomb survivors, Smith-Bindman, Brenner and others have calculated the risks of cancer development associated with CT and estimated that up to 2% of all cancers in the US are attributable to CT scans.[6,7] Beyond these theoretical extrapolations, Mathews and others demonstrated a dose-response risk of cancer development associated with CT scans in a large cohort of patients in Australia.[8]

Concurring with these concerns about CT, a number of professional medical societies and various governing bodies (BEIR- The National Research Council's Biological Effects of Ionizing Radiation VII Report, UNSCEAR- The United Nations Scientific Committee on the Effects of Atomic Radiation, and IRCP- The International Commission on Radiological Protection) have targeted cutbacks in unnecessary CT imaging and reduction of radiation doses with CT as specialty-wide goals.[9-12] The American College of Surgeons and the American College of Emergency Physicians have both included reductions in CT as part of their Choosing Wisely campaigns.[13,14]

Merck and colleagues in this issue of Western Journal of Emergency Medicine, note the risks of CT, comparing them to the risks associated with blood transfusion (for which clinicians universally obtain informed consent).[15] This is a thought-provoking and rational link that, combined with the fact that patients (and physicians) are unaware of CT risks, leads to the logical next-step of their novel trial of informed consent for abdominal/pelvic CT. In this multiphase, observational cohort study, the authors collected data on abdominal pain patients and built a multivariate logistic regression model to assess probability of CT utilization as a function of history, exam findings, diagnostic testing and disposition. Patients who had CT scans were included in a second multivariable model that estimated the likelihood of having a positive scan. In the next phase of the study, emergency providers used a one-page, standardized, written informed consent tool, which included potential biological risks and diagnostic benefits of CT, to engage patients in shared decision making. The authors report that the tool took less than one minute to use and was minimally disruptive to provider workflow. Patients in this implementation phase were stratified as "low" or "high" risk based on clinical factors (focal or rebound tenderness and the presence of a rigid abdomen). The investigators then built a logistic regression model to assess CT utilization among the low

and high risk groups after controlling for confounders with propensity score matching.[15]

Their results were striking. While CT utilization was unaffected in the high-risk group, the investigators noted a 24% reduction in CT utilization among low-risk patients after the implementation of their written informed consent protocol. Notably, they found no difference in adverse events or patient return visits within 30 days among the nearly 4,000 patients included in the study, indicating that their protocol was both safe and effective.[15]

Overall, these findings introduce a novel way to improve patient-centered care. Their informed-consent intervention was simple, safe, fast, and effective, achieving several goals of the Institute for Health Improvement's Triple Aims: (1) improving population health, (2) reducing costs and (3) enhancing the patient experience.[16] Decreasing the rate of low-yield CT scans may decrease costs and improve outcomes by minimizing unnecessary ionizing radiation and decreasing potentially invasive workups of incidental findings. At least as important are the potential positive effects of shared decision-making. Prior investigators have shown that patients want to be informed of the risks (and costs) of CT whenever possible and that many patients would prefer to avoid imaging when their risk of life-threatening injury is low.[17] Informed consent for CT may therefore improve patient satisfaction and patient care experience.

Should informed consent for CT be routinely obtained? Should it even become a standard of care? Although there are certainly some cases in which consent may not be feasible, most scenarios for CT use in the ED are truly not emergent enough to preclude informed consent/shared decision-making. We await further examinations of this important topic, most notably a large, multicenter study of shared-decision making in pediatric head trauma.[18] In the meantime, the work of Merck et al is compelling enough that we would advocate providing consent for CT in low risk abdominal pain cases.

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Vital Signs
from the Centers of Disease Control and Prevention's MMWR

Distracted Driving, A Major Preventable Cause of Motor Vehicle Collisions: "Just Hang Up and Drive"

In conjunction with the Morbidity and Mortality Weekly Report published by the Center for Disease Control and Prevention

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For years, public health experts have been concerned about the effect of cell phone use on motor vehicle collisions, part of a phenomenon known as "distracted driving." The Morbidity and Mortality Weekly Report (MMWR) article "Mobile Device Use While Driving - United States and Seven European Countries 2011" highlights the international nature of these concerns. Recent (2011) estimates from the National Highway Traffic Safety Administration are that 10% of fatal crashes and 17% of injury crashes were reported as distraction-affected. Of 3,331 people killed in 2011 on roadways in the U.S. as a result of driver distraction, 385 died in a crash where at least one driver was using a cell phone. For drivers 15-19 years old involved in a fatal crash, 21% of the distracted drivers were distracted by the use of cell phones. Efforts to reduce cell phone use while driving could reduce the prevalence of automobile crashes related to distracted driving. The MMWR report shows that there is much ground to cover with distracted driving. Emergency physicians frequently see the devastating effects of distracted driving on a daily basis and should take a more active role on sharing the information with patients, administrators, legislators, friends and family. [West J Emerg Med. 2015;16(7):1033-1036.]

CDC MORBIDITY & MORTALITY WEEKLY REPORT FINDINGS

In the March 15, 2013, issue of the *Morbidity and Mortality Weekly Report* (MMWR), the Centers for Disease Control and Prevention (CDC) reported information on self-reported mobile device use while driving in the United States and seven European countries.[1] The report described that among drivers ages 18-64, the prevalence of talking on a cell phone while driving at least once in the past 30 days ranged from 21% in the United Kingdom (UK) to 69% in the U.S. In addition, the prevalence of drivers who read or sent text or e-mail messages while driving at least once in the past 30 days ranged from 15% in Spain to 31% in both Portugal and the U.S.

To describe these trends, the CDC analyzed data from the 2011 EuroPNStyles and HealthStyles surveys, which were created by a worldwide social marketing and public relations firm.[1] These surveys were conducted among adults (age >18 years) to examine health-related attitudes and behaviors. In the U.S., the HealthStyles survey used was from September 30 to October 5, 2011. They randomly sampled 5,315 people, with 70% (3,696) completing the HealthStyles survey. The HealthStyles survey data were weighed to match nine characteristics (sex, age, annual household income, race/ethnicity, household size, education, U.S. census region, metropolitan status, and prior internet access) of the U.S. current population. The EuroPNStyles survey was conducted in July 2011 in Belgium, France, Germany, the Netherlands, Portugal, Spain, and the UK. Samples were selected to match each country's census proportion for age and sex. All countries reached 1,700 adults, with the exception of Spain and Portugal, which were only able to attain 850 adults. Both surveys asked if participants had driven in the past 30 days. If so, then they would continue to ask, "In the past 30 days, how often have you talked on your cell phone while you were

driving?" and "In the past 30 days, how often have you read or sent a text message or e-mail while you were driving?" Survey participants had the following response choices: "never," "just once," "rarely," "fairly often," and "regularly."

The U.S. results showed that, in 2011, more than two-thirds (68.7%) of drivers between ages 18-64 years had talked on their cell phone while driving at least once in the past 30 days. European percentages ranged from 20.5% in the UK to 59.4% in Portugal. Furthermore, 31.2% of U.S. drivers in the same age range reported they had read or sent text or e-mail messages while driving at least once in the past 30 days versus Europe's percentages ranged from 15.1% in Spain to 31.3% in Portugal. Finally, few differences by sex were observed in the U.S., although there was a significant difference by age. A larger percentage of people aged 25-44 years reported talking on a cell phone, reading or sending texts or email messages while driving compared to those aged 55-64 years.

The editorial note portion of the report listed seven limitations. First, both surveys might not be representative of each of the eight countries due to the sampling approaches not being completely random. Second, the HealthStyles sample was not dependent on computer and internet access, which was not the case for the EuroPNStyles sample; this could affect representation in each country. Third, findings could be subject to non-response bias. Fourth, findings might be subject to social desirability bias, due to different laws in each country that could influence use of devices while driving. Fifth, surveys did not ask about cell phone ownership or capabilities, so the "never" response could include people that do not have a cell phone. Sixth, recall bias has to be taken into consideration, because estimates were reported on driving in the past 30 days. Finally, the study was restricted to a certain age population (ages 18-64 years), which does not represent the whole driving population in each of the countries.

COMMENTARY

"This is the story of how my daughter Liz's car accident from texting while driving changed our lives forever. If you get a text, don't look at it while you're driving. It's not worth it," is the caption under the video posted to the National Highway Traffic Safety Administration (NHTSA)YouTube page.[2] The video tells the story of Liz Marks, a young woman in high school whose life was dramatically changed after she was involved in a crash caused by reading a text while driving. The crash left her blind in one eye, hard of hearing, with a diminished sense of smell and no longer able to create tears or fall asleep without medication. Liz shares her story in the video in hopes of reminding people what is at stake when someone texts while driving.

For years, public health experts have been concerned about the effect of cell phone use on motor vehicle crashes. While the specifics have changed over time [What about handheld vs. hands-free? What about texting? What about younger vs. older drivers?] what has not changed is the concern that people focusing on their phone are not focusing on their driving. The recent MMWR article, "Mobile Device Use While Driving – United States and Seven European Countries, 2011"– helps highlight the international nature of these concerns.[1]

Texting and making/taking calls on a cell phone are part of the general category of risky driving behavior referred to as "distracted driving." Recent estimates from the NHTSA from 2011 are that 10% of fatal crashes and 17% of injury crashes were reported as distraction-affected.[3] Of 3,331 people killed that year on public roadways in the U.S. as a result of driver distraction, 385 died in a crash where at least one driver was using a cell phone (12% of all distraction-affected fatal crashes). For drivers 15-19 years old involved in fatal crashes, 21% of the distracted drivers were distracted by the use of cell phones.

The HealthStyles and EuroPNStyles surveys reported by the MMWR demonstrate that anywhere from 20-70% of adults 18-64 years of age used a cell phone at least once in the 30 days prior to the survey. Text messaging use was closer to 15-30% across the eight countries involved. Although there are clearly limitations to these data, such as social desirability bias and recall bias, these rates appear to be reasonable approximations of actual use based on smaller samples subjected to actual observation in other studies.

While there are limited resources for injury prevention efforts, this is a worthwhile topic on which to focus those resources. For every traumatic death, there is a much larger number of injuries. For example, although "only" 3,331 people died in 2011 as a result of distraction-affected crashes, another 387,000 (estimated) were injured.[3] When we start to consider the societal impact of hundreds of thousands of injured people, time lost from work, time and expense required to be evaluated and treated by medical professionals, to repair vehicles, and factors harder to quantify, such as loss of ability to participate in various recreations and family activities, these all add up to a significant problem.

Younger drivers, who are at higher risk for these behaviors, generally underestimate the risk of distracted driving. A 2013 study noted that just under half of surveyed U.S. high school students 16 or older reported texting while driving at least once in the prior 30 days.[4] These students were also more likely to not always wear their seatbelts, ride with a driver who had been drinking, and to drive after drinking alcohol. In fact, the more often a student texted, the more likely he or she would engage in other risky behaviors. The prevalence of driving after drinking alcohol was 3% in the group that did not text even once in the prior 30 days while driving. However, this rate was 34% in the group that texted while driving on every one of the prior 30 days.

We know that younger drivers are overrepresented in fatal crashes. In 2007, while they comprised 9% of the U.S. population and 6% of the licensed drivers, 19% of all crash fatalities in the U.S. were related to young-driver crashes.[5] We know that younger drivers have more difficulty dealing with roadway hazards and perceiving traffic threats.[6] In response, many states

are implementing legislation to restrict the driving privileges of younger drivers through measures such as graduated drivers licenses and special restrictions on cell phone use by novice drivers. As of mid-2015, 38 states and the District of Columbia (DC) banned all cell phone use by novice drivers. 46 states (as well as DC, Puerto Rico, Guam, and the U.S. Virgin Islands) ban texting for all drivers, with another two having a texting ban that applies only to novice drivers. The states that allow teen texting are Arizona and Montana.[7] Graduated drivers licenses restrict carrying passengers and driving at night for the period between learning and full-privilege stage. This is in effect in some form in all 50 states and DC.[8]

Older, more experienced drivers do not necessarily have a better grasp of the true level of impairment that texting and talking on the phone involve. One study published in 2008 showed that the drivers who felt they were least affected by distractions turned out to be the most distracted as measured by velocity control and traffic signal reaction tasks.[9] A later survey of a convenience sample of 1,857 adults showed that 63% of respondents felt they could drive safely while distracted.[10]

How is it that despite years of advocacy, legislation, and exposure to news reports, so many people still do not seem to "get it"? The evidence is overwhelming that distracted driving is dangerous. It leads to decrements in traffic flow and overall safety (especially when texting).[11] Texting negatively affects specific driving tasks such as lane management and velocity control.[12] Handheld cell phones physically restrict head movement and range of gaze, and cell phone conversations have been shown to artificially constrict peripheral awareness as measured by visual fields.[13,14] Despite several states in which legislators apparently feel otherwise, driving while using a hands-free device is not actually safer than using a handheld phone.[15] Simple phone conversations worsened braking time and velocity control similarly to those with a blood alcohol concentration (BAC) of 0.04 in a crossover study of a dozen Australian volunteers. Furthermore, those who texted and engaged in more cognitively demanding conversations were more similar to those with BACs of 0.07 and 0.10.[16] For comparison's sake, even though a BAC of 0.04 is legal throughout the U.S., the risk of fatal motor vehicle injury increases in a steady dose-response relationship. With each and every drink including the first, the odds ratio (OR) for fatal injury is 1.74 for every 0.02 increase in BAC, which is roughly one drink. However, at BAC level of 0.08, the OR was 13.0.[17] Even something as simple as hearing a cell phone's ringtone causes a slower reaction time.[18]

Evidence of these dangers has been widely available for years. As suggested by Atchley et al, the problem may be that social norms have not yet changed to make distracted driving unappealing.[19] As a comparison, it is widely accepted now that drinking and driving is not a good idea. However, despite reports from the turn of the century that alcohol and automobiles did not mix well, it was not until the 1980s with the founding of Mothers Against Drunk Driving, related media, and governmental campaigns that the public started paying attention. From 1980 to 1985, over 700 new drunk-driving laws hit the books across the U.S., and drunk-driving deaths began to significantly decrease.[20] It finally became "uncool" to drink and drive. Similar efforts toward distracted driving will likely be a critical aspect of changing the perceptions of modern drivers. William Haddon, Jr., the first administrator of what became the NHTSA, is famous in injury prevention studies. His matrix consists of personal attributes (human factors), vector attributes (equipment), and environmental attributes (social norms and legislation) examined in pre-, intra-, and post-injury phases.[21] Considering distracted driving in this framework, changing attitudes can be just as important as changing the technology in the car.

The MMWR report on the HealthStyles and EuroPNStyles surveys shows that we have a lot of ground to cover. Fortunately, the evidence is on our side. We should certainly be sharing that evidence – gently – with those we meet in our emergency departments who have arrived after a motor vehicle collision. However, we should also be sharing it with our administrators, our legislators, and our friends and families. Emergency physicians see the devastating effects of distracted driving frequently, and should be a part of the solution rather than just noting the problem. We also need to ensure that we do not simply ignore it when it comes to our own driving behaviors. As difficult as it is, we all need to just hang up and drive.

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Systematic Review of ED-based Intimate Partner Violence Intervention Research

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Introduction: Assessment reactivity may be a factor in the modest results of brief interventions for substance use in the emergency department (ED). The presence of assessment reactivity in studies of interventions for intimate partner violence (IPV) has not been studied. Our objectives were to identify ED IPV intervention studies and evaluate the presence of a consistently positive effect on the control groups.

Methods: We performed a systematic search of electronic databases for English=language intervention studies addressing IPV in the ED published since 1990. Study selection and assessment of methodologic quality were performed by two independent reviewers. Data extraction was performed by one reviewer and then independently checked for completeness and accuracy by a second reviewer.

Results: Of 3,620 unique manuscripts identified by database search, 667 underwent abstract review and 12 underwent full-text review. Only three met full eligibility criteria; data on the control arm were available for two studies. In these two studies, IPV-related outcomes improved for both the experimental and control condition.

Conclusion: The paucity of controlled trials of IPV precluded a robust evaluation for assessment reactivity. This study highlighted a critical gap in ED research on IPV. [West J Emerg Med. 2015;16(7):1037-1042.]

INTRODUCTION

The emergency department (ED) has been identified as an ideal location to screen for conditions with public health significance, including violence, substance use, mental health disorders, and human immunodeficiency virus risk.[1] The ED offers access to a large proportion of the U.S. population,[2] a high prevalence of risky health behaviors,[3,4] and distinctly, a window of higher susceptibility to health messages.[5]

Intimate partner violence (IPV) has been a target of ED interventions for many years, not only because it is the site for injury presentations related to IPV, but also because its prevalence in the ED population is higher than in the general population and in other healthcare settings. However, IPV studies in general, and ED IPV studies in particular, have had a difficult time demonstrating improvement in outcomes after interventions.[6-8] IPV research has been dogged by many known challenges, some inherent to the problem itself, and these have served as explanations for the lack of successful interventions.[9] First, abuse may manifest in many different ways and affect victims differently, making the study population and relevant outcomes heterogeneous. Change may not occur immediately or in a linear fashion[10] requiring longer

time periods for follow up. Maintaining contact with the target population may be difficult given their circumstances, which may involve social isolation and restricted access to others, including healthcare providers. Finally, interventions themselves (e.g., shelters and separation from the home shared with the abuser) may restrict contact for follow-up measures.

Another possibility for lack of positive IPV intervention studies, however, is "assessment reactivity,"[11,12] the tendency of control subjects to change behaviors solely in response to survey instruments, likely due to increased self-awareness of the behavior and its negative consequences.[8] Such changes would minimize observed differences between control and test subjects, potentially obscuring the efficacy of an intervention. This phenomenon has been discussed frequently in ED substance use research. Although EDs have employed screening, brief intervention, and referral to treatment (SBIRT) programs to reduce substance use for over 20 years,[13,14] there have been conflicting data on program effectiveness. One theory for the lack of consistent effect shown by SBIRT is that the true effect size has been blunted by assessment reactivity.[15] Indeed, a number of ED substance use studies have demonstrated marked improvements in control groups.[16-18]

Could assessment reactivity influence outcomes of interventions for IPV? While interventions for IPV do not reach the source of the problem (the perpetrator of abuse), they do aim to change the behavior of the survivor in order to improve health outcomes. Many commonly used instruments for measuring IPV include extensive questions about the consequences of abuse, such as negative effects on health and children. Disclosure of prior trauma in general – though not specifically IPV – has been demonstrated to have mental and physical health effects, even including enhancement of immune function, potentially due to the cathartic nature of the disclosure.[19-23] Investigators have described striking responses to assessments among IPV survivors, including strong emotional reactions to divulging IPV, epiphanies about the nature of their relationships, and determination to seek help from domestic violence agencies and to use safety behaviors in the future.[24,25] Further, there is some evidence that women are more susceptible to assessment reactivity,[26] making its presence even more likely in IPV interventions, which are typically targeted to women.

Understanding the effect of assessment on IPV studies has potential implications for both clinical care and research.[27] In clinical practice, skepticism has dogged IPV screening recommendations; the United States Preventive Services Task Force did not advise routine screening for IPV until 2013,[28] citing a lack of evidence for their health benefits and safety. A known assessment effect might reframe incremental or borderline intervention effects in existing studies, bolstering the argument for screening. For researchers, a known or suspected assessment effect may prompt study design accommodations. For example, the Solomon four-group design, in which participants within control and intervention groups are randomized further into assessed and unassessed arms, acknowledges the potential for assessment to influence outcomes[29] and has been used to evaluate the presence of this effect in a variety of intervention studies involving health behaviors.[30-33]

To date, the phenomenon of assessment reactivity has not been examined in interventions for IPV in the ED. The objectives of this study were to perform a systematic literature review to identify ED-based studies comparing an intervention and control arm and to evaluate studies for consistent evidence of improvement in the control arm, which would substantiate the presence of assessment reactivity.

METHODS

Search Strategy

A medical research librarian worked with the research team to develop a systematic search strategy, including English-language studies published during or after 1990. The search was conducted in 13 databases. The team also reviewed ClinicalTrials.gov and references of all included articles to identify other potentially relevant studies. Search terms included the following: Emergencies, Emergency Service, Emergency Medicine, Accident and Emergency, Casualty; Trauma Ward; Emergency Department; Domestic Violence, Intimate Partner Violence, Partner Abuse, Spouse Abuse, Battering, Battered Women. The searches were completed between June and October 2013. Data extraction and synthesis were conducted from October to December 2013.

Study Selection

We included studies that provided any IPV initiative, whether screening with physician notification or a specific, well-defined intervention, that compared a "control" with a "test" group, and had pre- and post-assessment to determine clinically significant IPV-related outcomes, as defined by investigators. We excluded studies with only acceptability or attitudes as outcome measures.

Data Abstraction and Analysis

Investigators reviewed titles to identify potentially eligible articles and to eliminate duplicates across databases; secondary review was performed on a subset of titles from the full list of titles to verify the quality of the initial screen. During an initial training period, titles were reviewed as a group and any lack of consensus was resolved through discussion. Thereafter, group review occurred periodically throughout the study to maintain fidelity to research criteria.

Two investigators reviewed the abstracts of each article retained after title review. If at least one investigator felt a study was potentially eligible based on abstract review, the full manuscript was retained for review. Two investigators independently read the manuscripts to determine if each study met eligibility criteria. Any discrepancies in opinion were resolved by discussion with the senior investigator.

Using a standardized abstraction form, one investigator

extracted data on study design, study population, definition of IPV, nature of the intervention, assessments, and outcomes. Accuracy of information was confirmed by a second investigator. Two investigators independently computed quality scores for each study using Jadad criteria.[34] The Jadad scale was selected for use given its incorporation of common sources of bias in randomized controlled trials, its established validity and reliability,[35] and its ease of use. Given the small number of studies that met full eligibility criteria, we did not attempt to perform a pooled meta analysis, but examined studies descriptively only.

RESULTS

Of 3,620 unique studies initially identified by the search, title review yielded 667 abstracts for review: 12 met criteria for full text review. Of these 12, six were purely observational, without a studied intervention, one did not have a comparison group and two did not include an ED site, leaving three studies that met full criteria for inclusion in the current study. These studies' characteristics were summarized in the Table.

In Study 1,[36] adult women with IPV were recruited to a randomized trial of an Emergency Department Victim Advocacy (EDVA) protocol. The intervention arm received a session with a victim advocate, which involved empathic support, empowerment counseling, education about the dynamics of abuse, safety assessment, safety planning, linkage with community resources, and support and assistance with follow up. The comparison group received empathic support, safety assessment, and linkage with community resources from a social worker. Outcomes included readiness to end the abusive relationship, use of community resources, safety planning, occurrence of abuse and mental health. All outcome measures in both control and intervention arms demonstrated improvements as a function of time, not treatment condition.

Study 2 recruited adult women patients from the ED, family practice, or obstetrics/gynecology clinic.[27] Shifts or days were randomized to systematic screening for IPV. During screening times, research assistants placed positive questionnaires in the clinical charts. Any discussion or referrals were at the discretion of the treating provider. On control days, participants completed screening after their clinical encounter. Primary outcomes included occurrence of IPV and overall quality of life. Authors reported that the "trajectory of IPV recurrence risk was downward" and quality-of-life scores improved for all participants; the improvement appeared more rapid in the intervention group, but this effect disappeared in the more robust dataset with multiple imputation of missing data.

Study 3[37] recruited African-American women from an adult ED to participate in a randomized trial of an educational intervention for high-risk health problems. Eligible participants took a computerized health screening survey. Those who screened positive for IPV, alcohol or drug abuse or cigarette smoking were randomized to intervention or control groups. The intervention group received brochures tailored to their health issues, reviewed with them in person by a research assistant. The control group received brochures for neighborhood health clinics. Primary outcomes were contact with social support agencies and harm-reduction actions, such as making a smoking cessation plan. Although the study reported that the intervention group was more likely to contact service agencies, results stratified by study assignment were not available.

None of the studies used minimal or no-assessment groups at baseline.

DISCUSSION

In 1985, when Surgeon General C. Everett Koop cast light on the public health significance of domestic violence, the problem moved solidly into the domain of healthcare professionals. EDs provided some of the earliest clinically-based research data on the prevalence, health outcomes and co-occurring disorders of violence against women.[38-40] EDs have also been the site for testing large-scale computer-based screening in the waiting room, demonstrating that disclosure may be easier through a computer-based medium.[41] However, our field has published few clinical trials employing rigorous methods to examine the effect of screening and/or interventions for IPV on health outcomes of women.

Consistent with prior research, the present study used a liberal definition of "intervention" by including screening-only initiatives. We also accepted studies conducted in a variety of settings, as long as EDs were included. Even so, we identified only three controlled clinical trials of IPV initiatives in the ED. Our evaluation of assessment reactivity was limited primarily by this dearth of IPV studies. Additionally, one of the studies included provided no individual outcomes for the control group, so assessment effect could not be examined. Of the two remaining studies, both described outcome improvements in the control condition. One, however, provided an enhanced control condition, so the positive effect on controls was unlikely to be purely from assessments received.

It is important to note the high loss-to-follow-up rates in the included studies, ranging from 49 to 78%. Loss to follow up is a common problem in high-risk populations[42,43] and may bias results, potentially obscuring a positive outcome, e.g., if those in the intervention group are more likely to stay engaged and report ongoing abuse. Therefore, loss to follow up not only limits the conclusions that can be drawn from the described studies, but also serves as an alternate explanation to assessment reactivity for the lack of intervention effect observed in IPV studies.

Our investigation of assessment reactivity in the study of IPV in the ED was neither able to confirm nor refute its presence. As clinical trials of IPV emerge, it will be important to consider the potential impact of such study design factors on the measurement of outcomes. IPV interventions share many similarities to substance-use interventions, including needing to overcome significant reserve and shame around

Table. Randomized controlled trials of emergency department (ED) intimate partner violence (IPV) Interventions.

Study (First author, year)	Target population	Number of enrolled participants (% retained)	Intervention	Control	Primary outcomes for control condition
Study 1 (Hyman, 2001)	Women >18 years old screening positive upon nursing query for IPV in the ED (≥2 positive responses on a Domestic Safety Assessment)	102 (51% completed 3-4 month follow up in person)	Emergency Department Victim Advocacy (EDVA)	Standard Social Service (SSSI)	Readiness: Mean scores for inactive stages of change decreased and those for active stages of change increased for all participants as a function of time, not treatment condition. Community Resources: Mean number of resources used declined in the control group (which had higher resource utilization at baseline) but remained higher than for the intervention group. Safety Behaviors: All participants increased safety behaviors over time, regardless of treatment condition. Abuse: Index of Spouse Abuse (ISA) total score decreased as a function of time, not treatment condition. Mental Health: Global Severity Index (GSI) decreased as a function of time, not treatment condition; Impact of Event Scale (IES) and Structured Clinical Interview for DSM-IV (SCID) scores decreased for all participants.
Study 2 (MacMillan, H, 2009)	Women 18-64 presenting to an ED, family practice, or OB/GYN clinic completing a written self-interview screen	707 (57% screened, 59% nonscreened completed 18 month follow up by in-person assessment and written self-interview)	Systematic IPV screening (using the Women's Abuse Screening Test, WAST); clinician informed of positive screens.	Screening at the discretion of the treating clinician.	IPV Recurrence: Declined over time: 64% at 6 mos; 59% at 12 mos; 53% at 18 mos Quality of Life Scores: Improved over time: 50.6 +/- 17.2 at baseline; 50.5 +/- 17.9 at 6 mos; 52.5 +/- 18.0 at 12 mos; 52.7 +/- 17.9 at 18 mos
Study 3 (Houry, D, 2011)	African-American women 21-55 presenting to an ED who completed a computerized health screening survey	322 (22% completed 3 month follow up with computer screening and in-person assessment)	Brochures tailored to relevant health issues provided to patients and reviewed with them by research assistants.	Brochure with information about clinics in the area.	Not available.

disclosure and the opportunity to capitalize upon the ED "teachable moment"[3,44] to stimulate action around high-risk health issues. However, these factors also increase the possibility that simply divulging the problem can lead to change – a wonderful thing for those prioritizing brief, scaled-down interventions in this setting but critical to the understanding and interpretation of research results.

Our study is limited by its narrow inclusion of ED studies only. While this decision was made to target the setting where assessment reactivity seemed most likely to be influential, and in order to inform ED-based investigators developing future IPV interventions, it did limit the number of studies available for analysis. Future systematic reviews may include IPV interventions in other healthcare settings, including primary care and obstetrics and gynecology clinics.

Although we were not, ultimately, able to study assessment reactivity, our efforts did highlight a critical gap in emergency medicine literature. IPV intervention studies are needed, and they should meet the standards of other clinical trials, going beyond observational or quasi-experimental designs. Our study underscores that there is very little known about the effect of simply asking questions about IPV in the

ED, let alone about the effect of well-developed, standardized brief interventions and referrals to treatment. It is important for those arguing for or against IPV screening to remember that the absence of evidence is not evidence of absence.

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Screening for Fall Risks in the Emergency Department: A Novel Nursing-Driven Program

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Introduction: Seniors represent the fasting growing population in the U.S., accounting for 20.3 million visits to emergency departments (EDs) annually. The ED visit can provide an opportunity for identifying seniors at high risk of falls. We sought to incorporate the Timed Up & Go Test (TUGT), a commonly used falls screening tool, into the ED encounter to identify seniors at high fall risk and prompt interventions through a geriatric nurse liaison (GNL) model.

Methods: Patients aged 65 and older presenting to an urban ED were evaluated by a team of ED nurses trained in care coordination and geriatric assessment skills. They performed fall risk screening with the TUGT. Patients with abnormal TUGT results could then be referred to physical therapy (PT), social work or home health as determined by the GNL.

Results: Gait assessment with the TUGT was performed on 443 elderly patients between 4/1/13 and 5/31/14. A prior fall was reported in 37% of patients in the previous six months. Of those screened with the TUGT, 368 patients experienced a positive result. Interventions for positive results included ED-based PT (n=63, 17.1%), outpatient PT referrals (n=56, 12.2%) and social work consultation (n=162, 44%).

Conclusion: The ED visit may provide an opportunity for older adults to be screened for fall risk. Our results show ED nurses can conduct the TUGT, a validated and time efficient screen, and place appropriate referrals based on assessment results. Identifying and intervening on high fall risk patients who visit the ED has the potential to improve the trajectory of functional decline in our elderly population. [West J Emerg Med. 2015;16(7):1043-1046.]

INTRODUCTION

Seniors over the age of 65 years represent the fastest growing population in the U.S., accounting for 20.3 million visits to emergency departments (EDs) annually.[1] Over two million (10%) of these visits are preceded by a nonfatal fall,[2] highlighting the mounting problem of impaired mobility among this population. Approximately one third of individuals over the age of 65 will fall at least once yearly, leading to fractures, surgery, inpatient admissions, prolonged rehabilitation and death.[3]

The ED visit may be a sentinel event to prevent such falls and change the trajectory of older adults' functional decline. Identifying a senior at high risk of falls can lead to targeted therapies through pharmacy, social work, home health, and physical therapy (PT) referrals. In preparing for discharge from the ED or hospital, these teams can promote

individualized and multi-component exercise programs, the most effective strategy in reducing falls among community-dwelling elderly.[4] Despite a recommendation for ED fall risk screening by national emergency medicine societies, there are very few validated screening protocols specific to the ED.[5] A multidisciplinary approach including detailed medical and occupation therapy evaluations for those presenting to the ED after a fall has previously been described with effective results.[6] Less is known about such assessments for those seen in the ED who have not immediately fallen but are at high risk for falls, and for those receiving PT evaluations in the ED.

One tool used to identify risk of falling is the Timed Up and Go Test (TUGT). This validated assessment of gait and balance is quick, freely available, and requires minimal training and supplies (e.g. chair and timer).[7] To perform the TUGT, the patient's ability to rise from a seated position, walk three meters, turn, walk back and sit down is observed and timed. The TUGT is designed to predict occurrence of falls, as individuals 65 years and older with a TUGT of 12.4 seconds or greater are three times more likely to fall in the next year.[8,9] The purpose of this study is to describe the use of TUGT assessments performed by geriatric nurses in the ED and nurse initiated interventions for positive TUGTs.

METHODS

Setting

This study was conducted as part of the Geriatric ED Innovations through Workforce, Informatics, and Structural Enhancements (GEDI WISE) program. GEDI WISE is three-site initiative funded by the Centers for Medicare and Medicaid Services to improve the care of older patients in the ED. The study site was the ED of an urban, academic, Level 1 trauma center with 56 beds. The study site has an annual volume over 80,000 patients and an annual geriatric volume of over 16,000 patients, with an overall admission rate of 32% (inpatient and observation) and a baseline geriatric admission rate of 60% (inpatient and observation) prior to the implementation of GEDI WISE. Prospective data was collected on adults ≥65 years who had a geriatric nurse liaison (GNL) assessment between April 1, 2013 and May, 31, 2014.

GNL Assessments

As training for this initiative, GNLs participated in a multidisciplinary curriculum developed by emergency medicine and geriatric educational experts. In the ED, GNLs perform assessments of cognition, delirium, functional status, caregiver strain and gait for geriatric patients presenting to the ED through a previously described protocol.[10] TUGT was performed on patients at the discretion of GNLs and emergency physicians. GNLs were encouraged to assess patients with a recent fall, concern for gait, balance or strength impairment, or need for a mobility device. Those with unstable vital signs, pending or abnormal head imaging, acute fractures, or altered mental status did not receive a TUGT evaluation. Through a collaborative discussion with the GNL and the patient's clinical team (nurse, resident, or attending) a joint decision was made as to which fall risk intervention was most appropriate and should be pursued while the patient resided in the ED. Abnormal TUGT was defined as greater than 12 seconds, indicating high fall risk as previously described in the literature.[8,9]

Data Analysis

Approval for this project was granted by the institutional review board. Demographic data, mean TUGT and GNL-initiated therapeutic interventions performed during the ED visit were abstracted by review of the electronic medical record and Enterprise Data Warehouse. An abnormal TUGT or any concerns for gait or balance by direct observation could result in a therapeutic intervention. Interventions were categorized into PT, social work, Department on Aging referrals, and discussions with primary care physicians, family or caregivers. PT interventions included PT consults in the ED, PT consults during an anticipated observation or inpatient stay, home PT orders through home health, or outpatient PT orders.

RESULTS

During the study period, 19,511 geriatric patients were treated in the ED, and 1,135 (5.8%) were evaluated by a GNL. Of patients evaluated by a GNL, TUGT was performed on 443 (39.0%) patients. The average age of patients undergoing TUGT was 79.8 years, with 37% reporting a fall in the preceding12 months. Among those undergoing the TUGT, the documented chief complaint included "fall" or "fell" for 70 (15.8%) patients. Three hundred thirteen (70.7%) of patients evaluated with the TUGT were discharged from the ED, 65 (14.5%) were admitted as inpatients and 65 (14.5%) were admitted under observation status. High independence as measured by Katz Activity of Daily Living was seen in 56% (n=249). No cognitive impairment was found in 82% (n=363), and 7% (n=31) had moderate to severe cognitive deficits as measured by the Short Portable Mental Status Questionnaire (Table 1).

We saw positive TUGT scores in 368 of the 443 (83%) patients undergoing gait evaluation (i.e. required longer than 12 seconds to complete the three meter walk). Seventeen percent (n=75) had normal TUGT scores, 27% (n=120) required between 12.1 and 19 seconds, 36% (n=158) required between 20 and 32.6 seconds, and 20% (n=90) took longer than 32.6 seconds to complete the test. Assistive mobility devices were used at baseline in 201 of the 368 (55%) patients with positive TUGT scores.

PT consults were performed in the ED for 17.1% of patients with positive TUGT scores. For patients directly discharged home from the ED 12.2% were provided with a script for outpatient PT. Social work consults were completed in the ED for 44% of cases, and primary care providers were contacted by the GEDI team to notify them of a patient's ED evaluation or concern for gait instability in 7% of cases. For

Table 1. Participant characteristics (n=443).

Characteristic	n	%
Age, y (SD)	79.8	(±7.9)
Female	277	(62.5)
Race		
White	237	(53.5)
Black	157	(35.4)
Hispanic	30	(6.8)
Asian	13	(2.9)
Other or unknown	6	(1.4)
Cognition (SPMSQ)		
Normal	363	(82.0)
Mild impairment	46	(10.4)
Moderate or severe impairment	31	(7.0)
Could not assess	3	(0.7)
Functional status (Katz ADLs)		
Low independence	5	(1.1)
Moderate independence	137	(30.9)
High independence	249	(56.2)
Could not assess	52	(11.7)
Fall in last 12 months	165	(37.2)

SD, standard deviation; *SPMSQ,* short portable mental status questionnaire; *ADLs,* activities of daily living

Table 2. Emergency department (ED) interventions for positive timed up and go test (n=368).

Intervention	n	%
PT order in ED	63	(17.1)
Outpatient PT referral, ordered from ED	56	(12.2)
Home PT referral, ordered from ED	30	(8.2)
Social work referral in ED	162	(44)
Discussed with family or caregiver	75	(20.4)
Discussed with PCP	27	(7.3)
Department of aging referral	40	(10.9)
Discharged home from ED	274	(74.5)
Admitted to inpatient status	44	(12.0)
Placed in observation status	50	(13.6)

PT, physical therapy; *PCP,* primary care provider

those with positive TUGT scores, 74% were discharged home (n=274) and the remainder were admitted under inpatient or observation status (Table 2).

DISCUSSION

The rising number of elderly patients in the ED presents opportunities to identify those at high risk of falls, refer for a more in-depth mobility assessment with PT, and initiate mobility care plans. In this study describing the implementation of a falls-identification program in the ED, the TUGT test was successfully incorporated into the routine care of geriatric patients presenting for acute care evaluation. Though this study was performed with the support of a CMS award, a low-cost protocol is feasible. The TUGT is a formalized way of measuring how fast a patient walks. This test can be performed by a bedside nurse, or patient care technician, and does not necessarily require a dedicated GNL. The key to the protocol is having a plan for prolonged TUGT scores. For patients who are felt to be safe for discharge, outpatient PT is a reasonable option (often in conjunction with the patient's primary care physician). For patients who are to be admitted, inpatient PT would be appropriate. Similar screenings performed in EDs by patient care technicians for cognitive impairment, fall risk and functional decline have previously been incorporated into the work flow of a Level I trauma center ED where fewer than 25% of physicians routinely screened for geriatric syndromes.[11] The use of such personnel adds valuable information and provides insight into a patient's current functional status to stratify them into fall risk categories. Appropriate referrals to PT, both in the hospital and upon discharge, and discussion with social work, primary care providers and caregivers can be initiated.

Over 70% of our population was discharged home from the ED, many with slow TUGT scores, who would benefit from PT in this immediate sub-acute setting. Only 17% of patients with positive TUGT scores received a PT consult in the ED, and 20% received either an order for home or outpatient PT. PT consults in the ED were deferred to inpatient therapists if a patient was certain to require admission. Home or outpatient PT orders were not ordered if a patient was at their baseline functional status, they were undergoing therapy prior to presentation, or acuity of addressing other medical concerns took precedence. Further research is needed to determine if 12 seconds is an appropriate cutoff for ED patients, if any TUGT cutoff represents a requirement for safe discharge home, and if PT consultation provides a benefit to patients with prolonged TUGT scores. Additionally, optimal communication about fall risk needs across transitions of care should be developed.

LIMITATIONS

This is the first study showing that a protocoled method of identifying fall risk in elderly patients is possible for those presenting to the ED for acute care needs other than a recent fall. Several limitations deserve mention. This was a single-site study and was incorporated into a geriatric-specific protocol supported by specialized registered nurse (RN) staff already in place. All RNs performing the TUGT were initially trained as emergency medicine nurses and continued to have weekly ED shifts working in a traditional RN capacity. The TUGT is designed to be a simple test that

all health personnel can perform. EDs initiating similar screening programs may need to invest more energy in ensuring appropriate interventions for positive TUGT scores than the actual training of TUGT administrators.

We recognize that the TUGT is one screen in addition to many already being emphasized in the ED; however, targeting appropriate older patients may minimize the workload and is timely in light of geriatric-specific EDs evolving across the U.S. While a small percentage of the potentially eligible geriatric patients were screened with the TUGT, we believe the sample of patients who were assessed by GNLs represents a high-risk population, as identified by GEDI WISE protocol, or clinician consult; 15.8% of screened patients presented to the ED after a fall, and this may have increased the perceived benefit of the TUGT screen compared to a more widespread screening protocol. However we believe this high rate of previous fall in the screened population demonstrates appropriate targeting of screening to a population at high risk for repeat falls. Without intervention more that 20% will present to the ED within 12 months with another fall-related diagnosis.[12] Finally, previously defined TUGT cutoffs for outpatients may not be the most appropriate cutoffs for older adults in the ED who are presenting with acute medical conditions that may affect their gait.

CONCLUSION

In a healthcare system with rising numbers of geriatric patients seeking care in the ED, using available tools to identify patients at risk for debilitating, even fatal, falls before they occur is important for patient safety and functional independence. When at-risk patients are identified, interventions can be implemented to prevent future falls. With resources available in the ED such as nurses, social workers, physical therapists, and patient care technicians, the ED can serve as a key source of identifying seniors at risk of falls. Fall-risk identification with simple, validated tests, such as the TUGT and ED-based interventions, are important to change the trajectory of functional decline in our elderly population.

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Impact of Health Information Exchange on Emergency Medicine Clinical Decision Making

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Introduction: The objective of the study was to understand the immediate utility of health information exchange (HIE) on emergency department (ED) providers by interviewing them shortly after the information was retrieved. Prior studies of physician perceptions regarding HIE have only been performed outside of the care environment.

Methods: Trained research assistants interviewed resident physicians, physician assistants and attending physicians using a semi-structured questionnaire within two hours of making a HIE request. The responses were recorded, then transcribed for qualitative analysis. The transcribed interviews were analyzed for emerging qualitative themes.

Results: We analyzed 40 interviews obtained from 29 providers. Primary qualitative themes discovered included the following: drivers for requests for outside information; the importance of unexpected information; historical lab values as reference points; providing context when determining whether to admit or discharge a patient; the importance of information in refining disposition; improved confidence of provider; and changes in decisions for diagnostic imaging.

Conclusion: ED providers are driven to use HIE when they're missing a known piece of information. This study finds two additional impacts not previously reported. First, providers sometimes find additional unanticipated useful information, supporting a workflow that lowers the threshold to request external information. Second, providers sometimes report utility when no changes to their existing plan are made as their confidence is increased based on external records. Our findings are concordant with previous studies in finding exchanged information is useful to provide context for interpreting lab results, making admission decisions, and prevents repeat diagnostic imaging. [West J Emerg Med. 2015;16(7):1047-1051.]

INTRODUCTION

Background

The use of electronic health information exchange (HIE) offers the hope of increased provider efficiency, decreased diagnostics utilization and decreased administrative costs.[1-3] The emergency department (ED) is a primary target for improvement, where providers make decisions on high volumes of unfamiliar patients in the absence of prior information.[4-6]

Studies and provider perception indicate cost savings can occur when HIE is used,[1-3,7-12] such as in the decreased use of diagnostic imaging.[13-15] Previous qualitative studies were conducted with the provider during non-clinical time,[16-19]

with two others adding clinical workflow observation to their interview methodology.[16-20]

Importance

Determining how ED providers integrate HIE information can be logically expected to increase the value and decrease barriers to use, resulting in routine adoption to maximize the benefits for our care system overall.

Goals of this Investigation

This mixed-method pursued the nuanced utility of HIE technology on providers' clinical decisions by collecting the specific reasons for making an information request and the specific utility of the information retrieved during an individual patient encounter.

METHODS

Study Design

This prospective observational mixed-methods study used a brief semi-structured provider interview performed by a research assistant. This was completed within two hours of electronically requesting external records via HIE technology. The recorded interviews were transcribed for subsequent analysis. The institutional review board approved the study protocol.

Study Setting

This study was performed in a single urban tertiary care hospital staffed with board-certified emergency medicine physicians, residents and physician assistants in a Midwestern state between June and August of 2013. The institution has used an integrated electronic health record (EHR) in use since 2006 (Epic Systems Corporation, Verona, WI). The vendor-supplied HIE technology has been in use since 2011 (Epic CareEverywhere). All providers are trained and experienced at viewing records through this HIE system and no additional login steps are required. At the time of the study, the hospital could request and receive records from over 70% of the regional acute care hospitals and 50% of the ambulatory clinics. This high regional density results in a high proportion of requests, resulting in detailed data.

Study Participants

Interviews were conducted with the primary emergency medicine provider for an ED patient encounter, often a resident or physician assistant. Medical students and the principal investigator were not interviewed.

Enrollments resulted from a convenience sample of patient encounters during hours of research assistant coverage (1200 to 2300 daily). The ED clerk notified the research assistant of a new request for external records to generate candidates.

The study goals and methods were announced via meetings and email. Providers were excluded if they chose to opt out of the entire study at any point, or could decline an individual interview for any reason, without opting out of future enrollments. Interviews were limited to a maximum of two encounters per provider to limit bias.

Methods of Measurement

The interview was conducted using a digital recorder and computer using an interview script embedded within a secure web-based data capture system. Categorical questions were captured as discrete responses and all other interview content was transcribed for subsequent qualitative analysis. The interview contained a total of seven questions, four of which had open-ended qualitative components. The investigators planned an interim analysis after 40 interviews had been performed and coded, based on prior experience. If that analysis determined that thematic saturation were reached, no additional enrollments would be performed.

Primary Data Analysis

The type of clinical information providers sought and obtained were categorized from the interview transcripts. We used a content analysis approach to identify emerging themes and constructs from interview transcripts. Content analysis is an iterative process that uses a constant comparative method.[21]

RESULTS

During the two-month study period, we obtained 40 interviews from 29 providers. Of the 29 providers, seven were attendings, 11 were residents and 11 were physician assistants. No providers prospectively opted out from the study or declined an interview request.

Of the 40 encounters studied, 93% (37) resulted in successful retrieval of electronic records from an outside institution. In the three failed requests providers did not fall back to requesting records via fax machine, which is the only other option to retrieve external records on patients where the CareEverywhere connection was not successful.

Of the 37 successful cases, providers reported a change in clinical decision-making in 32% (12) of the encounters and no change in 66% (25) of the encounters. In three of the patients where no change was made, providers reported increased confidence in their existing management plan after obtaining additional information. Ninety-two percent (34) of cases had a specific information need in mind when making a request, but in 38% (14) pf cases, unanticipated useful information was retrieved.

Qualitative Themes

Corresponding example quotes for each theme are presented in the Table.

Specific Information Needs are Driving Requests for Outside Information

Providers initiated requests when specific information

Table. Representative interview quotes of emergency physicians participating in study on health information exchange.

Themes identified	Representative interview quote
Specific information needs driving requests for outside information	I wanted her most recent echocardiogram report from her most recent cardiology visit and her most recent ED visit, if any, and I found the first two, and it doesn't look like she had any recent ED visit.
	We had a woman who had problems with chronic abdominal pain and she wasn't sure of what her actual diagnosis was and what workup had been done. But she was able to say she had been admitted … What I had wanted to get was just the discharge summary talking about what the diagnosis and what her previous workup was.
	Um, well specifically I was looking for medications [and] diagnoses, because I guess if he was on Coumadin I would have … umm, I don't know if I would've changed [my plan].
The importance of unexpected information	[We found] that his Depakote was not specifically for seizures but for other psychiatric concerns ... [it] would've otherwise … led us down more of a seizure pathway, as compared to ruling out a prior history of seizures.
	He was seen for a similar complaint two days prior.
	Yeah, he had frequent visits to the ED requesting uh, admission for both medical and behavioral health reasons. Um, with, uh, they felt a secondary gain, um, as motivation.
Prior lab results serve as important reference points	We did [make changes] because we found out that he had a baseline hemoglobin of like 7 to 8, so we held off on doing a transfusion.
	[We requested information on] baseline labs to see if there were any changes.
The importance of information in disposition decisions	[We] reviewed prior lab testing including a BMP, specifically looking at the patient's sodium level ... [The patient] will now be admitted under observation compared to being discharged home, after reviewing these tests.
Increased confidence in decision making	I think that just by knowing what her official diagnosis was and that the appropriate workup had been done, it was that reassurance that I didn't do extra imaging … I am not sure that I would have done the imaging anyway, but it was reassuring and helpful.
	No, but it gave me some good background information and baseline labs and her appropriate medications that she is going to be on.
Changes in decisions for diagnostic Imaging	Because labs and imaging were done less than twenty-four hours ago at a different hospital, I did not do any additional testing that I would have done had we not been able to access the records.
	The patient is here and is about 5 weeks pregnant, and the question was whether or not she already had an ultrasound done elsewhere and actually she's done them at three other hospitals and had ultrasounds done at all of those hospitals so I will not be doing an ultrasound here today.

ED, emergency department; *BMP,* basic metabolic panel

needs existed, most often prior test results and visit notes. In some cases, providers were searching for a broader target, such as lists of prior diagnoses or medications.

The Importance of Unexpected Information

Providers reported finding helpful unexpected information. Often they learned of recent visits for similar concerns at other healthcare settings.

Increased Confidence in Decision Making

Some providers noted that they didn't make a change to their management plan, but found the external information increased their confidence in their existing management plan.

The Importance of Information in Disposition Decisions

Providers reported external information provided better context for making a disposition decision.

Prior Lab Results Serve as Important Reference Points

Prior lab results were also identified as important information needs, particularly to assist interpretation of lab results obtained during the current encounter.

Changes in Decisions for Diagnostic Imaging

When prior imaging results were available, providers often changed their plan to prevent repeat diagnostic imaging studies.

DISCUSSION

This small-sample, mixed-methods survey is primarily hypothesis generating, and our discussion is focused on the nuances not found in previously reported work on HIE.

Providers in our study were driven to request records

only when they had a specific need, an expected finding. Often the need was very specific, such as a specific test result. Less frequently, the need was general, such as a diagnosis or medication list. Unertl et al. similarly identified that providers commonly use HIE when prompted by learning of a recent encounter at another hospital.[20]

However, in one third of encounters, providers found useful unexpected information. Therefore, a measurable amount of helpful data exists but providers don't know to ask for it. Automated requests to the HIE are routine aspects of some systems.[2] Technology, policy and workflow changes designed to routinely trigger HIE requests may further enhance the known HIE utility and benefits.

A small number of providers who reported no change to their plan as a result of HIE information reported increased confidence based on the information, a finding not reported in previous studies. Further study would be needed to determine the impact of this increased confidence on provider and patient satisfaction and other outcomes.

Providers identified the importance of historical lab values as a key aspect of HIE. This finding may have implications for user interface design. As our health record system does not integrate external and internal results into the same view, future system design changes may find reduced barriers to HIE data use through safely co-mingling external data with internal data to providers with a more streamlined method of placing external data into the proper context.

When deciding whether to admit or discharge at the conclusion of an ED visit, providers report that HIE was valuable in providing context for a specific patient. This is concordant with other studies identifying potential reductions in admissions if HIE is used.[7,8] It has been stated that deciding to admit someone to the hospital "may be the most expensive, regular discretionary decision in U.S. healthcare."[22] Providing improved awareness of a patient's history may help target the use of expensive hospital beds to those who appropriately need these resources. It may be helpful to routinely collect external information on patients for whom the decision to admit or discharge is not a clear-cut one.

Further study is warranted to identify characteristics of patients that indicate an unknown information gap exists. For example, patients who report taking medications that aren't on file locally may be likely to have detailed care information elsewhere. Even small markers of external information may help provide important context to a provider who is trying to create the best plan of care. Until an ED has eliminated all workflow barriers to routine HIE in all patients, our study seems to indicate providers will only jump through the hoops of HIE when they know there is something out there they need. Realistically, many organizations are not even close to routine and seamless HIE, so further study may help define which patients have a better outcome for their presenting problem when the provider has all the context needed for that patient's care.

LIMITATIONS

Only one quarter of providers interviewed were attending physicians and represents only one hospital's ED experience, both of which may limit the generalizability of our findings. The convenience sample under-represents the experiences of providers who do not make HIE requests and excludes late night and early morning hours when there are fewer options of obtaining health information. Clinical decisions later in a patient encounter but after the provider interview may under-represent the impact of HIE.

CONCLUSION

We found that providers report that information collected via electronic exchange was the direct cause of a change in clinical decision making one third of the time. Providers usually have a key piece of information in mind when requesting external records, but often find unanticipated information that they report as useful. Some instances of HIE use did not directly change decisions but the data were considered useful as it increased provider confidence in their plan. Themes emerged that may help guide workflow and software development in the domain of HIE.

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Direct Versus Video Laryngoscopy for Intubating Adult Patients with Gastrointestinal Bleeding

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Introduction: Video laryngoscopy (VL) has been advocated for several aspects of emergency airway management; however, there are still concerns over its use in select patient populations such as those with large volume hematemesis secondary to gastrointestinal (GI) bleeds. Given the relatively infrequent nature of this disease process, we sought to compare intubation outcomes between VL and traditional direct laryngoscopy (DL) in patients intubated with GI bleeding, using the third iteration of the National Emergency Airway Registry (NEARIII).

Methods: We performed a retrospective analysis of a prospectively collected national database (NEARIII) of intubations performed in United States emergency departments (EDs) from July 1, 2002, through December 31, 2012. All cases where the indication for intubation was "GI bleed" were analyzed. We included patient, provider and intubation characteristics. We compared data between intubation attempts initiated as DL and VL using parametric and non-parametric tests when appropriate.

Results: We identified 325 intubations, 295 DL and 30 VL. DL and VL cases were similar in terms of age, sex, weight, difficult airway predictors, operator specialty (emergency medicine, anesthesia or other) and level of operator training (post-graduate year 1, 2, etc). Proportion of successful first attempts (DL 261/295 (88.5%) vs. VL 28/30 (93.3%) p=0.58) and Cormack-Lehane grade views (p=0.89) were similar between devices. The need for device change was similar between DL [2/295 (0.7%) and VL 1/30 (3.3%); p=0.15].

Conclusion: In this national registry of intubations performed in the ED for patients with GI bleeds, both DL and VL had similar rates of success, glottic views and need to change devices. [West J Emerg Med. 2015;16(7):1052-1056.]

INTRODUCTION

Endotracheal intubation (ETI) is an essential skill in the resuscitation of critically ill patients. ETI ensures oxygenation and ventilation to patients in respiratory distress and helps to protect the airway from gastric contents during regurgitation which may occur during conditions such as gastrointestinal (GI) bleeding. Traditionally, ETI has been performed using direct laryngoscopy (DL) whereby the structures of the airway are directly visualized by the provider, although other techniques have rapidly been adopted by emergency physicians.[1] Emergency airway management is complicated by many factors including the critically ill nature of the patient population and limited time to prepare for airway maneuvers.[2] As a result, emergent ETI is associated with increased risk of bradycardia, hypoxia and death.[3-5]

Video laryngoscopes (VL) have been developed to help reduce the risk of these complications. VL has been shown to improve ETI success rates and improve the laryngoscopic view.[6,7] VL also improves ETI success across providers.[8,9] Despite these benefits, concerns still

arise over the utility of VL in select populations where the camera capturing the image may become obscured by blood or vomitus.[10] One of these select populations are those patients with upper GI bleeding. Patients with GI bleeding may require ETI for airway protection; however, few data have examined the ideal airway management strategy in this population. We sought to compare intubation outcomes between patients with GI bleeds managed with VL and those managed with DL.

METHODS

Study Design

We performed a retrospective analysis of data from a multicenter registry of emergency department (ED) intubations. Each center used in the registry had approval by its institutional review board.

Setting

NEAR is a collaboration of one community and 12 academic hospitals. Each center had a site investigator who was responsible for ensuring compliance, defined as data entry on >90% of ED intubations, confirmed by comparison of registered patients with computer-generated coding reports for intubation procedures. Contributing center characteristics have been published previously.[11]

Intubation details were recorded onto a standardized intubation form by the intubator, accessed at www.near.edu, using a center-specific login and password. Data were entered using a custom-designed web-based data entry tool and imported directly into a relational database (Microsoft Access®, Microsoft Corporation, Redmond, WA) at the coordinating center (Department of Emergency Medicine, Brigham and Women's Hospital, Boston, MA). Full details regarding site on-boarding and compliance reporting for NEAR have been previously described.[11] We collected data on intubations from July 1, 2002, through December 12, 2012.

Outcomes and Covariates

Variables captured in the database include demographic patient information, indication for intubation, intubation methods, devices used, number of attempts, intubation success or failure, operator characteristics, intubation events and patient disposition. We used operational definitions regarding attempts, methods and adverse events that have been published previously.[11] An "attempt" was any single effort to place a tracheal tube, which was defined by the leading edge of the laryngoscope blade passing the alveolar ridge. We defined a "method" as any single approach to securing the airway, using specific technique and drugs, such as orotracheal rapid sequence intubation. We report information regarding intubating conditions, intubator discipline and experience, methods, devices used to intubate, and intubation success, stratified by device.

Selection of Patients

All adult ED patients entered into the database from July 1, 2002 through December 31, 2012, with an attempt at intubation and a medical indication of 'GI bleed' were eligible for analysis. Pediatric patients (age<15) were excluded.

Method of Measurement

We included patient, provider and intubation characteristics. Data were compared between intubation attempts initiated as DL and VL using parametric and non-parametric tests when appropriate. We also evaluated the univariate odds ratios for successful first attempt success for patient, providers and intubation characteristic, including type of laryngoscope (DL or VL). P-values<0.05 were considered to be significant. We completed all analysis using Stata v.12 (Stata Corp, College Station, TX).

RESULTS

Of the 17,583 adult patients in the NEARIII registry, we identified 325 intubations with the indication listed as "GI bleed." Of these, 295 had their initial intubation attempted with DL and 30 with VL. DL and VL cases were similar in terms of age, sex, weight, difficult airway predictors, operator specialty (emergency medicine, anesthesia or other) and level of operator training (post-graduate year 1, 2, etc) (Table 1).

First-attempt success was similar between DL and VL (261/295 (88.5%) vs 28/30 (93.3%), p=0.58). Cormack-Lehane views are also similar between the two groups (p=0.78). The need for device change did not differ between DL and VL (2/295 (0.7%) vs 1/30 (3.3%), p=0.15) (Table 2). No matter the initial method, all GI bleed patients identified in the registry were successfully intubated without the need for a supraglottic device or surgical airway.

Type of laryngoscope (DL vs. VL), patient age, height, and weight were not associated with first-attempt success in the univariate analysis (Table 3). Method of intubation (no sedation, sedation only or rapid sequence intubation) did not affect first-attempt success. While increasing number of difficult airway characteristics (DAC) overall did decrease the odds of first-attempt success (OR 0.66 95% CI [0.47-0.94], p=0.02), there was no specific DAC (e.g. neck mobility, Mallampati, or intra-incisor distance) associated with first-attempt success.

DISCUSSION

We identified 325 intubations in GI bleed patients with 295 where intubation was attempted initially with DL and 30 VL with no difference in intubation outcomes (first-attempt success, glottic view or need to switch device). There were more DL then VL cases. This likely reflects the integration of VL over time within the registry. VL use was rare during the first several years and became more common only near the end of the registry. In the first three years (2002-2004) VL was

Table 1. Patient and operator demographics in a study comparing direct laryngoscopy and video laryngoscopy performed in emergency departments.

Characteristic	Total % (n=325)	DL % (n=295)	VL % (n=30)	P-value
Mean age (SD), years	57.8 (14.9)	57.6 (15.1)	59.9 (13.6)	0.43
Gender, % male (n)	69.2 (225)	69.2 (204)	70 (21)	0.92
Median weight (IQR), kilograms	70 (70-80)	70 (70-80)	70 (65-80)	0.58
DACs				
Median total DACs (IQR)	1 (0-2)	1 (0-2)	1 (0, 2)	0.67
None	28.9 (94)	29.2 (86)	26.7 (8)	0.78
Limited neck mobility (n=315)	5.7 (18)	6.3 (18)	0 (0)	0.16
Limited Mallampati[#] (n=304)	62.2 (189)	61 (169)	74.1 (20)	0.18
Intra-incisor distance <3 fingers (n=309)	36.3 (112)	36.3 (102)	35.7 (10)	0.95
Thyromental distance <2 fingers	0	0	0	
Obstruction (n=315)	6.4 (20)	7 (20)	0 (0)	0.13
Facial trauma (n=314)	3.8 (12)	4.2 (12)	0 (0)	0.25
Method of intubation				0.34
OTI	4.9 (16)	5.4 (16)	0 (0)	
Sedation only	1.2 (4)	1.4 (4)	0 (0)	
RSI	93.9 (305)	93.2 (275)	100 (30)	
Operator specialty				0.77
Emergency medicine	96.9 (315)	97 (286)	96.7 (29)	
Anesthesia	0.9 (3)	1 (3)	0 (0)	
Other	2.2 (7)	2 (6)	3.3 (1)	
Operator PGY level				0.83
1	10.2 (33)	9.8 (29)	13.3 (4)	
2	34.8 (113)	35.3 (104)	30 (9)	
3	34.8 (113)	34.2 (101)	40 (12)	
4	5.2 (17)	5.1 (15)	6.7 (2)	
Attending	15.1 (49)	15.6 (46)	10 (3)	

DL, direct laryngoscopy; *VL,* video laryngoscopy; *SD,* standard deviation; *DAC,* difficult airway characteristics; *IQR,* interquartile range; *OTI,* oral intubation without sedation; *RSI,* rapid sequence intubation; *PGY,* post-graduate year
[#]Mallampati>1.

chosen as the first device in less than 1% of all intubations yet was used in nearly a third of intubations during the last three years of data collection (2010-2012).[1] It is also possible that DL was preferentially chosen over VL because of the perceived challenges of obtaining a clear image with brisk bleeding.

NEAR includes both community and academic centers. As a result, there are operators of various experience captured within the registry. While the experience of the operators was similar between the VL and DL groups, second-year residents had a lower odds of first-attempt success compared to attendings. The exact reason is likely multifactorial. Previous work has shown that there is a learning curve associated with VL in emergency airway management;[12] however, this did not occur with first-year residents. First-year residents may be more closely supervised then second-year residents; however, further investigation will be needed to evaluate these differences. Our data confirm previous work showing that overall, trainees perform intubations with a high rate of success.[13]

GI bleeding is a common reason for admission to the hospital with 250,000 to 300,000 admissions in the United States every year and peptic ulcer disease being the most common cause of upper GI bleeds.[14,15] How frequently patients with GI bleed require airway management for airway protection is unknown. In our study using 10 years of multicenter data we identified only 325 intubations. This is a relatively small number given that roughly 30,000 patients die annually in the U.S. as a result of complications from GI bleeds.[15] While patients with GI bleeds may require airway management in several areas of the hospital (intensive care units, EDs, etc.), we focused our efforts on those that required management in the ED. Given the infrequent nature of ED

Table 2. Number of attempts, and Cormack-Lehane grade view by device. All intubations were ultimately successful and none required supraglottic or surgical airways.

Variable	DL %, (n=295)	VL %, (n=30)	p-value
Number of attempts			
1	88.5 (261)	93.3 (28)	0.58
2	8.8 (26)	3.3 (1)	
>2	2.7 (8)	3.3 (1)	
Median number of attempts (IQR)	1 (1-1)	1 (1-1)	0.78
Grade of view			
I	63.6 (185)	65.5 (19)	0.89
II	29.9 (87)	27.6 (8)	
III	5.2 (15)	6.9 (2)	
IV	1.4 (4)	0 (0)	
Device change	0.7 (2)	3.3 (1)	0.15

DL, direct laryngoscopy; *VL,* video laryngoscopy; *IQR,* interquartile range

intubation for GI bleeds, a prospective study comparing DL and VL is unlikely. Our data suggest that patients with GI bleeds requiring airway management in the ED may be managed with VL successfully and with outcomes similar to those managed initially with DL.

Despite these results, concerns may exist that VL will not be of use in this patient population as the camera may become obscured by blood. We found no difference in intubation outcomes between those airways managed initially with DL and VL. While we were unable to quantify the amount of bleeding in these patients, there was no difference in the need to change device (e.g. from VL to DL), suggesting that the phenomenon where the camera may become obscured by blood necessitating device VL abandonment for DL occurs infrequently. VL may in fact be useful in treating these critically ill patients in need of emergent airway protection, especially for operators experienced with VL.

While the use of VL has grown in the ED over the past decade, there are several reasons why providers and hospital may select various devices. There are different types of VL available with different blade shapes and various techniques need for each.[16] VL is more expensive then traditional DL and may not be as readily available in all facilities.[1] Some VL offer the advantage of recording ETI attempts to allow for offline review for educational purposes.[17] Despite these benefits, operators may experience equipment malfunction with VL such as screen failure, although the overall incidence of this is unclear and likely varies by VL device.[18] Given the low number of VL intubation in the registry, we did not stratify by VL device. Further work may be needed to determine if there are differences in ETI success by the type of VL device used.

Table 3. Univariate odds ratios for first attempt success.

Variable	OR	95% CI	p-value
Video laryngoscope as first device*	1.21	(0.35-4.2)	0.76
Age	1.01	(0.99-1.03)	0.35
Gender**	1.2	(0.58-2.45)	0.63
Weight	1	(0.98-1.01)	0.58
Method			
No medications	(Reference)		
Sedation only	0.14	(0.01-1.67)	0.12
RSI	1.14	(0.25-5.23)	0.87
Operator PGY			
Attending	(Reference)		
1	0.29	(0.07-1.27)	0.1
2	0.27	(0.08-0.95)	0.04
3	0.99	(0.24-3.99)	0.99
4***			
Difficult airway predictors			
Total DACs	0.66	(0.47-0.94)	0.02
Limited neck mobility	0.44	(0.14-1.41)	0.17
Limited Mallampati#	0.69	(0.34-1.47)	0.34
Intra-incisor distance <3 fingers	0.81	(0.4-1.64)	0.56

OR, odds ratio; *RSI,* rapid sequence intubation; *PGY,* post-graduate year; *DAC,* difficult airway characteristics
*Reference=Direct Laryngoscopy.
**Reference=Male.
***All intubations performed by PGY-4 residents were successful on the first attempt.
#Mallampati>1.

LIMITATIONS

Our study has several limitations. First, this is a self-reported registry and under-reporting of complications, attempts, and adverse events are subject to recall bias. We have no indication that this took place and compliance standards of ≥90% help ensure the population tested is indicative of airway management practices in these centers. We were unable to confirm the amount and location of bleeding. While it is possible that some patients were intubated for shock in the setting of lower GI bleeding, the immediate threat to oxygenation and airway patency is in the setting of brisk upper GI bleeds and it is reasonable to assume these were cases of robust upper GI bleeding. We were also unable to further detail other patient characteristics between the VL and DL groups (anticoagulation use, nasogastric decompression prior to intubation attempts, Child-Pugh score of patients, etc.). The number of DL cases is much higher than VL cases. Previous work has shown that the rate of VL has increased over the time course of NEARIII; however, the

majority of airways are still managed with DL in the ED.[1] While a randomized trial would be the optimal method for addressing this, it is unlikely given the relatively infrequent nature of this disease process even in this national registry spanning nearly a decade of data collection. Finally, the decision to use VL or DL was operator preference. While the DL and VL populations were similar in our measured covariates, it is possible that VL was used by operators who felt more comfortable with their use. It is unknown if similar results would be obtained during random device selection.

CONCLUSION

In this national registry of ED intubations performed in patients with GI bleeding, DL and VL had similar rates of success, glottic views and need to change devices. VL may be a viable option in this population.

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Ultrasound of Sternal Fracture

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PRESENTATION

A 61-year-old female was brought in by ambulance after being the restrained driver of a head-on motor vehicle collision at 40MPH. There was positive airbag deployment and intrusion from the other vehicle. During workup, the patient complained of midline chest pain, and left chest wall pain. The patient was not in acute respiratory distress, and had the following vital signs: temperature 37°C, heart rate 84, blood pressure of 150/64, respiratory rate 18, and oxygen saturation of 97% on two liters of oxygen. On physical exam, breath sounds were heard bilaterally, with no acute cardiopulmonary issues identified. A bruise was identified on the lower abdomen, which was thought to be a potential seatbelt sign. A focused assessment with sonography for trauma was negative, and an ultrasound of additional chest and mediastinal structures was performed for the chest tenderness (Figure 1).

DIAGNOSIS

Sternal fracture has been observed in approximately 10% of patients with blunt chest trauma, with the most common mechanism of injury being motor vehicle accidents.[1] Isolated sternal fractures most often have a benign course, but can rarely cause secondary cardiac injury.[2] Patients with chest trauma typically undergo radiograph imaging in the emergency department to help rule out acute life-threatening cardiopulmonary injuries such as aortic dissection, tension pneumothorax, and cardiac tamponade, among other pathologies. Typically, these imaging techniques involve a portable chest radiograph, followed by a computed tomography (CT) of the chest if applicable.[3] Standard AP chest radiographs have a low sensitivity for diagnosing sternal fractures, with the majority of fractures being identified by lateral chest radiograph or CT (Figure 2). Because lateral chest radiographs are typically not performed in the acute trauma workup, many sternal fractures are not diagnosed until later in the trauma evaluation.[1,4]

Recent studies have compared the sensitivity and specificity of chest radiographs and ultrasound in determining the presence of sternal fracture. The sensitivity and specificity of chest radiograph were 70.8% and 75.0%, respectively with ultrasound showing a sensitivity and specificity as high as 100%.[4] Ultrasound has the advantage of increased sensitivity and specificity for diagnosing sternal fractures in comparison to chest radiographs, and avoids the excess radiation and time commitment of mobilizing patients to perform a chest CT.[4] Ultrasound is not accurate in identifying the degree of displacement of sternal fractures, but can accurately identify related hematomas and pleural effusions.[4]

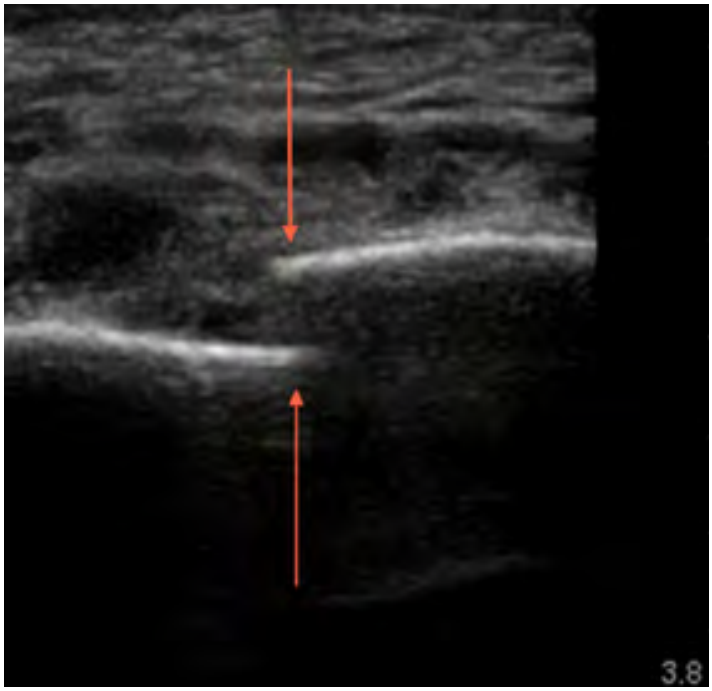

Figure 1. Ultrasound image of the sternum, with the red labeling the two ends of a displaced sternal fracture.

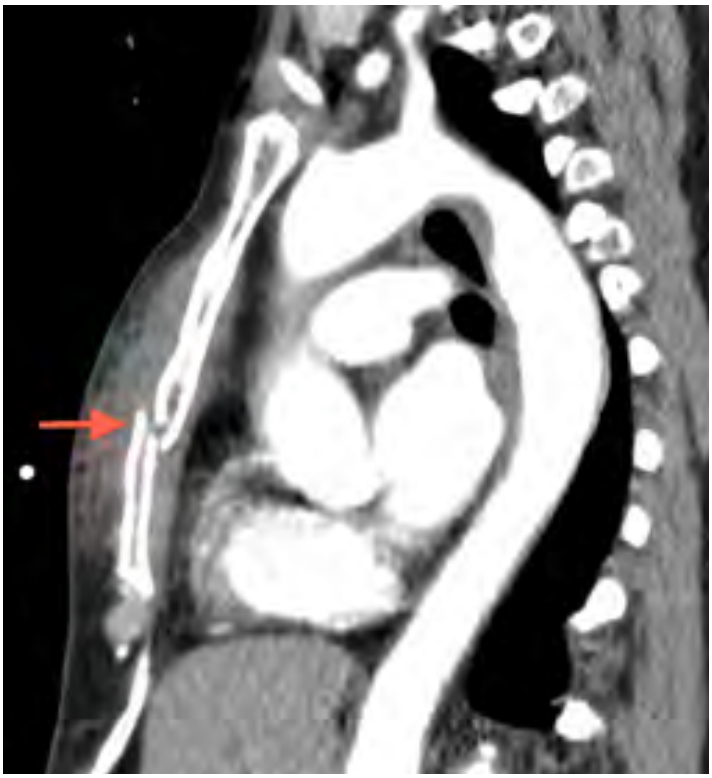

Figure 2. Computed tomography identifying the same displaced sternal fracture.

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Derivation and Validation of Predictive Factors for Clinical Deterioration after Admission in Emergency Department Patients Presenting with Abnormal Vital Signs Without Shock

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Introduction: Strategies to identify high-risk emergency department (ED) patients often use markedly abnormal vital signs and serum lactate levels. Risk stratifying such patients without using the presence of shock is challenging. The objective of the study is to identify independent predictors of in-hospital adverse outcomes in ED patients with abnormal vital signs or lactate levels, but who are not in shock.

Methods: We performed a prospective observational study of patients with abnormal vital signs or lactate level defined as heart rate ≥130 beats/min, respiratory rate ≥24 breaths/min, shock index ≥1, systolic blood pressure <90mm/Hg, or lactate ≥4mmole/L. We excluded patients with isolated atrial tachycardia, seizure, intoxication, psychiatric agitation, or tachycardia due to pain (ie: extremity fracture). The primary outcome was deterioration, defined as development of acute renal failure (creatinine 2x baseline), non-elective intubation, vasopressor requirement, or mortality. Independent predictors of deterioration after hospitalization were determined using logistic regression.

Results: Of 1,152 consecutive patients identified with abnormal vital signs or lactate level, 620 were excluded, leaving 532 for analysis. Of these, 53/532 (9.9±2.5%) deteriorated after hospital admission. Independent predictors of in-hospital deterioration were: lactate >4.0mmol/L (OR 5.1, 95% CI [2.1–12.2]), age ≥80 yrs (OR 1.9, CI [1.0–3.7]), bicarbonate <21mEq/L (OR 2.5, CI [1.3–4.9]), and initial HR≥130 (OR 3.1, CI [1.5–6.1]).

Conclusion: Patients exhibiting abnormal vital signs or elevated lactate levels without shock had significant rates of deterioration after hospitalization. ED clinical data predicted patients who suffered adverse outcomes with reasonable reliability. [West J Emerg Med. 2015;16(7):1059-1066.]

INTRODUCTION

Identifying emergency department (ED) patients at risk for adverse clinical outcomes is an integral part of the early ED evaluation. Prior studies show that vital sign abnormalities, such as elevated respiratory rate, tachycardia, hypotension, and elevated shock index (heart rate [HR]/systolic blood pressure), as well as elevated lactate level identify a population of patients with a relatively higher risk of short-term adverse outcomes.[1-3] These markers are regularly assessed early in the ED evaluation to help ED providers risk

stratify patients.[3,4]

While patients with persistent hypotension and shock are clearly at increased risk for adverse outcomes,[2,5-10] risk stratification is more challenging in normotensive and fluid responsive patients.[2,8,11] However, data showing the rates of adverse outcomes among those patients exhibiting markedly abnormal vital signs without shock (persistent hypotension despite resuscitation or need for vasopressors) are lacking. This risk has been assessed to a limited extent in infected patients with elevated lactate but no hypotension, who are shown to have a significant risk of adverse outcomes.[2,8,11] Yet diagnoses are often obscured during the ED evaluation,[12] making the application of risk stratification data difficult to apply when limited to a single diagnosis. Understanding the rates, types, and predictors of serious adverse outcomes in an undifferentiated ED population exhibiting abnormal vital signs without shock would inform triage decisions, and help practitioners anticipate those patients who may require more aggressive interventions or a higher level of care at disposition.

This study evaluated undifferentiated ED patients who exhibited markedly abnormal vital signs or lactate levels, without overt shock. The objectives of this study were 1) to identify risk factors independently associated with clinical deterioration (defined as intubation, acute renal dysfunction, vasopressor use or death) occurring between hospital admission and discharge, and 2) to understand the overall risk of clinical deterioration in this population.

METHODS

Study Design

This was a prospective, observational cohort study of consecutive patients found to have physiologic instability in the ED. The study was conducted at a large, urban, academic ED with 55,000 annual visits. The derivation study period was November 11, 2012, to January 31, 2013. The validation cohort was from February 1, 2013 ,to March 20, 2013. This study was granted waiver of informed consent after expedited review from our human subjects committee.

Participants

Inclusion criteria were all adult (age 18 or older) patients with one or more of the following vital signs abnormalities: HR>130 beats/min, respiratory rate >24 breaths/min, systolic blood pressure <90mm/Hg), shock index >1, or lactate >4mmol/L. These criteria were used based on prior studies showing the association of these vital signs and laboratory abnormalities with adverse patient outcomes.[2,3,13-15] Exclusion criteria were the following: patients with tachycardia due to atrial fibrillation with rapid ventricular response or supraventricular tachycardia who were then discharged once rate control was achieved, vital sign abnormalities due to intoxication, withdrawal, psychiatric disorder, seizure, or simple trauma (ie: fracture). We also excluded patients who were discharged from the ED. Lastly, we excluded patients with shock in the ED. Shock was defined as persistent hypotension (systolic blood pressure <90mmHg) despite at least 1L of intravenous fluids or the need for vasopressors to treat hypotension.

We continuously and prospectively screened patients in the ED for possible inclusions using our information technology system. If patients had qualifying vital signs in triage, in nursing notes, or through the bedside monitors (two readings more than five minutes apart), or a serum lactate lactate >4mmol/L, then the patients were identified for possible inclusion in the study. Identified patients then underwent a confirmatory chart review to affirm the presence of inclusion criteria and absence of exclusion criteria. The confirmatory review occurred after patients were discharged and without subsequent knowledge of the hospital course.

Data Collection

Elements of the history of present illness, triage vital signs, physical examination, past medical history, and medications were abstracted for each enrolled patient from the hospital record. Abstraction was performed by research assistants trained, directly supervised by the principal investigator, who periodically reviewed data collection for accuracy, in accordance with published guidelines.[16] The history of present illness and physical examination portions were abstracted exclusively from the emergency attending and resident charts. Basic demographics, length of stay, and disposition data were obtained from a hospital database. Likewise, all laboratory values were obtained from a hospital database.

An emergency physician adjudicated each patient's underlying cause of instability, based on accepted definitions.[17,18] Underlying causes were classified as septic, cardiogenic, hemorrhagic, hypovolemic, anaphylactic, neurogenic, and other. To determine inter-rater reliability, a second physician reviewer likewise adjudicated the first 500 charts, and the agreement between the two reviewers was found to be sufficient to proceed with a single adjudication for each patient (kappa=0.8).

Outcome

The primary outcome was clinical deterioration occurring after hospitalization represented by the composite outcome of acute renal failure (creatinine 2x baseline), non-elective intubation, need for vasopressors, or death. This outcome could occur at any point after the patient left the ED until they were discharged from the hospital. Patients with acute renal failure or intubation in the ED qualified as having in-hospital deterioration only if they had new deterioration events after admission. Our secondary outcome was deterioration at any time after presentation to the ED, including any point during hospitalization, between ED triage and hospital discharge. The physician reviewer assessed for the presence and timing of deterioration.

We performed data analysis using SAS v9.3 statistical software (SAS Institute Inc., Cary, NC). Comparison of patient demographics and co-morbidities between patients with and without deterioration was performed with Chi-square for binary variables and Student's T-Test for continuous variables. We constructed a multivariate logistic regression model to determine predictors of deterioration after admission was constructed. Lactate concentrations were stratified into "high" (≥4.0mmol/L), "intermediate" (4.0mmol/L> lactate ≥2.0mmol/L), and "low" (≤2.0mmol/L). We included a lactate-missing variable to impute for the 158 patients who did not have lactate measured,[19] although we do not present the results from the lactate missing variable with the model results. Other notable transformations included creating a binary variable for age ≥80 years, bicarbonate ≤20mEq/L, and a binary variable for initial HR≥130 beats per minute. We performed a univariate analysis of each covariate, using a chi-square to assess for a significant relationship. Clinical covariates with p>0.1 were removed from the modeling process. All significant variables were then used to create a logistic regression model with deterioration after admission as the outcome, and a stepwise selection process to create the final model. We validated the model using a validation cohort that consisted of the next 254 continuous patients that met study criteria, and reported the area under the curve (AUC) to assess the model on this group. The validation cohort was identified in the same manner and subjected to the same inclusion and exclusion criteria as the derivation cohort.

We used the logistic regression model as the basis for determining the sample size needed for the study. Based on the n/10 rule, we estimated that we would require at least 50 patients who suffered our primary outcome of deterioration after admission in order to include five predictors in our model. We estimated an in-hospital deterioration rate of 10% for the population based on observations from our initial data collection, and therefore determined at least 500 patients would be required to have five predictors in our model. Our validation cohort was meant to have at least half the number of patients in the derivation cohort: 250 patients.

RESULTS

For our initial cohort (Figure 1), we identified 1,152 patients among 12,050 patients presenting to the ED as having vital signs meeting inclusion criteria. Of these, 620 were excluded (Supplemental Table 1), leaving 532 patients for our analysis. Of these 532 patients, we found 53/532 (9.9%) patients met the primary outcome of deterioration after admission: 22 acute renal dysfunction (4.1%, 95% confidence interval (CI) ±1.3), 20 needing mechanical ventilation (3.8%, 95% CI±1.3), 12 requiring vasopressors (2.3%, 95% CI±1.3) and 37 (7.0%, 95% CI±1.3) who died during hospitalization (Figure 1). Including those patients who had adverse outcomes in the ED, 87 (16.4%, 95% CI±3.2) patients reached the secondary deterioration outcome overall: 46 developed acute renal dysfunction (8.6% , 95% CI±2.4), 31 required mechanical ventilation (5.8% 95% CI±2.0), 12 required vasopressors (2.3%, 95% CI±1.3), and 37 died (7.0% 95% CI±1.3)(Table 1).

Table 2 shows the study demographics and displays the clinical characteristics for the study patient population. Table 3 demonstrates the clinical characteristics between the group of patients who suffered deterioration and those that did not. These tables include an unadjusted univariate measure to determine if a significant difference exists between the two groups for each covariate. The covariates that have a significant relationship ($p<0.05$) with the outcome are indicated. The covariates with $p<0.1$ from this table were included in the creation of the logistic regression model to predict in hospital deterioration.

The final logistic regression model predicting deterioration from this patient population is shown in Table 4. The covariates independently associated with adverse outcomes were the following: lactate ≥4.0mmol/L, HR≥130 beats per minute, age ≥80 years, and bicarbonate ≤20mEq/L during the ED stay. The AUC for this derivation model was 0.74, with sensitivity of 70% and specificity 63%.

We compared the rates of covariates from the final model between infectious and non-infectious causes (Figure 2). A HR≥130 was more likely in patients with infection ($p<0.01$); however, no difference was found in incidence of the other model covariates between infected and non-infected groups. Then the model was re-run with infectious etiology as a binary predictor, the AUC of the model remained 0.74, and the infection term was not significant. The model was re-run on the validation cohort, with AUC=0.70. We used chi-square to test the statistical similarity of the model performed on the derivation and validation populations, which showed no difference between the model's predictive value ($p=0.70$). ROC curves showing the model performance in the derivation and validation cohorts are displayed in Figure 3.

DISCUSSION

This study of undifferentiated ED patients with markedly abnormal vital signs or elevated lactate without shock found that a significant proportion (16.4%) of these patients suffered clinical deterioration, and nearly 10% had deterioration events after being admitted from the ED. While not directly assessed, many patients in this population had improvement in hemodynamics during their ED course. This study identified independent risk factors for in-hospital deterioration so that ED and in-patient providers can better anticipate clinical course and appropriately assign level of in-patient care.

In the univariate analysis, we identified covariates associated with deterioration. Some covariates were surprisingly not associated with increased adverse outcomes, including diabetes, and congestive heart failure. Similarly, active cancer has a significant association with deterioration in the univariate analysis, but surprisingly was not significant in the modeling

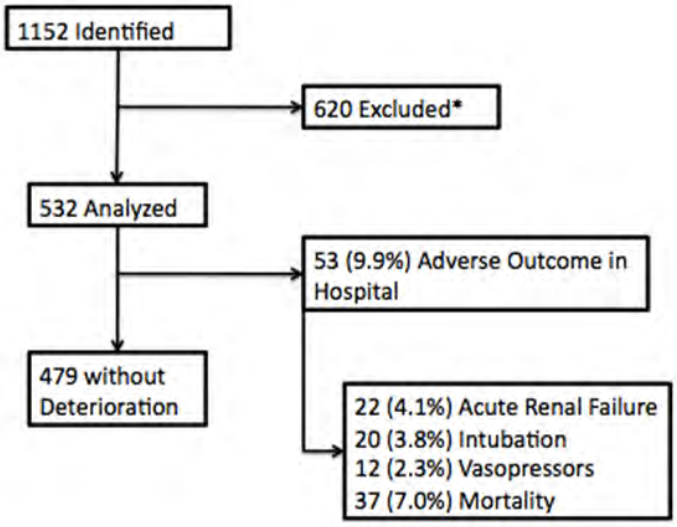

Figure 1. Flowchart of study enrollment, exclusions, and primary outcome. *See Supplemental Table 1 for rates of exclusion by criteria.

process. The decreased rate of deterioration in patients without any pre-existing medical problems was expected, as was the association of altered mental status with deterioration, since mental status changes can represent a form of organ dysfunction. Also, higher average lactate concentration has been associated with progression of disease,[8,20] and was expected to be associated with increased event rates.

The multivariate logistic regression model allows for each independent covariate's effect on the deterioration outcome to be determined. This model provides a few significant results for clinicians tasked with determining a disposition for ED patients. An elevated lactate is associated with increased adverse outcomes, even after controlling for patients who did not have a lactate drawn. While the prior studies of lactate concentrations have generally looked at septic patients,[2,7-9,11,20] this result suggests that an elevated lactate level is associated with increased adverse outcomes in this general ED population. Interestingly, a lactate ≥4.0 mmol/L, occurred more frequently in the non-infected patient population, reiterating its usefulness as a predictor in undifferentiated patients,[21,22] Likewise, a bicarbonate ≤20mEq/L, was a significant predictor of deterioration after controlling for elevated lactate levels, which should remind clinicians that acidosis, with or without elevated lactate levels increases the odds of adverse outcomes after hospitalization. Lastly, an initial HR≥130 beats/min increased the odds of deterioration during hospitalization. This occurred more frequently in patients with infection, which may be caused by an adrenergic response to infection or compensation for relative hypovolemia. Regardless, significant tachycardia at presentation likely reflects more serious underlying pathology compared to the other vital sign abnormalities used to triage patients in the ED.

Clinical investigations describing at-risk ED patient populations are in response to the inherent difficulty physicians face in identifying patients who will have adverse outcomes. The present study aligns with prior studies that have shown a clinically meaningful rate of disease progression,[8] progressive organ failure,[11,20] and mortality[2,23] in similar populations, albeit with different inclusion criteria. Prior studies have generally been limited to patients with sepsis, whereas this study includes undifferentiated patients. In prior studies that evaluated the demographics of unstable patients, the population of patients with sepsis accounts for roughly 38-43%,[24,25] similar to the 46% of patients in this study with an infectious cause.

Prior studies have also attempted to identify the clinical characteristics of these at-risk populations that are associated with adverse clinical outcomes.[2,9,11,20,26] Howell, et al., shows a strong association between lactate concentrations and mortality among patients without hypotension, although this study was limited to patients with sepsis. The degree to which this association exists in patients with infection versus those without infection remains unknown, but the present study supports the conclusions of the Howell study. In the patient population used by Song, et al., all had a lactate concentration between 2.0 and 4.0mmol/L and suspected infection. Their investigation provides other predictors of disease progression, including initial organ dysfunction and SOFA scores, but again it is limited to a population with infection.

Our model was not limited to a single underlying etiology, but included all causes of instability. This may explain the lack of significant associations between certain covariates and our outcome. Covariates more classically associated with worse outcomes in a single disease may become less significant when used to predict adverse outcomes across a spectrum of diseases. This study does not suggest that these elements would not have a significant effect on outcomes if we were evaluating a single cause of instability, and it does not replace prior studies that evaluate predictors of adverse outcomes within a single etiology.[11,20] Instead, this study is meant to be applicable regardless of the underlying cause, and especially in the undifferentiated patient and early ED evaluation. By enrolling patients regardless of the underlying cause, this study bypassed the need to differentiate patients into infectious and non-infectious categories, which as stated before is inherently difficult during the initial evaluation[12].

The primary outcome of deterioration represents different types of adverse outcomes that occurred after admission to the hospital. Each type represents a meaningful clinical end-point, as well as significant morbidity and discomfort endured by the patient and increased resource utilization. Importantly, this study may assist clinicians in the early identification of patients with a higher risk of disease progression and adverse outcomes. By facilitating improved risk stratification, our findings may enable more appropriate resource allocation, thereby improving patient outcome and reducing costs associated with care.

Limitations

This study had several limitations. We were able to collect a vast amount of clinical data, but many aspects of the history and physical examination we derived through chart abstraction possibly leading to misclassification bias. The use of a composite outcome that included four different clinical end-points may have been too inclusive. While each end-point does represent a significant adverse outcome, creating a composite outcome from very different end-points may have diminished the strength of association between different covariates and the outcome. It could be argued that death should be used as the single outcome of interest. This may become the foundation for further study; however, we believe that by including the other components of the deterioration outcome, we were able to develop a more sensitive tool that may allow practitioners to intervene earlier thereby avoiding mortality. As well, these other outcomes represent meaningful progression of disease that might be avoided with appropriate early management. Along these same lines, choosing to non-electively intubate or administer vasopressors is physician dependent to a certain extent, and there is a possibility that practice variation could affect whether or not a patient met the primary outcome.

An additional limitation was the large number of patients excluded from this study. Our screening criteria,

Table 1. Location of deterioration events during the hospital course. Some patients had more than one deterioration event.

	Deterioration location		
Deterioration	ED	Inpatient	Total
Acute renal failure (%)	24 (4.5)	22 (4.1)	46 (8.6)
Intubation (%)	11 (2.1)	20 (3.8)	31 (5.8)
Vasopressors (%)	0 (0)	12 (2.3)	12 (2.3)
Death (%)	0 (0)	37 (7.0)	37 (7.0)

ED, emergency department

Table 2. Patient demographics and underlying diagnosis. Factors with p<0.1 were included as candidate variables in the multiple regression model.

	Deterioration	No deterioration	p-value
n	53	479	
Diagnosis (%)			
Sepsis	22 (47.3)	222 (46.4)	0.50
Cardiogenic	8 (15.1)	54 (11.3)	0.41
Hemorrhagic	5 (9.4)	35 (7.3)	0.58
Hypovolemic	2 (3.8)	63 (13.2)	0.05
Other	16 (30.2)	105 (21.9)	0.17
Age (95% CI)	66.8 (64.2 – 73.5)	59.8 (58.0 – 61.6)	<0.01
Female (%)	24 (45.3)	263 (54.9)	0.18
Past medical history (%)			
None	6 (11.3)	105 (21.9)	0.07
Diabetes	17 (32.1)	136 (28.4)	0.57
Coronary artery disease	8 (15.1)	78 (16.3)	0.82
Myocardial infarction	3 (5.7)	28 (5.9)	0.95
Congestive heart failure	10 (18.9)	95 (19.8)	0.87
Hypertension	24 (45.3)	210 (43.8)	0.84
Dementia	3 (5.7)	32 (6.7)	0.78
Active cancer	18 (34.0)	104 (21.7)	0.04
COPD	14 (26.4)	74 (15.5)	0.04
End stage liver disease	4 (7.6)	26 (5.4)	0.53
Chronic renal insufficiency	9 (17.0)	55 (11.5)	0.24
Dialysis	2 (3.8)	29 (6.1)	0.50
Stroke	4 (7.6)	26 (5.4)	0.53
Transplant	0 (0.0)	14 (2.9)	0.21
HIV	1 (1.9)	16 (3.3)	0.57
Anticoagulation	16 (30.2)	117 (24.4)	0.36

COPD, chronic obstructive pulmonary disease; *HIV,* human immunodeficiency virus

Table 3. Clinical characteristics of patients by outcome. Factors with p<0.1 were included as candidate variables in the multiple regression model.

History present illness (%)	Deterioration	No deterioration	p-value
Fever	15 (28.3)	159 (33.2)	0.47
Nausea/vomiting	7 (13.2)	108 (22.6)	0.12
Diarrhea	4 (7.6)	37 (7.7)	0.96
Chest pain	6 (11.3)	71 (14.8)	0.49
Shortness of breath	26 (49.1)	159 (33.2)	0.02
Abdominal pain	8 (15.1)	100 (20.9)	0.32
Cough	15 (28.3)	156 (32.6)	0.53
Dysuria	2 (3.8)	14 (2.9)	0.73
Melena	2 (3.8)	26 (5.4)	0.61
Hematemesis	3 (5.6)	5 (1.0)	0.01
Other bleeding	2 (3.7)	17 (3.6)	0.93
Rash	2 (3.7)	18 (3.8)	0.99
Physical exam (%)			
Altered mental status	6 (11.3)	42 (8.8)	0.53
Pulmonary crackles	5 (9.4)	46 (9.6)	0.97
Asymmetric lung sounds	12 (22.6)	75 (15.7)	0.19
Guaiac negative	3 (5.7)	32 (6.7	0.78
Rectal shows blood	0 (0)	9 (1.9)	0.31
Guaiac positive	1 (1.9)	9 (1.9)	0.99
Rectal shows melena	0 (0)	8 (1.7)	0.34
Abdominal distention	6 (11.3)	18 (3.8)	0.01
Abdominal tenderness	9 (17.0)	86 (18.0)	0.86
Lower extremity edema	15 (28.3)	55 (11.5)	0.01
Cellulitis	1 (1.9)	17 (3.6)	0.52
Initial vital signs (95% CI)			
Temperature (F)	98.4 (98.0-98.8)	98.7 (98.6-98.9)	0.06
Heart rate	108.8 (103.7-114.0)	106.5 (104.4-108.6)	0.38
Systolic blood pressure	110.6 (103.8-117.4)	113.8 (111.4-116.2)	0.31
Diastolic blood pressure	67.5 (62.7-72.3)	67.4 (65.9-68.9)	0.97
Respiratory rate	21.5 (20.2-22.7)	21.3 (20.7-21.8)	0.76
SaO2	97 (96.1-98.0)	97 (96.7-97.3)	0.92
Shock index	1.03 (0.97-1.1)	0.96 (0.94-0.98)	<0.01
Laboratory data (95% CI)			
Lactate	2.82 (2.43-3.21)	1.99 (1.88-2.09)	<0.01
White blood cells (count/mm^3)	12.1 (10.7-13.6)	10.7 (10.1-11.3)	0.04
Bands (%)	6.2 (2.13-10.3)	2.54 (1.30-3.79)	0.02
Hematocrit (%)	37.5 (35.8-39.3)	36.3 (35.6-37.0)	0.16
Bicarbonate (mEq/L)	22.5 (21.0-24.0)	24.9 (24.5-25.4)	<0.01
International normalized ratio	1.68 (1.19-2.17)	1.67 (1.49-1.85)	0.96
Aspartate aminotransferase (IU/L) (mEq/dL)	97 (58.7-135.2)	58.2 (47.6-68.9)	<0.01
Alanine aminotransferase (IU/L)	57.7 (42.1-73.4)	43 (35.0-51.0)	0.09

Table 4. Final multivariate logistic regression predicting deterioration after hospital admission.

Predictor	β-coefficient	Std error	Odds ratio (95% CI)	p-value
Lactate ≥4.0	1.62	0.45	5.1 (2.1 – 12.2)	<0.01
Bicarbonate ≤20	0.66	0.33	1.9 (1.0 – 3.7)	0.04
Age ≥80 years	0.93	0.34	2.5 (1.3 – 4.9)	<0.01
Initial heart rate≥130	1.11	0.36	3.1 (1.5 – 6.1)	<0.01

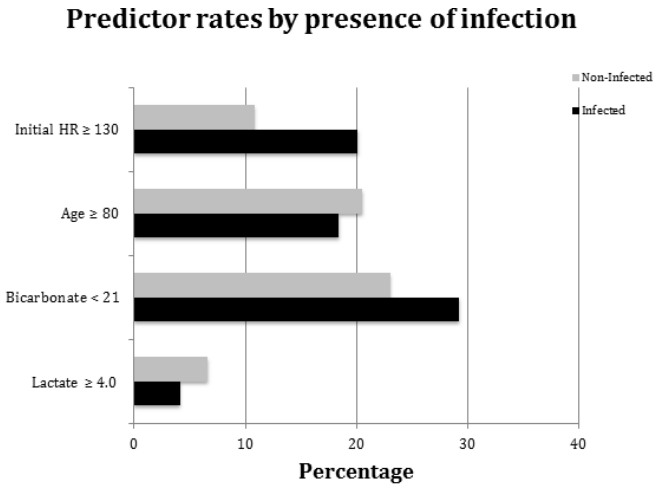

Figure 2. Percentage of model covariates in patients with and without infection.
HR, heart rate

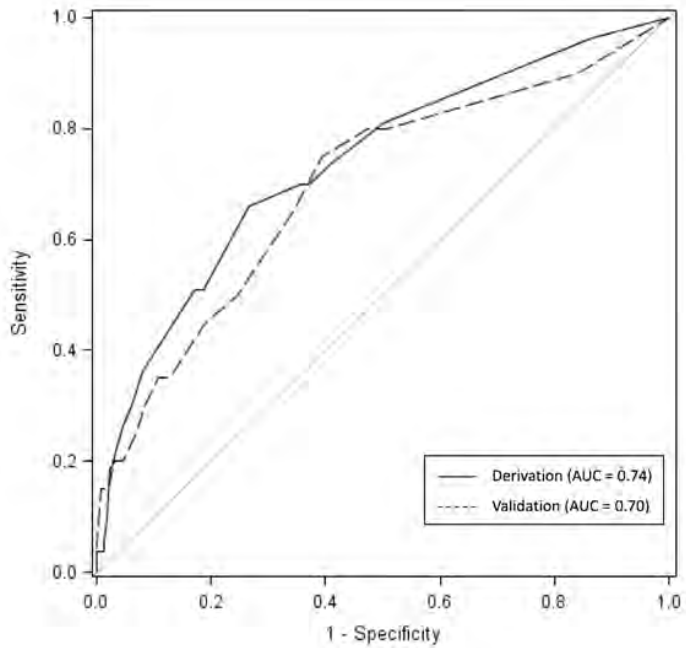

Figure 3. ROC curves demonstrating model performance in Derivation (solid) and Validation (dashed) cohorts.
AUC, area under the curve

like many triage screening tools, were overly sensitive in order to capture all moderately sick patients. Therefore, our exclusions were designed to remove those patients whose clinical stability would not be questioned by an experienced provider, i.e, patients with intoxication. Similarly, we excluded patients who were discharged from the ED. Such patients are likely to have had markedly abnormal vital signs or elevated lactate that rapidly improved with intervention suggesting a milder illness not requiring ongoing monitoring or in-patient treatment. However, this may exclude a small number of patients who would have been admitted, and therefore included in the study, if seen by an alternative provider. Also, we did not take into account how hemodynamics or lactate changed during a patient's ED stay. While such trends clearly influence disposition decisions, the timing of repeat vital signs and lactate measurements was not able to be standardized due to our data collection methods, thereby preventing us from incorporating changes in hemodynamics and lactate into our models. Lastly, we did not assess for do not resuscitate/do not intubate (DNR/DNI) status in the ED or in the hospital. This may have had a significant effect on the rates of patients suffering adverse outcomes. However, age and other comorbidities that can be associated with a DNR/DNI order were not strong predictors of deterioration. Therefore, it is less likely that this variable represents a significant gap in the model.

CONCLUSION

This study provides a framework for understanding the population of emergency patients who exhibit abnormal vital signs or elevated lactate in the absence of overt shock. This population is clinically relevant based on the high rate of adverse outcomes, and our analysis suggests predictors to identify those patients more likely to suffer adverse outcomes during hospitalization. Our results will help clinicians risk stratify these patients and identify the appropriate resuscitation and resource needs. A large amount of unaccounted variability remains in the model predicting deterioration, and future studies should explore the potential of newer medical devices and novel biomarkers for risk stratification.

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Association of Emergency Department Length of Stay and Crowding for Patients with ST-Elevation Myocardial Infarction

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Introduction: With the majority of U.S. hospitals not having primary percutaneous coronary intervention (pPCI) capabilities, the time spent at transferring emergency departments (EDs) is predictive of clinical outcomes for patients with ST-elevation myocardial infarction (STEMI). Compounding the challenges of delivering timely emergency care are the known delays caused by ED crowding. However, the association of ED crowding with timeliness for patients with STEMI is unknown. We sought to examine the relationship between ED crowding and time spent at transferring EDs for patients with STEMI.

Methods: We analyzed the Centers for Medicare and Medicaid Services (CMS) quality data. The outcome was time spent at a transferring ED (i.e., door-in-door-out [DIDO]), was CMS measure OP-3b for hospitals with ≥10 acute myocardial infarction (AMI) cases requiring transfer (i.e., STEMI) annually: Time to Transfer an AMI Patient for Acute Coronary Intervention. We used four CMS ED timeliness measures as surrogate measures of ED crowding: admitted length of stay (LOS), discharged LOS, boarding time, and waiting time. We analyzed bivariate associations between DIDO and ED timeliness measures. We used a linear multivariable regression to evaluate the contribution of hospital characteristics (academic, trauma, rural, ED volume) to DIDO.

Results: Data were available for 405 out of 4,129 hospitals for the CMS DIDO measure. These facilities were primarily non-academic (99.0%), non-trauma centers (65.4%), and in urban locations (68.5%). Median DIDO was 54.0 minutes (IQR 42.0,68.0). Increased DIDO time was associated with longer admitted LOS and boarding times. After adjusting for hospital characteristics, a one-minute increase in ED LOS at transferring facilities was associated with DIDO (coefficient, 0.084 [95% CI [0.049,0.119]]; p<0.001). This translates into a five-minute increase in DIDO for every one-hour increase in ED LOS for admitted patients.

Conclusion: Among patients with STEMI presenting to U.S. EDs, we found that ED crowding has a small but operationally insignificant effect on time spent at the transferring ED. [West J Emerg Med. 2015;16(7):1067-1072.]

INTRODUCTION

Timeliness of myocardial perfusion is an important predictor of long-term outcomes for patients with ST-elevation myocardial infarction (STEMI).[1] Since the majority of hospitals in the U.S. do not have primary percutaneous coronary intervention (pPCI) capabilities,[2] many STEMI patients require transfer to pPCI-capable facilities to restore myocardial perfusion. More time spent at transferring emergency departments (EDs) has been shown to be associated with increased mortality for patients with STEMI.[3] Further heightening the importance of the role of the ED and its timeliness is that most patients with STEMI initially present to U.S. EDs.[4] Not only are transfers from U.S. EDs increasing in frequency for patients with STEMI,[5] but the time spent at transferring EDs is longer and more variable than either the transportation or pPCI center phases. Considering

the role of the emergency care system is to rapidly identify, coordinate and treat time-sensitive emergency conditions like STEMI, the timeliness and performance of the ED for patients with STEMI is central to high-quality care.

To measure the timeliness of transferring EDs, the American Heart Association (AHA) recognizes a quality measure called the "door-in-door-out" time (DIDO) interval.[6] While no specific time benchmark is endorsed, studies recommend that DIDO should be no longer than 30 or 45 minutes before clinical outcomes are diminished.[3,7] However, only 10% of transferred STEMIs met the more stringent 300-minute benchmark.[3] Potentially influencing the ability of EDs to meet these timeliness goals is ED crowding. Studies of ED crowding and prolonged ED length of stay (LOS) have found associations with lower quality care.[8] However, the influence of ED crowding and timeliness of patient transfer for STEMI is unknown. Considering that unique policies exist, such as prehospital and triage electrocardiograms (EKGs), and guidelines for timeliness, EDs have developed policies to identify STEMIs in the setting of crowding. Therefore, we sought to quantify the association between ED crowding and time spent at transferring EDs for patients with STEMI in U.S. EDs.

MATERIALS AND METHODS

We analyzed the Centers for Medicare and Medicaid Services (CMS) hospital quality data from 2012. The primary outcome, DIDO, is CMS measure OP-3b, ED Median Time to Transfer a Patient with acute myocardial infarction (AMI) for acute coronary intervention. OP-3b data included hospitals with ≥10 AMI cases annually. While the term AMI includes a broader group of cardiovascular emergencies, OP-3b only measures those with STEMI and new left bundle branch block requiring acute coronary intervention.[9] We selected four surrogate measures of ED crowding for our analyses. Our primary measure of ED crowding was ED-1: median ED LOS for admitted patients. We hypothesized that ED LOS for admitted patients would explain significant variation in DIDO for several reasons. First, boarding of admitted patients in the ED was identified by the 2006 Institute of Medicine report, Hospital-Based Emergency Care, as a key cause of crowding in the ED.[10] Second, the proportion of ED patients admitted and higher inpatient occupancy rates were associated with increased ED LOS.[11] Last, ED admitted LOS may be more reflective of STEMI ED patient care as the severity of illness for STEMI patients is more comparable to patients admitted from the ED rather than those who are discharged.

Beyond ED admitted LOS, we included additional ED timeliness measures in our analyses: 1) discharged LOS (OP-18b: Median ED LOS for Discharged Patients); 2) boarding time (ED-2: Median time from admit decision time to time of departure from ED for ED patients admitted to inpatient status); and 3) waiting time to be seen by a clinical provider (OP-20: Door to Diagnostic Evaluation by a Qualified Medical Professional).

We identified facilities that were eligible to report OP-3b. Of those that reported OP-3b, we examined the distribution of DIDO times by facility types and facility characteristics. Facility types were obtained from the AHA annual survey and included academic, trauma center, rural/urban location (U.S. Department of Agriculture classification) and number of hospital beds (i.e., bed size). Facility characteristics included ED patient volume, ED admitted LOS, ED discharged LOS, boarding time, and waiting time. We used a bivariate linear regression model to determine the relationship between DIDO and ED crowding measures (admitted LOS, discharged LOS, boarding time, and waiting time). We used a multivariable linear model to evaluate the contribution of hospital characteristics to DIDO. The model assumed normally distributed errors, homoscedasticity, and a low degree of multicollinearity. We also selected the longer of the two DIDO benchmarks, 45 minutes, since few EDs met the more stringent 30-minute benchmark and would be unlikely to be implemented in practice.[3] We tested whether ED crowding measures were affected if EDs met this 45-minute benchmark for DIDO using a two-sample t-test with a level of significance of $P<0.05$. We conducted all analyses using Stata v13.1 (College Station, TX).

RESULTS

We identified 405 out of 4,129 hospitals eligible for inclusion with >10 cases; 1,406 had between one and 10 cases to report, 923 had no cases, and 1,395 did not have results available for the reporting period. Included facilities were primarily non-academic (99.0%), non-trauma centers (65.4%), in urban locations (68.5%). Overall median DIDO was 54.0 minutes (IQR 42.0, 68.0). We report DIDO performance by facility characteristics and ED crowding measure (Table 1 and 2).

Of the reporting hospitals, 30.1% (119/396) met the 45-minute DIDO benchmark. In bivariate linear regression analyses of the four ED crowding measures and DIDO, median ED admitted LOS (coefficient, 0.044 [95% CI [0.012-0.076]]; p=0.007) and boarding time (coefficient, 0.043 [95% CI [0.001-0.085]]; p=0.047) were significantly associated with DIDO, while waiting time (p=0.6) and ED discharged LOS (p=0.2) were not associated with DIDO. Hospitals with an average DIDO <45 minutes had a significantly lower median ED admitted LOS than hospitals with DIDO ≥45 minutes (259 vs. 283 minutes; p=0.008). Similarly, median boarding times were significantly lower for those with average DIDO <45 versus those ≥45 minutes (90.0 vs. 105 minutes; p=0.027).

After adjusting for hospital characteristics, a one-minute increase in ED LOS at transferring facilities was associated with DIDO (coefficient, 0.084 [95% CI [0.049-0.119]]; $p<0.001$). This translates into a five-minute increase in DIDO for every one-hour increase in ED LOS for admitted patients. Among hospital characteristics, urban setting (coefficient,

Table 1. Door-in-door-out (DIDO) performance by hospital characteristics. All times are in minutes.

	N	%	Mean DIDO	Median DIDO	Interquartile range
All hospitals	405	100	59.5	54.0	42.0, 68.0
Academic status					
Academic	4	1.00	71.0	76.0	58.5, 83.5
Non-academic	399	99.0	59.4	54.0	42.0, 67.0
Trauma status					
Trauma	140	34.6	62.2	54.0	43.0, 68.0
Non-trauma	265	65.4	58.1	53.0	42.0, 67.0
Rural/urban status					
Rural	127	31.5	65.0	59.0	45.0, 75.0
Urban	276	68.5	56.9	52.0	42.0, 66.0
Hospital bed size* (by groups)					
1-3	149	37.0	63.2	53.0	43.0, 70.0
4	161	40.0	57.8	55.0	42.0, 66.0
5-8	93	23.1	56.6	52.0	42.0, 68.0
Emergency department yearly volume (quartile)					
Q1: 16-12,772	26	6.72	66.0	54.5	45.0, 84.0
Q2: 12,954-27,420	130	33.6	63.3	55.0	45.0, 68.0
Q3: 27,720-48,812	170	43.9	54.3	52.0	40.0, 63.0
Q4: 49,264-337,128	71	18.1	57.5	55.0	43.0, 70.0

Hospital bed size ranges from the American Hospital Association website: 1) 6-24, 2) 25-49, 3) 50-99, 4) 100-199, 5) 200-299, 6) 300-399, 7) 400-499, 8) 500+.

Table 2. Door-in-door-out performance by operational characteristics of emergency department (ED) crowding measures by quartile.*

	N	%	Mean DIDO	Median	Interquartile range
ED admitted length of stay (LOS) (ED-1: median ED LOS for admitted patients)					
Q1: 84-215 minutes	68	17.1	54.0	51.5	38.5, 63.0
Q2: 216-259	139	35.0	60.1	51.0	44.0, 64.0
Q3: 260-314	105	26.4	54.2	54.0	41.0, 64.0
Q4: 316-1,031	85	21.4	66.9	60.0	48.0, 76.0
ED discharged LOS (OP-18b: median ED LOS for discharged patients)					
Q1: 60-112 minutes	82	21.0	56.0	53.0	42.0, 66.0
Q2: 113-135	127	32.5	58.7	53.0	41.0, 65.0
Q3: 136-162	105	26.9	58.6	55.0	43.0, 68.0
Q4: 163-860	77	19.7	62.0	53.0	43.0, 70.0
Boarding time (ED-2: median time from admit decision time to time of departure from ED for ED patients admitted to inpatient status)					
Q1: 0-61 minutes	86	21.7	58.4	51.5	41.0, 67.0
Q2: 62-88	122	30.8	58.2	52.0	43.0, 64.0
Q3: 89-126	110	27.8	58.8	55.5	46.0, 66.0
Q4: 127-584	78	19.7	61.4	59.0	42.0, 73.0
Door-to-diagnostic evaluation (OP-20: door to diagnostic evaluation by a qualified medical professional)					
Q1: 0-19 minutes	90	23.1	55.2	50.0	40.0, 62.0
Q2: 20-28	98	25.2	60.2	56.0	46.0, 66.0
Q3: 29-40	114	29.3	59.2	55.5	45.0, 70.0
Q4: 41-749	87	22.4	60.8	52.0	42.0, 70.0

*Door-in-door-out by ED crowding measures by quartile.

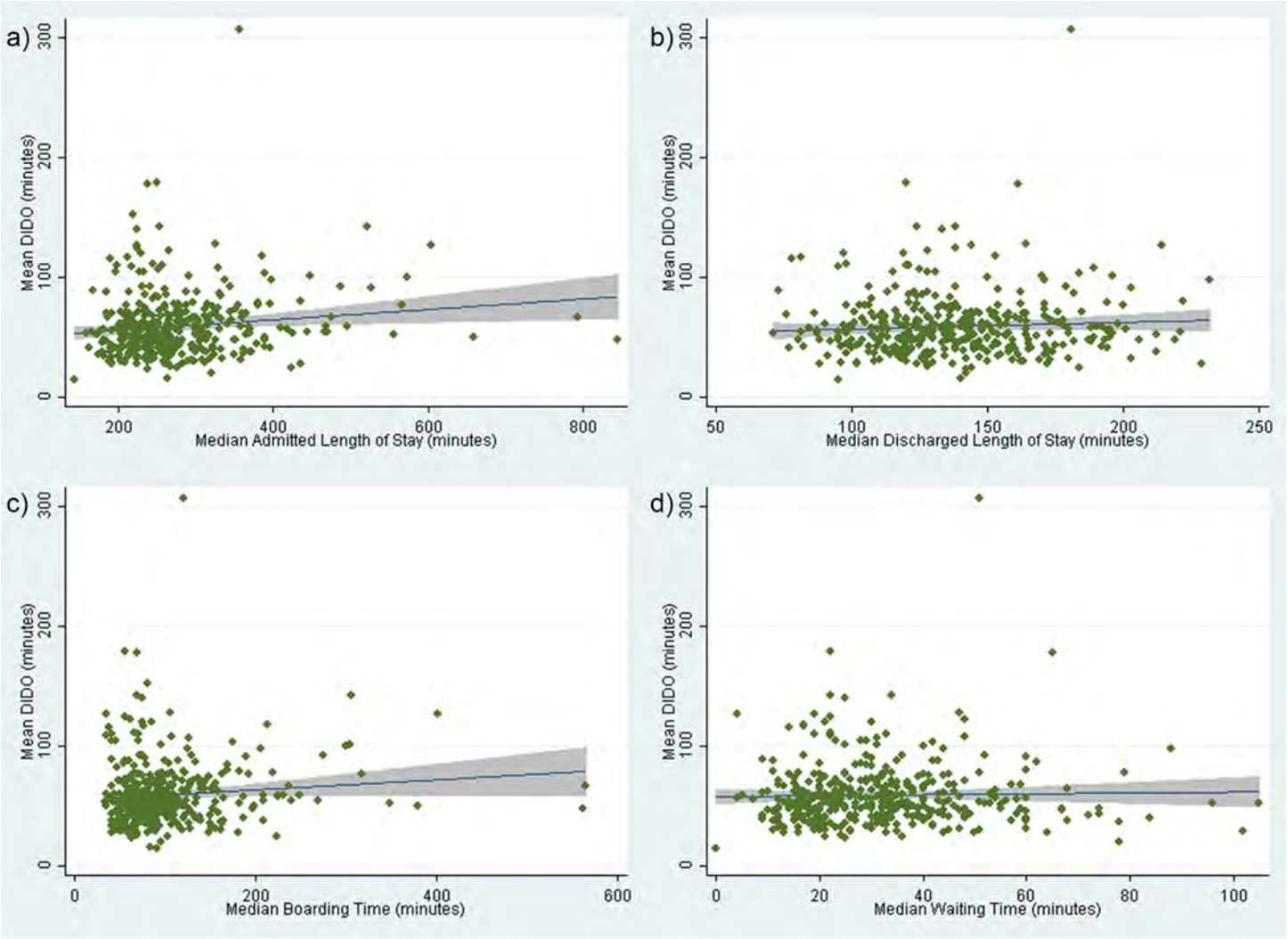

Figure. Scatterplots of Door-In-Door-Out (DIDO) times versus emergency department (ED) crowding measures: a) ED admitted length of stay (LOS); b) ED discharged LOS; c) Boarding time; and d) Waiting time. The lines represent the fitted values from the bivariate model and the shaded gray area represents the 95% confidence interval.

-9.52 [95% CI [-15.6 - -3.47]]; p=0.002), the third (coefficient, -13.3 [95% CI [-24.8- -1.73]]; p=0.024) and fourth (coefficient, -13.7 [95% CI [-26.8 - -0.655]]; p=0.040) highest quartiles of ED patient volumes were associated with shorter DIDO times. The scatterplots of each measure versus DIDO can be seen in the Figure.

We tested model assumptions of linearity, normality, homoscedasticity and correlation. To test for linearity, we plotted the standardized residuals against continuous predictor variables. We did not observe a nonlinear pattern, indicating that the linearity assumption was reasonable. The distribution of standardized residuals was slightly skewed due to the presence of outliers. We determined these outliers to be appropriate data points and decided to include them in the model. We tested for homoscedasticity by plotting residuals against fitted values, which produced a random scatter indicating homoscedasticity. Finally, we checked for multicollinearity using variance inflation factor (VIF). All explanatory variables had low VIF values.

DISCUSSION

We found that longer DIDO time for STEMI patients requiring transfer for acute coronary intervention was associated with a longer ED admitted LOS. However, an approximately one-hour increase in ED admitted LOS was associated with only a five-minute longer DIDO time – unlikely to be clinically significant as this duration represents approximately 4% of the maximum recommended benchmark. Such a small increase in DIDO for a large increase in ED LOS suggests that crowding may have a minimal effect on an ED's ability to identify and transfer patients requiring acute coronary intervention.

Since the presentation of individual time-sensitive diseases (e.g., STEMI) can occur infrequently depending

upon the ED's patient volume, measures that capture hourly and daily ED performance for the general ED population may represent more effective measures of a system's readiness to handle time-sensitive emergencies. Our findings suggest that measures dissimilar to the admitted population (e.g., overall ED LOS) may not reliably reflect timeliness for critical conditions such as STEMI. Moreover, performance measures involving admitted patients may be a better indicator of the quality of time-sensitive conditions (e.g., STEMI) compared with other crowding measures. For example, the boarding time measure captures the ED population who are admitted and waiting for a hospital bed. Considering that hospital congestion can limit bed availability in the ED, the degree of boarding affects not only admitted patients, but those who may be discharged home as well. On the other hand, other measures involving discharged patients and waiting time to see a clinician may not reflect the key process step for rapid diagnosis of a STEMI, namely EKG use. For example, in order to comply with the AHA guidelines for a rapid EKG,[6] EDs have developed evidence-based triage protocols to obtain EKGs on patients with symptoms suggestive of STEMI at arrival prior to clinician evaluation.[12] Concerning EKGs and patients with presentations consistent with STEMI can result in the patient bypassing any triage line and trigger early activation of the transfer process. Patients with a suspected STEMI are therefore likely to have a much shorter waiting time to be seen by an ED clinician as a direct result of these policies. However, patients with suspected STEMI represent a minority of the ED population, and therefore, true waiting times are likely to be much longer.

While we found a minimal influence of ED crowding on transfer timeliness, one finding of our study is that nearly 70% of included EDs did not meet the recommended 45-minute DIDO threshold. This finding is consistent with other studies examining the 45-minute benchmark.[7] This suggests that there is a substantial opportunity to improve the timeliness of transfers for patients with STEMI from U.S. EDs. As other studies have also identified a similarly poor national transfer performance,[3,13] we recommend enhancing the prominence of transfer performance by publicly reporting the proportion of patients meeting the 45-minute benchmark. Doing so would provide more meaningful data to consumers and for quality improvement efforts.

LIMITATIONS

Our results should be considered in light of several limitations. As this is an administrative dataset, we did not know the pPCI capabilities of facilities, which may affect the timeliness and decision to transfer. We also did not know the proximity of each facility to pPCI centers; however, rural/urban status is a proxy measure for this facility characteristic. Since these facilities had ≥10 transfers annually, our results are not generalizable to facilities with lower patient volume (i.e., less than 10 transfers). While there were 1,395 facilities that had results unavailable for the reporting period, this likely had minimal effect on our results as eligible facilities face large financial penalties for not reporting measure OP-3b to CMS. Further, this group also includes critical access hospitals that likely care for few patients with STEMI.

CONCLUSION

Among STEMI patients presenting to U.S. EDs, we found that ED crowding has a small but operationally insignificant effect on STEMI DIDO times. These results suggest that ED performance during the transfer of STEMI patients is minimally affected by ED crowding. As few EDs meet a recommended transfer time of 45 minutes, we propose that CMS report the proportion of STEMI patients who meet recommended DIDO times.

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Voluntary Medical Incident Reporting Tool to Improve Physician Reporting of Medical Errors in an Emergency Department

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Introduction: Medical errors are frequently under-reported, yet their appropriate analysis, coupled with remediation, is essential for continuous quality improvement. The emergency department (ED) is recognized as a complex and chaotic environment prone to errors. In this paper, we describe the design and implementation of a web-based ED-specific incident reporting system using an iterative process.

Methods: A web-based, password-protected tool was developed by members of a quality assurance committee for ED providers to report incidents that they believe could impact patient safety.

Results: The utilization of this system in one residency program with two academic sites resulted in an increase from 81 reported incidents in 2009, the first year of use, to 561 reported incidents in 2012. This is an increase in rate of reported events from 0.07% of all ED visits to 0.44% of all ED visits. In 2012, faculty reported 60% of all incidents, while residents and midlevel providers reported 24% and 16% respectively. The most commonly reported incidents were delays in care and management concerns.

Conclusion: Error reporting frequency can be dramatically improved by using a web-based, user-friendly, voluntary, and non-punitive reporting system. [West J Emerg Med. 2015;16(7):1073-1078.]

INTRODUCTION

The emergency department (ED) is an error prone environment, with previous studies reporting 51–70% of errors occurring in the ED as preventable.[1-3] This proportion is higher than any other patient care area in those studies. ED clinicians manage multiple patients in a complex-chaotic environment. High cognitive loads and frequent interruptions have been reported as fundamental sources of medical error in the ED.[2,4,5] In regard to crowding,[6,7] the ED remains an extremely decision-dense environment, where competing interests must be frequently re-prioritized according to continuously changing conditions. Identifying and remediating these errors, as well as mitigating harm, have become fundamental operational imperatives of ED leadership.

Medical errors must be accurately identified and contextualized in order to appropriately analyze them and create prevention strategies.[8] Incident reporting systems are valuable systems to aid in the identification of errors.[9-12] However, most are institution-based and centrally managed by the risk management and quality assurance (QA)

departments of the hospital, rather than the departments in which the error occurred.[13,14] Lack of service line ownership, along with burdensome reporting processes and fear of liability and embarrassment[15] have been described as the reasons for extremely low physician incident reporting rates.[13,16]

In 2008, our institution's emergency medicine (EM) QA committee analyzed the existing process of error evaluation and discovered that the process was ineffective and inefficient. Very few ED errors were voluntarily reported to the hospital-wide (centralized) system and those reported often lacked sufficient detail for meaningful analysis. The majority of errors were identified based on inconsistent and non-standardized referrals from other services or electronic medical record (EMR) reviews using the following triggers: (1) unscheduled return to the ED within 72 hours of initial visit with admission/hospital observation; (2) death in the ED; (3) death within 72 hours of admission; and (4) an unanticipated escalation of care ("rapid response") within 24 hours of admission. The yield of actionable errors from other service lines and triggered reviews was poor. Both methods required extensive EMR review to identify involved personnel and determine which details were relevant. Accounts obtained from the involved clinicians regarding patient encounters were non-standardized, often incomplete, and subject to recall bias due to delays of 30 days or more from the date of the incident.

A more timely and efficient method to identify errors that occur in the ED was necessary in order to create an actionable medical error registry. Therefore, as part of a quality improvement strategy, a plan was developed to create a registry that would facilitate continuous analysis of ED errors. The objective of the analysis was to identify the system, cognitive and non-remediable factors that contributed to the error in order to make recommendations to prevent the recurrence of the error. Increasing the reporting of larger proportion of all potential errors was critical to the development of a robust error registry. The QA committee was comprised primarily of emergency physicians certified by the Physician Quality and Safety Academy, an intra-institutional program designed to educate physicians in the application of improvement science methods and strategies to attain departmental and institutional quality goals.
In this article, we describe how a service line specific, voluntary, incident reporting system was created and used to improve emergency provider reporting in a peer-review protected environment. The focus of this article is on the development of the incident reporting system and its effect on reporting, rather than on the incident review process. To our knowledge, there are no publications that describe mechanisms that increased ED physician incident reporting.

METHODS

The reporting system was developed in an EM residency training program with two sites, an urban tertiary referral, Level I trauma center with an annual census of 60,000 ED patient visits, and a county hospital with an annual census of 70,000 ED patient visits. The incident reporting system was based on the characteristics described by Dr Leape,[17] and used the characteristics described for a successful incident reporting system. These included being voluntary, simple to use, non-punitive, confidential, timely, responsive, and system oriented.

The first phase of the development was designed to address the inefficiencies of the prior system, adopt characteristics of successful error reporting systems, and remove the reporting barriers outlined in the literature.[17-21] The system operated independently of the hospital-wide reporting systems at both EDs in order to ensure that the EM QA committee maintained the ability to manage reported data. Access to the system was limited to EM faculty, residents and advanced practice providers (APP). The rationale for this limitation was to ensure that the initial focus was on those participants that the literature identified as poor reporters. All iterations of the system were web-based and password protected, accessible from any location with Internet access. Data entry was limited to a single page and standardized for listed incident types. The required fields were related to patient and clinician identification, selection of a predefined incident types and a free text narrative. We limited the incident types to seven general categories familiar to reporters and easily identifiable to those without quality science expertise, specifically: management concern, delay in care, procedural issue, medication error, handoff-checkout issue, near miss, consultation issue, and diagnostic error. The system limited users to one incident type per report; however, there was no limit on the number of involved clinicians that could be selected.

All reported data were stored on a password-protected database accessible solely by the QA committee members. Each incident reporter was identified using the username and password required for access and that information was displayed only to the EM QA committee. The rationale for mandatory reporter identification to the committee was to ensure that reporters submitting unclear or incomplete reports could be contacted for clarification. All clinicians involved with an incident report were contacted by email and asked to complete a standard paper form that included sections for the following: (1) a free text narrative of the patient encounter, (2) selection of predefined contributing factors (system, cognitive, and non-remediable), (3) their impression of the patient acuity during their evaluation. as well as (4) their impression of state of the department before, during and after the patient encounter. The committee used the involved clinicians' impression of the patient acuity and state of the department to gain a better appreciation of the environmental context in which the clinical decisions were made. Only the EM QA committee members had access to the details of the involved clinician reports. The multidisciplinary EM QA committee, made up of both quality science and clinical domain experts

including physicians, APPs, and nurses, reviewed the reported incidents and provided feedback to the involved and reporting clinicians either directly or during the monthly QA conference. In an attempt to mitigate the negative associations of incident reporting as only representing errors, "Interesting case" and "Resident/APP excellence" menu items were added as new incident types in August 2010.

The second major iteration of the system included email notification of all identified involved clinicians immediately following the initial incident report submission, based on the rationale that by decreasing turnaround time from incident occurrence to clinician notification would decrease clinician recall bias. Involved clinicians, following such notification, could read the submitted incident narrative without knowledge of the reporter's identity. Clinicians were able to renounce involvement in the incident with a single click or recount their perspective of the patient encounter using a free-text narrative and checkboxes. They were also required to select from the predefined system, cognitive and non-remediable factors that contributed to the error using checkboxes. Repeat email notifications were sent to the involved clinician if they did not respond within 72 hours of incident submission. Each clinician could review the list of incidents that they reported as well as those in which they were listed as the involved clinician. The summary of the QA incident review along with suggestions to decrease the recurrence and harm of the incident could be viewed from that list. This last feature allowed the QA committee to provide timely, direct and individualized feedback to the involved as well as the reporting clinicians. The QA committee also had the ability to remove incorrectly assigned clinicians as well as assign new clinicians identified during the incident review. Critical care cases, documentation issue, triage issue and boarding issue were added as new incident types, and the ED clinical pharmacist was given access to report incidents. All the iterative modifications of the system were based upon the feedback provided by the users and agreed upon by all members of the QA committee.

Formal review of reported incidents by the EM QA committee occurred each month. Monthly cases were anonymously presented to residents, APPs, faculty physicians and nursing leadership to discuss errors with educational merit, disseminate policy or system modifications, generate consensus on best practices, and reinforce commitment to patient safety. Objectives of the case presentations were to encourage clinicians to (1) recognize the error prone nature of the ED, (2) report near misses, errors, and adverse events without fear of negative repercussions, (3) increase collaboration with other ED staff and medical disciplines to seek out and sustain safer workflows and processes, and (4) provide feedback of the errors identified in the ED.

This project was approved by the institutional Committee for the Protection of Human Subjects. It was part of a QA/process improvement strategy to decrease the recurrence of medical errors in the ED.

RESULTS

Between March 2009 and December 2012, 1,229 incidents were reported. The total incident reports for 2009, 2010, 2011 and 2012 were 81, 177, 410 and 561 respectively. When compared to the total ED visits over this time period, the rate of reported incidents were 0.07%, 0.15%, 0.34% and 0.44% for fiscal year 2009 to 2012 respectively (Figure 1). Incident reporting at the tertiary care ED steadily increased over the years; however, a four-fold increase in incident reporting was noted at the county ED after the second quarter in 2011.

Figures 2 and 3 illustrate the data entry and review sections of the latest version of the medical incident-reporting system. Table shows the number of distinct ED faculty, resident and APP reporters at both EDs as well as their relative percentage of available ED clinicians that year. With the exception of the APPs at the tertiary ED, the number of faculty, resident and APP reporters increased each year at both EDs. The number of resident reporters at the county ED dramatically increased in 2012.

Increased faculty participation was demonstrated every year; 33% of faculty reported an incident in 2009 while 76% of faculty reported an incident in 2012. Similar results were noted with resident and APP participation. Resident participation increased from 24% of residents reporting an incident in 2009 to 72% reporting an incident in 2012, and APP participation increased from 4% of midlevel clinicians reporting an incident in 2009 to 61% reporting an incident in 2012.

Faculty submitted the most incident reports each year at both EDs (Figure 1). Generally the number of reports by each reporter type at both EDs increased each year. The most significant increase in faculty and APPs reporting occurred in 2011 at the county ED.

The average number of reports per distinct reporter increased each year at both hospital sites with the exception of the faculty physician reports at the tertiary care ED in 2012.The most commonly reported incidents each year were management concern and delay in care.

DISCUSSION

We have described the successful design, implementation and utilization of a department-specific incident reporting system, a core component of a comprehensive quality improvement process. The frequency of incident reporting by physicians increased from 81 reported incidents in 2009 to 561 in 2012. To provide perspective as to the number of incidents reported, our tertiary care institution, which is an 800-bed hospital, receives approximately 1,000 incidents/year reported by physicians, which includes all the departments of the hospital, in their central variance reporting system. With the creation of our department-specific tool as part of our comprehensive quality improvement program, we generated 50% of those reports as a single department.

We believe that the increase in reported incidents also represents a shift in the safety culture of the department, as

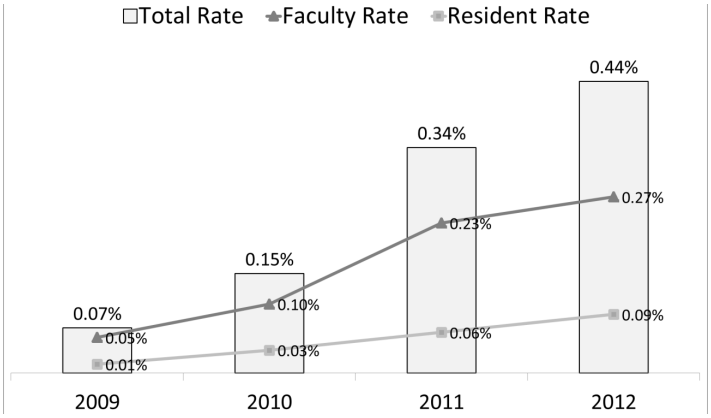

Figure 1. Annual total rate of all incidents reported with faculty and trainee rates of incident reporting.

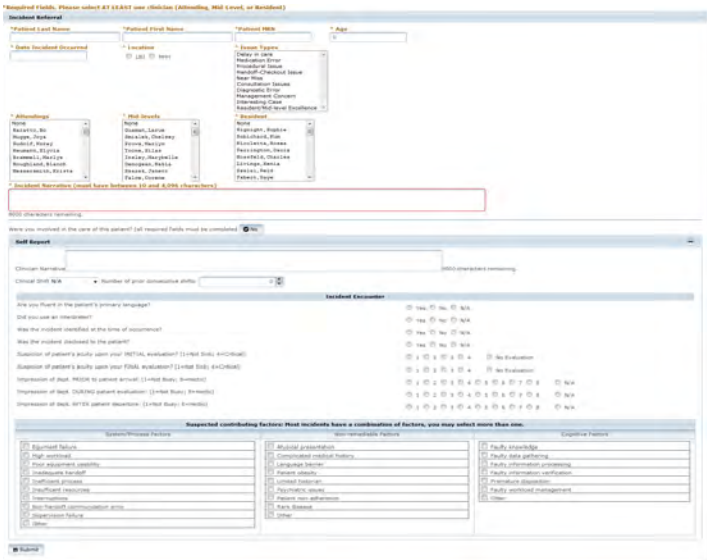

Figure 2. Screen shot of the data entry section of latest iteration of the medical incident reporting system. The attending, midlevel and resident names in this image are fictitious. Any resemblance to real persons, living or dead, is purely coincidental.

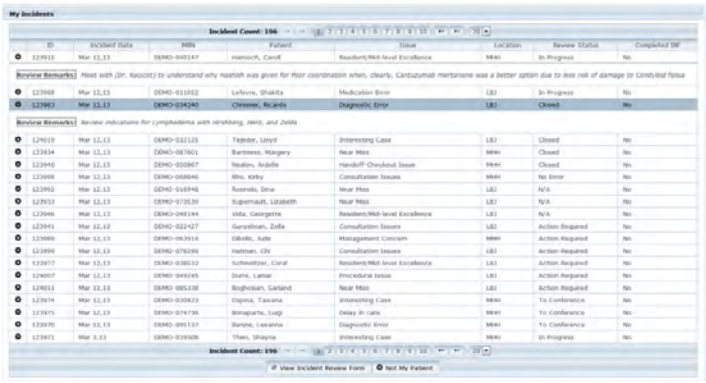

Figure 3. Screen shot of the incident review section of latest iteration of the medical incident reporting system. The "Self Report" section of the data entry section is only displayed if the reporter indicates involvement in the incident. The review remarks in the incident review section contain the feedback from the EM QA committee for each incident and are only displayed by user selection. Medical record numbers and patient names in the adjacent image are fictitious. Any resemblance to real persons, living or dead, is purely coincidental.

increasing comfort with reporting is becoming a part of the routine ED operation. In addition, this system has allowed a more complete assessment of reported incidents by providing more comprehensive data regarding the encounter, allowing for a more accurate understanding of factors that may have played a role. Despite the increase in reported events and better understanding of the involved factors in the potential error, it is very difficult to assess the impact of these processes on patient outcomes due to the fact that it is difficult to measure the number of subsequent patient encounters with similar clinical presentation that were managed in a more appropriate manner. Anecdotal evidence from our reported incident reviews suggests findings similar to other published studies.[22,23] For example, our trigger-based EMR review process was inefficient and ineffective for the detection of near misses, medication errors and procedure errors. Even though the majority of errors identified via the traditional trigger-based EMR chart review were treatment delays, diagnostic errors and inappropriate dispositions, higher proportions were noted with our reporting system.

This project also corroborates the findings of previous studies,[13, 24] showing that trainees did not report incidents as frequently as the faculty. However, in our study the rate of reporting for the trainees improved in similar fashion to the faculty reporting. This is an important finding as it reiterates the importance of adequate curriculum development and education in the area of practice-based learning and system-based practice core competencies, which have been part of the evaluation of U.S. trainees for the past decade. We incorporated the data from reported incidents into performance improvement projects for the trainees and faculty, required for trainees by the Accreditation Council for Graduate Medical Education and for faculty as part of their re-certification process.

In addition to being consistent with prior publications that described the characteristics of a successful reporting systems and suggested methods to remove barriers to physician reporting,[17,18,21,25] our project suggests other characteristics necessary to improve reporting and subsequent review. Our iterative developmental process with active feedback solicitation suggested that a successful system must do the following: (1) provide immediate notification to the involved clinicians to decrease the recall bias, (2) allow the involved clinicians to enter their narrative of the patient encounter directly into the system for a timely incident review, (3) allow the involved clinicians to receive timely, direct and individualized feedback from the system

Table. Number for distinct reporters per reporter type and the relative percentage of emergency department (ED) clinical staff.

	Tertiary ED			County ED		
Year	Faculty	Resident	Midlevel	Faculty	Resident	Midlevel
2009	12/37 (32%)	11/43 (24%)	0/5 (0%)	8/37 (22%)	0/9 (0%)	1/23 (4%)
2010	19/45 (42%)	22/45 (49%)	2/7 (29%)	12/42 (29%)	3/32 (9%)	6/21 (29%)
2011	23/42 (53%)	26/53 (49%)	1/10 (0%)	24/42 (57%)	6/53 (11%)	13/22 (59%)
2012	29/41 (71%)	31/60 (52%)	0/16 (0%)	26/38 (68%)	29/60 (48%)	14/23 (61%)

regarding incidents they were either involved in or reported to ensure that accessing the system becomes habitual, (4) include non-medical error incident types to the reporting system to mitigate negative connotations associated with use of the system, (5) allow for analysis of the reported incidents (at least initially) by peer experts who understand the environmental context in which the incident occurred, and (6) allow for restructuring of the incident review process and workflow as reporting increases is necessary to ensure timely feedback.

To our knowledge, this is the first report describing a service specific incident reporting tool as part of a comprehensive quality improvement process to improve physician reporting and subsequent analysis of the incidents to better ascertain the involved factors in the occurrence of errors.[26] We have also provided a potential plan for other departments attempting to create a similar system at their individual institutions.

LIMITATIONS

The first and most important limitation is the inability to determine a true denominator in order to measure error reporting rates. However, we have provided a rate of incident reports as compared to total ED visits for the respective years to further clarify that the reported incidents did truly represent an increase in incident reporting. Second, differentiating the portion of the reported incidents resulting from an adoption of a safety culture from the portion resulting from access to an improved reporting system is difficult. In addition, in this type of work it is very difficult to delineate the true impact on patient outcomes of increased incident reporting. However, without an appropriate mechanism for reporting potential errors, not even the best intended safety systems can increase the identification, analysis and remediation of errors. Lastly, we understand that due to the voluntary nature of such systems, this process of error identification is subject to selection bias and likely represents only a fraction of existing errors.

CONCLUSION

Our project illustrates that error reporting frequency by physicians can be dramatically improved by using a web-based, user-friendly, voluntary, and non-punitive reporting system. To be successful, such a system must evolve to meet the requirements of users. Our study also suggests that transparent and decentralized service-specific incident review and quality improvement teams could support error-reduction strategies for the hospital system by increasing incident reporting, analysis, and interventions within specific service lines.

Despite the inability to capture all errors, these reported incidents represent an important opportunity for improving patient safety, and can serve as an foundation for improvement in the education of our trainees in the areas of practice-based learning and system-based practice, as well as in creating performance improvement projects required for re-certification of the faculty. This project is a critical component of transforming the departmental culture into one that is patient centered, self-reflective, and proactive regarding practice improvement.

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DISCLOSURES

None of the authors have any conflicts of interest to disclose in regards to this study.

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The Changing Use of Intravenous Opioids in an Emergency Department

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Introduction: Government agencies are increasingly emphasizing opioid safety in hospitals. In 2012, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) started a sentinel event program, the "Safe Use of Opioids in Hospitals." We sought to determine if opioid use patterns in our emergency department (ED) changed from 2011, before the program began, to 2013, after start of the program.

Methods: This was a retrospective study of all adult ED patients who received an intravenous opioid and had a serum creatinine measured. We recorded opioids used, dose prescribed, and serum creatinine. As an index of the safety of opioids, uses of naloxone after administration of an opioid was recorded.

Results: Morphine is still the most commonly used opioid by doses given, but its percentage of opioids used decreased from 68.9% in 2011 to 52.8% in 2013. During the same period, use of hydromorphone increased from 27.5% to 42.9%, while the use of fentanyl changed little (3.6% to 4.3%). Naloxone administration was rare after an opioid had been given. Opioids were not dosed in an equipotent manner.

Conclusion: The use of hydromorphone in our ED increased by 56% (absolute increase of 15.4%), while the use of morphine decreased by 30.5% (absolute decrease 16.1%) of total opioid use from 2011 to 2013. The JCAHO program likely was at least indirectly responsible for this change in relative dosing of the opioids. Based on frequency of naloxone administered after administration of an opioid, the use of opioids was safe. [West J Emerg Med. 2015;16(7):1079-1083.]

INTRODUCTION

Preventing adverse medication events is a high priority for healthcare providers, hospitals, and governmental agencies. In 2012, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) issued a sentinel event-alert program, "Safe Use of Opioids in Hospitals."[1] Since the start of the program, governmental and regulatory agencies have closely evaluated the use of opioids when assessing hospitals. One area of interest has been the use of morphine in patients with renal dysfunction. Morphine has two major metabolites: morphine-6-glucuronide and morphine-3-glucuronide.[2] Morphine-6-glucuronide can accumulate in patients with renal dysfunction, leading to respiratory depression and failure.[2] With heightened awareness of this risk, our hospital has, through various

measures, such as pharmacy-order verification and intervention, limited the prescribing of morphine for patients with renal dysfunction in the emergency department (ED).

In intensive care settings, participation of dedicated pharmacy services has reduced medication errors.[3,4] While such services have been less studied in EDs, pharmacists are becoming more involved in emergency care, assisting with medication reconciliation and order verification.[5] One area in which pharmacists are intervening is in suggesting alternative opioids for morphine in patients with renal dysfunction. Intravenous opioid alternatives include hydromorphone and fentanyl; hydromorphone is the more commonly used opioid because the pharmacokinetics of fentanyl are shorter acting.[6,7]

In addition to recognizing the importance of using opioid replacement for morphine in patients with renal dysfunction, it must be appreciated that opioid medications should be dosed in equipotent amounts. In the era of electronic medical recordkeeping, dosing choices often are pre-selected, or an option is given to manually input a desired dose. About the time the "Safe Use of Opioids in Hospitals" program was begun, the makers of hydromorphone reduced the recommended dosing range from 0.2-2mg to 0.2-1mg.[8] Despite the manufacturer's recommendation, however, our institution did not change our pre-selected doses until 2014.

Given that around the start of 2012, JCAHO instituted the "Safe Use of Opioids in Hospitals" program, and the manufacturer of hydromorphone reduced its recommended dosing, we have examined whether these measures affected our usage of opioids in the ED. We compared opioid usage in the year 2011, before publication of the advisories on opioid use, to usage in 2013. Our aims were to determine if there was a change in which opioids were used, to determine if the medications were dosed in an equipotent manner, and to determine if there was a change in opioid-related adverse events, as defined by the use of naloxone after an opioid was given.

METHODS

This retrospective study was performed in an academic, urban, tertiary care, Level I trauma center which has an emergency medicine training program. The department has an annual census of approximately 85,000. In part one of the study, data was abstracted from the first 35,000 subjects seen each year (2011 and 2013) who met all inclusion criteria. The inclusion criteria were the following: patients aged 18 years or older; parenteral opioid administered during the ED visit; and serum creatinine measured during the visit. The intravenous opioids studied were morphine, fentanyl, and hydromorphone. If subjects met inclusion criteria we collected the following data: opioid used, opioid dose, serum creatinine, and, if available, weight. In the second part of the study, all ED use of naloxone during 2011 and 2013 was evaluated. We aimed to quantify how frequently naloxone was used after an opioid was given and if any particular opioid was associated with increased naloxone use.

Initial statistical evaluation of the data included a student's t-test to evaluate for statistical significance. Despite log transformation of the data due to the non-normal distribution, every result reached statistical significance, despite no clinical difference in the data, due to the large size of the data being analyzed. We therefore chose to present the data in the form of medians with interquartile ranges. This study was approved by our institutional review board.

RESULTS

Composite data and opioid-specific data are summarized in Tables 1a, 1b, and 1c. In composite data it can be seen that the total doses of opioid administered and the doses per patient were moderately higher in 2013 than in 2011. Patients' median serum creatinine concentrations in the two years were not significantly different. Recorded weights were available in only 3% of the subjects, so this measurement was excluded from further analysis.

In opioid-specific data, no significant differences between the years 2011 and 2013 in patients' ages, dose per administration of opioid, or medium serum creatinine concentrations were recorded for patients who received fentanyl, hydromorphone, or morphine.

We assessed the equivalency values for the use of hydromorphone and fentanyl compared with morphine in 2011 and 2013. In both years, we found that the opioids were not prescribed in a dose-equivalent manner. That is, the usual dose of hydromorphone prescribed (1mg) was equivalent to 7mg of morphine, whereas the usual dose of morphine prescribed was 4 mg. The usual dose of fentanyl prescribed (50μg) was equivalent to 5mg of morphine.[9]

The use of naloxone is presented in Tables 2a and 2b. The rate of usage of naloxone was similar in 2011 and 2013. No differences between 2011 and 2013 in the patients' ages or serum creatinine concentration, or in doses of naloxone given were found. In 16 of the 22 patients given naloxone after administration of an opioid, the patients' home medication lists included sedative hypnotics, including benzodiazepines; sleep medications; or medications classified as "muscle relaxants." Additionally, three of the patients had ethanol levels of 120mg/dL, 156mg/dL, and 180mg/dL, respectively. No single opioid (fentanyl, hydromorphone, or morphine) was associated with uniquely higher rates of naloxone usage. Only a small percentage of patients who received naloxone received it after the administration of an opioid in our department (about 2%); the vast majority of naloxone was given for diagnostic purposes.

DISCUSSION

The principal aim of this study was to determine if JCAHO's "Safe Use of Opioids in Hospitals" program and the manufacturer's reduced recommended dosage of hydromorphone (both instituted in about early 2012) influenced the prescribing practices for opioids in our ED. We

Table 1a. Demographics and composite data in study of opioid administration.

	2011	2013
Total patients (N)	35,000	35,000
Male	18,812 (45.1%)	19,155 (54.6%)
Total doses administered	79,879	86,800
Fentanyl	2,855 (3.6%)	3,728 (4.3%)
Hydromorphone	21,950 (27.5%)	37,269 (42.9%)
Morphine	55,074 (68.9%)	45,803 (52.8%)
Doses/patient	2.28	2.48

Table 1b. Demographics and composite data in study of opioid administration.

	Median	IQR (25-75%)	Median	IQR (25-75%)
Age (yrs)	44.8	31.5-57.3	45.5	32.0-58.1
Creatinine (mg/dL)	0.81	0.63-1.08	0.91	0.60-1.02

Table 1c. Opioid-specific data.

	Median	IQR (25-75%)	Median	IQR (25-75%)
Fentanyl				
Age (yrs)	44.9	30.1-56.9	43.9	31.8-58.1
Dose/administration (μg)	50	30.0-100.0	50	40.0-100.0
Creatinine (mg/dL)	0.83	0.72-1.14	0.76	0.60-1.04
Hydromorphone				
Age (yrs)	43.2	31.2-53.6	42.2	33.3-55.2
Dose/administration (mg)	1.0	1.0-1.0	1.0	0.6-1.0
Creatinine (mg/dL)	0.79	0.64-0.99	1.0	0.59-1.05
Morphine				
Age (yrs)	44.2	31.1-56.9	43.0	31.2-57.4
Dose/administration (mg)	4.0	4.0-4.0	4.0	4.0-4.0
Creatinine (mg/dL)	0.82	0.68-1.00	0.86	0.61-1.00

Table 2a. Summary of naloxone use in the emergency department.

	2011	2013
Total patients who received naloxone (N)	537	598
Male	202 (37.6%)	246 (41.2%)
Patients given naloxone after opioid was given	10	12

Table 2b. Summary of naloxone use in the emergency department.

	Median	IQR (25-75%)	Median	IQR (25-75%)
Age (yrs)	49.6	36.1-56.0	48.6	35.2-55.2
Dose (mg)	0.4	0.4-1.0	0.4	0.2-1.0
Creatinine (mg/dL)	0.93	0.8-0.96	0.94	0.73-1.51

sought to determine if there was a change in which opioids were used, if the medications were dosed in an equipotent manner, and if there was an increase in opioid-related adverse events, as defined by the use of naloxone after receiving an opioid in the ED.

We found, first, a modest increase in the percentage of hydromorphone prescribed, with a corresponding decrease in the percentage of morphine prescribed. The explanation for this change is not definitely known. However, we believe that JCAHO's program was at least indirectly responsible: The program drew attention to the risks of morphine in patients with renal dysfunction, and our pharmacy responded by emphasizing this risk and in limiting the prescribing of morphine in such patients. Our prescribers also increasingly perceived hydromorphone as generally safer than morphine, at least in patients with renal disease. Whether this perception is justified, however, is not definite since hydromorphone, like morphine, has renally cleared metabolites. Hydromorphone-3-glucoronide, the principle active metabolite of hydromorphone, is renally cleared, and dose reductions for hydromorphone in patients with renal failure also are recommended.[9,10] Hydromorphone-3-glucoronide has been associated also with neuroexcitatory behavior, such as seizures, which occur as often or more often with morphine metabolites.[10] One potential advantage of hydromorphone is that hydromorphone-3-glucoronide is not associated with respiratory depression mediated by the mu-2 receptor, whereas morphine-6-glucoronide is.[11] The safest opioid in renal failure is fentanyl, which has no renally excreted metabolites,[11] but fentanyl is not favored in ED use because of its short duration of action.[6]

Our second major finding was that during the study period we did not prescribe opioids in an equipotent manner; the median dose of hydromorphone was almost double that of the median morphine dose, and fentanyl also was used at a somewhat higher dose than morphine. When evaluating our interquartile ranges, our study showed that we typically gave a dose of 4mg of morphine and 1mg of hydromorphone, which is equivalent to 7mg of morphine. This practice did not change between 2011 and 2013, perhaps because our institution did not update the pre-selected dosing choices in the electronic prescribing system. As institutions set up and modify electronic order set options, attention should focus on dose equivalency since providers often default to pre-selected order entry. At our institution, there also appears to be a belief that hydromorphone has superior analgesic effect, but our data suggest that patients are receiving a significantly more potent doses of hydromorphone than of morphine, and this difference may account for a difference in observed analgesic effect. With the varying complexities of opioid metabolism in high-risk patients, such as those with renal failure, it is important that educational programs, such as ours, adjust appropriately to changing policies for opioid prescribing.

Our third major finding was that naloxone was infrequently needed after opioid use in the ED. Also, no association of a specific opioid with naloxone use was identified. About 98% of naloxone used in our ED was given as a diagnostic or therapeutic aid prior to any opioid given, not in response to suspected adverse reaction to the opioid we had given. Several patients who required naloxone had sedative hypnotic medications listed on their daily medication list, so we suspect that they may have had pre-admission use of agents that could have potentiated the effects of the opioids we administered. However, we did not abstract the medication lists of those patients who received opioids but did not require naloxone, so we cannot draw conclusions about risk factors for naloxone use in our population. The very low frequency of naloxone use after administration of an opioid in our series is evidence that the use of opioids in our department is safe. Of note, we defined in this study that the use of naloxone after an opioid represented an adverse drug event. However, this may not represent a clinical error. Several examples of this were noted during chart abstraction such as a patient with abdominal pain receives an opioid early in their course only to become septic from their intra-abdominal infection and become somnolent. Providers recognizing they treated with an opioid gave naloxone to see if clinical improvement occurred. This would be considered appropriate clinical care, but represented an adverse drug event as defined by our study.

Our final major finding was that total opioid doses increased from 2011 to 2013 at 79,879 to 86,800 doses respectively. This represented a change from 2.28 doses per patient to 2.48 doses per patient of a parenteral opioid. In the era of increasing opioid addition and awareness of opioids, this is a trend that should be further examined.[13] However, this is likely multi-factorial and other reasons such as ED crowding and longer wait times prior to being treated by a healthcare provider should be considered. Regardless the cause, physicians need heighted awareness of opioid use and prescribing patterns.

LIMITATIONS

Our study has limitations. Our inability to collect weights on a significant proportion of our patients prevented us from calculating weight-bases dosing of opioids prescribed. Second, this analysis did not include patients who did not have an objective measurement of renal function, so the results cannot be extrapolated to all patients in the ED. Third, because of the large amount of our data it was not feasible to extract the medical records and medication lists of all patients included in the study; rather, we extracted data from the electronic medical record with the help of our Institutional Clinical Translational Science Center, where coding errors could have occurred.

CONCLUSION

We concluded that, in our ED, the percentage use of

hydromorphone increased, while the percentage use of morphine decreased, between the year 2011 and 2013. Although not proven, this change may have resulted from the effects of JCAHO's program on "Safe Use of Opioids in Hospitals" and opioid-prescribing policies instituted within our medical center. We found also that during the period of the study we had not prescribed opioids on an equipotent basis with morphine. Education on equipotent dosing of opioids is important, as adverse events due to these errors are preventable. Finally, naloxone was infrequently needed after administration of an opioid, a finding that suggests that opioids are used safely in our ED.

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Opioid Considerations for Emergency Practice

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On a backdrop of increasingly distressing opioid misuse in our communities, and safety concerns expressed by The Joint Commission and others, emergency physicians are further increasing their utilization of these important agents in our patients.[1,2] Are we selecting the best opioid for our patients? Are we providing the relief they need? And are we doing this safely? We all hope these questions can effectively be answered yes, now and into our futures.

The timely report by Sutter et al.[3] quantifies the increasing use of opioids in their academic ED, demonstrating an increasing preference for hydromorphone (15% absolute increase in 2 years) over morphine (16% reduction), and a stable smaller proportion receiving fentanyl. The authors speculate that this change was driven by new pharmacy rules and electronic record restrictions on the use of morphine, promulgated in their organization. Additionally, in their practice, equipotent dosing of these agents was not generally performed. Finally, naloxone administration concurrent with the ED encounter after an opioid was documented infrequently (0.2% of total naloxone administrations). Generally, patients are satisfied when timely and effective analgesia is received, but disparities and individual variability in practice are still challenges going forward.[4,5]

The Patient Safety Movement Foundation recommends that "all patients receiving IV opioids have continuous … pulse oximetry" and those patients receiving supplemental oxygen have continuous respiratory rate monitoring. At a time when alarm fatigue and ED-crowding are factors which may distract providers from adequate monitoring, excessive monitoring may add additional burdens which may not ultimately benefit overall ED patient safety. Clinical personnel close to the bedside during the known peak action of the drug administered can provide both thoughtful monitoring and the immediate ability to respond.. The authors also point out that naloxone reversal was used ~73% of the time for patients with an increased likelihood of respiratory depression. This indicates that patient selection is important in avoiding adverse effects of opioids. Clearly patients with intoxication, sedation and other medications sedative-hypnotic agents on-board should be vigorously monitored and opioid dosing constrained.[6] Pre-existing headache, back pain, mental health, and substance use disorders were significantly associated with both additional ED and alcohol- or drug-related encounters (ADEs) . The use of schedule II long-acting opioids was strongly associated with ADEs and strong cautions against such practices seem warranted.[7]

It has been well documented that we are using opioids to effectively reduce patient suffering, in many differing clinical conditions.[8-10] Time to effective analgesia is especially important for those with severe pain from whatever source. Efforts to reduce unnecessary administration and use of opioids are appropriate, but they should not constrain our ability to provide necessary relief. This includes short-term ED prescriptions for analgesics, where no clear contribution to subsequent abuse can be shown.[11,12] However, given the recent association between opioid prescription and subsequent recurrent use, we should exercise appropriate cautions and use non-opioids when possible.[13]

Increasingly states have adopted approaches to monitor and provide practitioner feedback opportunities to monitor prescription drug prescribing. Reducing over-consumption, diversion and other misuses of prescription medications is an important goal shared by emergency medicine practitioners.[14]

Providing for life-saving and innovative interventions in the ED and our communities should be strongly considered. Mechanisms and policy for advancing the use of community based reversal of opioid over-doses is life-saving.[15] The administration of agents (like buprenorphine/naloxone) beginning during ED based care, has recently been shown to be beneficial compared to other strategies for opioid addicted patients.[16]

So it seems we have effective analgesic agents with a good safety margin when used appropriately with safe monitoring. Our ability to utilize them appropriately appears to depend upon early administration, dosage adjustment for patients at risk of adverse effects, appropriate monitoring, and advocating for innovations which will assist in reducing the risk of substance abuse and treatments.

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Transformative Leadership: Emergency Physicians Lead AOA and AMA

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This was a historic summer in Chicago for emergency medicine. On July 18, 2015, John W. Becher, DO, became the 119th president of the American Osteopathic Association (AOA), while a month earlier, on June 9, 2015, Steven J. Stack, MD, became the 170th president of the American Medical Association (AMA). This is the first time that emergency physicians have led the two largest professional physician organizations in the United States, and the first time that an emergency physician has led the AMA. Together, these two groups represent more than 330,000 medical students, residents, and practicing physicians, with the AMA representing nearly 232,000 members[1] and the AOA representing almost 110,000 osteopathic physicians and physicians-in-training.[2]

The election of emergency physicians to guide the AMA and AOA for the coming year is historic in the context of our specialty's evolution in organized medicine and, more broadly, as a leader in population health. The biographies of Dr. Becher and Dr. Stack reflect this evolution. For several decades, Dr. Becher has been the chair of emergency medicine at the Philadelphia College of Osteopathic Medicine (PCOM), one of the oldest academic departments of emergency medicine. While he has been involved in organized medicine and emergency medicine leadership positions throughout his career, Dr. Stack is the youngest AMA president in 160 years.[3] In the early days of our specialty, when a fledgling department of emergency medicine was being established at PCOM and a few other medical schools around the country and both MD and DO emergency physicians were working to establish specialty recognition and board certification, it would have been almost unimaginable that in a few short decades an emergency physician would become one of the youngest presidents in the history of the AMA. It is a testament to the growth and strength of our specialty and to the accomplishments of emergency physician leaders in the house of medicine.

The impact of emergency medicine on the leadership development of both Drs. Becher and Stack was evident in their inauguration speeches.[4,5] Drs. Becher and Stack gave credit to the central role of their training and experiences as emergency physicians in preparing them to lead their respective organizations. They cited the ability to adapt quickly under unexpected circumstances, being prepared for the unexpected, the unique place of emergency medicine in caring for patients and communities in their most vulnerable times, and the team-centered nature of clinical care in the emergency department as ways that emergency medicine equipped them to be leaders in organized medicine. Finally, Drs. Becher and Stack stressed their roles as servant leaders working within larger teams, both in their clinical work and as presidents of the AOA and AMA. Dr. Stack put this leadership lesson succinctly: "The lesson from the pages of history could not be more clear: an empire built by one man will not stand. An empire built by many endures."[5]

From a population health perspective, having emergency physicians at the helm of the AOA and AMA is a unique opportunity to impact U.S. healthcare for years to come, from how physicians are trained to how care is delivered to the presence of physicians in public policy discussions. Drs. Becher and Stack have discussed common themes during their tenure on the AOA and AMA boards of trustees and in their respective inauguration speeches: innovating medical education; meeting patient's primary healthcare needs; and, advocating in the public policy and legislative arena.

The education and training of an adequate physician workforce is a priority for the AOA and the AMA.[6-8] Specifically, both organizations have been part of larger stakeholder discussions of how to accelerate innovations and reforms in medical education that will prepare the physician of the future to engage in the challenges of a dynamic healthcare environment, and to encourage the longevity of those physicians once in practice. These transformations will occur in both undergraduate medical

education and graduate medical education (GME), with a renewed focus on competency-based outcomes, a unified GME accreditation system on the horizon, and continuing threats to GME funding.

Supporting strategies that meet the primary healthcare needs of patients was also a theme of both inauguration speeches. Specifically, Dr. Stack pointed to the need to improve outcomes for the millions of Americans with pre-diabetes and hypertension.[5] Dr. Becher highlighted the special role of the osteopathic profession in training primary care physicians.[4] And both leaders, as emergency physicians, stressed the integrated teams and interdisciplinary focus necessary to provide optimal outcomes across the care continuum.

Lastly, they discussed the need for engagement in advocacy for public policies that allow physicians to provide care in a system that meets the "Triple Aim" of improving the patient experience, improving population health, and reducing costs.[9] Among the issues raised by Dr. Becher and Dr. Stack include the transition to value-based reimbursement, meaningful use implementation, and the role of non-physician clinical providers.[7,10,11]

This is a historic year for emergency medicine as two of our specialty's leaders guide America's physicians during an era of healthcare transformation. The examples of Drs. Becher and Stack prove the unique preparation and skills emergency physicians bring to the challenges facing 21st century healthcare.

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Inability of Physicians and Nurses to Predict Patient Satisfaction in the Emergency Department

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Introduction: Patient satisfaction is a commonly assessed dimension of emergency department (ED) care quality. The ability of ED clinicians to estimate patient satisfaction is unknown. We sought to evaluate the ability of emergency medicine resident physicians and nurses to predict patient-reported satisfaction with physician and nursing care, pain levels, and understanding of discharge instructions.

Methods: We studied a convenience sample of 100 patients treated at an urban academic ED. Patients rated satisfaction with nursing care, physician care, pain level at time of disposition and understanding of discharge instructions. Resident physicians and nurses estimated responses for each patient. We compared patient, physician and nursing responses using Cohen's kappa, weighting the estimates to account for the ordinal responses.

Results: Overall, patients had a high degree of satisfaction with care provided by the nurses and physicians, although this was underestimated by providers. There was poor agreement between physician estimation of patient satisfaction (weighted κ=0.23, standard error: 0.078) and nursing estimates of patient satisfaction (weighted κ=0.11, standard error: 0.043); physician estimation of patient pain (weighted κ=0.43, standard error: 0.082) and nursing estimates (weighted κ=0.39, standard error: 0.081); physician estimates of patient comprehension of discharge instruction (weighted κ=0.19, standard error: 0.082) and nursing estimates (weighted κ=0.13, standard error: 0.078). Providers underestimated pain and patient comprehension of discharge instructions.

Conclusion: ED providers were not able to predict patient satisfaction with nurse or physician care, pain level, or understanding of discharge instructions. [West J Emerg Med. 2015;16(7):1088-1093.]

INTRODUCTION

Patient satisfaction is an increasingly important metric that is being measured in emergency departments (ED) across the country. Patient satisfaction scores have a wide effect on outcomes for patients, providers, and healthcare organizations. For patients, previous studies have associated high levels of patient satisfaction with improved outcomes.[1] In terms of outcomes for providers, high satisfaction scores have been associated with a lower rate of patient complaints and possibly a lower rate of malpractice claims.[2,3] In addition, patient satisfaction scores are commonly tied to physician compensation. A recent study reported that 59% of physicians reported that their compensation was tied to their satisfaction scores in what is essentially a pay-for-performance model. Conversely 20% of providers reported that their employment had been threatened as a result of patient satisfaction data.[4]

For healthcare organizations, patient satisfaction scores are playing an increasing role in determining overall reimbursement. In 2012 the Center for Medicare and Medicaid services (CMS) began development of a Hospital Consumer Assessment of Healthcare Providers and Systems (HCAPS) patient satisfaction survey. While the exact implementation of this program is unclear, it stands to tie a significant portion of reimbursement from Medicaid to the results of the patient satisfaction survey.[5]

Given the increasing importance placed on patient satisfaction in EDs nationwide, extensive efforts have been made to identify factors that contribute to patient satisfaction; and interventions have been developed to improve overall satisfaction. Staff interpersonal skills, perceived wait times, effective and timely analgesia, the use of ED structure information cards and follow-up telephone calls have all been shown to influence patient satisfaction.[6-10] Various strategies have been employed to improve overall patient satisfaction from adjusting provider staffing to standardizing communication with patients, and even playing background music in the ED.[11-13]

To date there is minimal evidence to suggest that providers are able to accurately predict patient satisfaction. As an increasing number of programs are designed to improve patient satisfaction, it is crucial that providers are able to accurately estimate patient satisfaction. Our study evaluated the provider's ability to predict patient satisfaction.

METHODS

Study Design and Setting

This cross-sectional was performed at the University of Alabama at Birmingham (UAB) Hospital, an urban academic teaching hospital. The ED has 50 beds, all of which are private, and sees approximately 72,000 patients per year. The institutional review board at UAB approved this study.

Selection of Participants

Based on research staff availability, a convenience sample of 100 eligible patients was selected at the time of discharge from the ED. Patients were enrolled over a two-month period (July-August 2013), seven days a week between 6am and 11pm. Research staff used the Cerner FirstNet Triage and Tracking system to identify patients being dispositioned. Eligibility criteria included English-speaking ambulatory patients over 18 years old and deemed healthy enough to participate in the study. Exclusion criteria included intoxicated patients, prison inmates, patients with a primary psychiatric diagnosis, patients 18 years of age and under, and patients who entered the department as a trauma alert.

Method of Measurement:

At the time of disposition, research assistants approached eligible patients in their private treatment rooms. Prior to the patient exiting the department, study staff administered a face-to-face interview that consisted of 10 questions regarding their satisfaction with the visit and their pain management. Each of the questions were Likert items that allowed the patient to rate their satisfaction with physician care, nursing care, pain level and their understanding of the discharge instructions on a scale of 1 to 5.

Our survey was designed to resemble the format of our Press Ganey ED patient satisfaction surveys. Responses were measured on a scale of 1 to 5.[14] Our survey asked the patient to verbally rate their satisfaction with their nursing care, satisfaction with their physician, their pain level at the time of discharge and their understanding of discharge instructions. (See Addendum 1.) After interviewing the patient, research assistants interviewed the treating resident physician and nurse. Physicians and nursing staff were blinded to patient responses.

Data Analysis

We used descriptive statistics to characterize the patient sample. We used kappa statistics to evaluate the agreement between patient and physician responses and patient and nurse responses on like questions from their respective interviews. To account for the ordered data, we used weighted kappa. To provide a clear analysis, we simplified the five-point scale used in the interview into a three-point scale. On the three-point scale, we categorized scores of 1-2 as "satisfied," 3 as "neither" satisfied nor dissatisfied and 4-5 as "dissatisfied."

We used Excel to manage data (Microsoft, Inc., Redmond, Washington) and performed statistical analyses with Stata v. 13.0 (Stata, Inc., College Station, Texas).

RESULTS

Demographics (Table 1)

The mean age of patients completing the survey was 49.9 years. Thirty-one patients were rated with an emergency severity index of 2, 61 were rated 3, and 8 were rated 4. Sixty-six patients spent less than four hours in the ED, and a total of 45 patients were admitted.

Table 1. Demographics of patients included in patient satisfaction study.

Demographics	Demographic values (SD)
Mean age (SD)	49.9 (17.3)
Emergency severity index (ESI) (Number of patients)	
2	31
3	61
4	8
Mean ESI (SD)	2.77 (0.58)
Mean emergency department length of stay (SD)	3.66 hours (2.33)
Admission rate	45%

ESI, emergency severity index

Patient Satisfaction (Tables 2 and 3)

Overall patients had a high degree of satisfaction with 99% of patients reporting that they were satisfied with the nursing care and 96% reporting a similar degree of satisfaction with physician care. Despite the generally high level of satisfaction, there was poor agreement between the patient's responses and the provider's estimation of these responses. There was poor agreement between nurse and patient responses (weighted κ=0.11, standard error: 0.043);); similarly, there was poor agreement between physician and patient responses (weighted κ=0.23, standard error: 0.078). Providers tended to underestimate the patient's degree of satisfaction. Providers underestimated patient satisfaction with nursing in 12% of cases and with physicians in 18% of cases. There were no cases where nurses overestimated patient satisfaction and only one case where physicians overestimated patient satisfaction.

Pain Levels (Table 4)

Patients reported a wide variety of pain levels at discharge with ~62% reporting no pain, 20% reporting moderate pain, and 18% reporting that they were experiencing the a high level of pain. Both physician and patient responses (weighted κ=0.43, standard error: 0.082) and nurse and patient responses (weighted κ=0.39, standard error: 0.081) had poor agreement when estimating a pain level. Both nurses and physicians underestimated the patient's pain in 20% of cases. In 8% of the nurse's cases and 6% of the physician's cases, the patient reported severe pain while the providers predicted that the patient was in no pain.

Discharge Instructions (Table 5)

Patients reported that they fully understood their discharge instructions in 87% of the cases. Nurses underestimated patient comprehension in 6% of cases and physicians underestimated this response in 17% of cases. Nurses overestimated comprehension in 12% of cases, compared to 10% with physicians. There was poor agreement between physician and patient responses (weighted κ=0.19, standard error: 0.082) as well as nurse and patient responses. (weighted κ=0.13, standard error: 0.078)

We found that there was poor agreement between patient responses and provider estimates of the patient responses across all aspects of our survey. Overall providers tended to underestimate the level of patient satisfaction. In addition, providers underestimated patient's level of pain at discharge, and tended to underestimate a patient's comprehension of their discharge instructions.

DISCUSSION

In our study we found that providers are not able to reliably predict patient responses to questions similar to those commonly found on patient satisfaction surveys. While previous studies have attempted to identify factors that may contribute to patient satisfaction, few studies to date have evaluated provider's ability to predict patient satisfaction.

Boudreaux et al. examined whether providers were able to accurately estimate patient satisfaction. Providers were asked to predict the patient's response to a 22-question survey that focused on overall satisfaction and included questions regarding satisfaction with nursing and physician care and understanding of discharge instructions. Responses were obtained from 478 patients and 59 providers. The authors found that providers consistently underestimated the patients' reported satisfaction.[15]

Our study addressed a major limitation that was found in the paper by Boudreaux et al. Rather than asking providers to estimate patient satisfaction with a particular visit, they were asked to estimate the overall survey results for all the patients that had been seen in the department during the study

Table 2. Comparison between nurse assessment and patient report of satisfaction with emergency department nursing care. Percentages reflect column percentages. Weighted kappa for agreement between nurse and patient ratings=0.11 (Standard Error: 0.043).

	Patient reported satisfaction with nurse		
Nurse estimation of satisfaction	Satisfied	Neither	Dissatisfied
Satisfied	87 (87.9)	0 (0)	0 (0)
Neither	10 (10.1)	1 (100)	0 (0)
Dissatisfied	2 (2)	0 (0)	0 (0)

Table 3. Comparison between physician assessment and patient report of satisfaction with emergency department physician care. Percentages reflect column percentages. Weighted kappa for agreement between physician and patient ratings=0.20 (Standard error: 0.058).

	Patient reported satisfaction with physician		
Physician estimation of satisfaction	Satisfied	Neither	Dissatisfied
Satisfied	78 (81.3)	1 (33.3)	0 (0)
Neither	13 (13.6)	1 (33.3)	0 (0)
Dissatisfied	5 (5.2)	1 (33.3)	1 (100)

Table 4. Comparison between nurse and physician assessment and patient report of pain level. Percentages reflect column percentages. Weighted kappa for agreement between nurse and patient ratings=0.39 (Standard error: 0.081). Weighted kappa for agreement between physician and patient ratings=0.43 (Standard error: 0.082).

	Patient reported pain level		
Pain level estimation by provider	No pain	Moderate pain	Severe pain
Nurse estimation of pain level			
No pain	53 (85.5)	6 (30)	8 (44.5)
Moderate pain	7 (11.3)	10 (50)	6 (33.3)
Severe pain	2 (3.2)	4 (20)	4 (22.2)
Physician estimation of pain level			
No pain	52 (83.9)	10 (50)	6 (33.3)
Moderate pain	8 (12.9)	7 (35)	4 (22.2)
Severe pain	2 (3.2)	3 (15)	8 (44.5)

Table 5. Comparison between nurse and physician assessment and patient report of how well the patient understood his/her discharge instructions. Percentages reflect column percentages. Weighted kappa for agreement between nurse and patient ratings=0.13 (Standard error: 0.078). Weighted kappa for agreement between physician and patient ratings=0.19 (Standard error: 0.082).

	Patient reported understanding of discharge instructions		
Estimation of understanding of discharge intructions by provider	Fully understand	Somewhat understand	Don't understand
Nurse estimation of understanding of discharge instructions			
Fully understand	81 (93.1)	6 (85.7)	4 (66.7)
Somewhat understand	5 (5.8)	1 (14.3)	2 (33.3)
Don't understand	1 (1.1)	0 (0)	0 (0)
Physician-estimation of understanding of discharge instructions			
Fully understand	70 (80.5)	6 (85.7)	2 (33.3)
Somewhat understand	14 (16.1)	1 (14.3)	2 (33.3)
Don't understand	3 (3.4)	0 (0)	2 (33.3)

period. Asking providers to provide such a general estimate of satisfaction provides little information in terms of their ability to predict patient responses in particular situations. Our study asked providers to predict a response for an individual patient interaction. By focusing on a particular patient interaction, our data more closely evaluated the provider's ability to assess various variables and predict patient satisfaction.

In our study we found that providers have difficulty predicting patient satisfaction. Our providers tended to underestimate the level of satisfaction that patients had with their care. Due to a high overall rate of satisfaction, our providers did not encounter a large number of unsatisfied patients. Providers did correctly identify all patients that were either dissatisfied or neither satisfied nor dissatisfied their care. Unfortunately, based on the extremely low incidence of dissatisfaction and relatively small sample size, our study does not provide compelling evidence that providers can accurately predict dissatisfied patients.

We found that providers underestimated patient pain at the time of discharge. Cases where a provider underestimates the patient's pain accounted for 20% of our visits. These visits may represent instances where the patients received inadequate analgesia. Previous studies have suggested that adequate pain control can improve patient satisfaction.[16] Our data suggests that providers are not able to reliably predict a patient degree of pain at discharge. Given the association between patient satisfaction and pain level, ED providers should focus on performing a more accurate assessment of a patient's pain and providing appropriate analgesia prior to discharge.

The majority of our patients reported that they understood their discharge instructions. Despite the reportedly high level of comprehension, providers underestimated patient comprehension in 10-12% of cases. Boudreaux et al. found that patient comprehension of discharge instructions was a significant predictor of overall patient satisfaction.[17] Providers should continue to focus on identifying patients who have

poor comprehension of discharge instructions in order to improve overall satisfaction.

Our study illustrates the difficulty providers have when they are asked to predict patient responses to questions regarding patient satisfaction. Nationwide as more attention is placed on improving overall patient satisfaction, various initiatives have been developed in an effort to enhance the patient's ED visit. Programs such as hourly rounding on ED patients, developing a system for follow-up communication after discharge from the ED have been credited with improving patient satisfaction scores. Typically these initiatives are applied to broad range of patients, such as all patients discharged home, rather than targeting specific patients who are at risk of having a low level of patient satisfaction.[18]

The inability of providers to accurately predict patient responses may lead to poor resource utilization when implementing programs to improve patient satisfaction. We found that providers had difficulty distinguishing between satisfied and unsatisfied patients. Identifying unsatisfied patients could allow departments to focus resources on improving particular at-risk interactions rather than applying broad initiatives to all patients in the ED. Our study demonstrated that providers have difficulty predicting patient responses to a wide variety of satisfaction metrics. As efforts to improve patient satisfaction continue to grow, departments should also focus on enhancing a provider's ability to accurately assess patient satisfaction.

LIMITATIONS

We surveyed patients at the end of their ED visit, while previously most patients have received surveys at home several days to weeks after their ED visit. This delay between discharge and responding to the survey may influence the patient's responses; therefore, our results may not be generalizable.

We relied on patient assessment of comprehension of their discharge instructions. We chose this subjective estimation to approximate the questions found on common patient satisfaction surveys. It is possible that patients overestimated their actual comprehension, as previous studies have reported a much lower rate of comprehension than we found, with Engel et al. reporting significant knowledge deficits in terms of return instructions and home care instructions in up to 80% of patients discharged from the ED.[19] While our data accurately reflects patient self-assessment, it may not reflect actual comprehension of discharge instructions.

We used a five-point pain scale to assess patient's satisfaction with their pain control, as is common in other satisfaction surveys. Commonly in the ED pain is scored on a 0-10 point scale. There may be some inconsistency in patient responses when they are asked to respond using a five-point scale after using a 10-point scale during their ED visit. While patient responses using a five-point scale may not be directly transferrable to the standard 10-point system, our data accurately reflect the scoring used on common patient satisfaction studies.

A disproportionately large subset of included patients were admitted, potentially skewing results.

CONCLUSION

Physicians and nurses are not able to accurately predict patient responses to standard patient satisfaction surveys. As increasing emphasis is being placed on patient satisfaction nationwide, efforts should be made to improve a provider's ability to predict a patient's level of satisfaction with his or her care.

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The Need for More Prehospital Research on Language Barriers: A Narrative Review

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Introduction: Despite evidence from other healthcare settings that language barriers negatively impact patient outcomes, the literature on language barriers in emergency medical services (EMS) has not been previously summarized. The objective of this study is to systematically review existing studies of the impact of language barriers on prehospital emergency care and identify opportunities for future research.

Methods: A systematic review with narrative synthesis of publications with populations specific to the prehospital setting and outcome measures specific to language barriers was conducted. A four-prong search strategy of academic databases (PubMed, Academic Search Complete, and Clinical Key) through March 2015, web-based search for gray literature, search of citation lists, and review of key conference proceedings using pre-defined eligibility criteria was used. Language-related outcomes were categorized and reported as community-specific outcomes, EMS provider-specific outcomes, patient-specific outcomes, or health system-specific outcomes.

Results: Twenty-two studies met eligibility criteria for review. Ten publications (45%) focused on community-specific outcomes. Language barriers are perceived as a barrier by minority language speaking communities to activating EMS. Eleven publications (50%) reported outcomes specific to EMS providers, with six of these studies focused on EMS dispatch. EMS dispatchers describe less accurate and delayed dispatch of resources when confronted with language discordant callers, as well as limitations in the ability to provide medical direction to callers. There is a paucity of research on EMS treatment and transport decisions, and no studies provided patient-specific or health system-specific outcomes. Key research gaps include identifying the mechanisms by which language barriers impact care, the effect of language barriers on EMS utilization and clinically significant outcomes, and the cost implications of addressing language barriers.

Conclusion: The existing research on prehospital language barriers is largely exploratory, and substantial gaps in understanding the interaction between language barriers and prehospital care have yet to be addressed. Future research should be focused on clarifying the clinical and cost implications of prehospital language barriers. [West J Emerg Med. 2015;16(7):1094-1105.]

INTRODUCTION

Emergency medical services (EMS) systems operate in multicultural environments. Language discordance between providers and patients in the prehospital setting occurs frequently. More than 20% of households in the United States report a home language other than English, and limited-English proficiency (LEP) speakers are a rapidly growing population.[1] EMS providers deliver care in chaotic and dynamic situations, such as at the scene of a collision on a roadside or in a patient's home surrounded by distressed family members. EMS providers rely on accurate and efficient communication to ensure

personal safety, rapidly assess patients, and make decisions about appropriate care. Language barriers heighten the uncertainty of EMS work.

The deleterious impact of language barriers on medical care has been widely documented in outpatient and hospital-based settings, including increased rates of communication errors, unnecessary invasive procedures and testing, and increased costs of care.[2-7] However, the impact of language barriers is less well-understood in the prehospital setting and the literature has not been previously reviewed.[8-12] The objective of this systematic review with narrative synthesis is to summarize the existing literature on the impact of language barriers on prehospital care and identify opportunities for future research.

METHODS

Search Strategy

Publications were identified through a four-prong, sequential search strategy: 1) database searches, 2) web-based search, 3) citation searches, and 4) review of conference proceedings. Both published and gray literature were searched to identify all relevant research. Gray literature includes a variety of document types, such as theses or posters, collected and maintained by libraries or institutional repositories but which are not commercially published.[13] The search strategy was reviewed by a research librarian at the University of New Mexico Health Sciences Library & Informatics Center to refine search terms.

1. Database searches*:* Three primary academic databases, PubMed/Medline, Clinical Key, and Academic Search Complete, were searched to identify relevant publications. PubMed/Medline (1966–March 2015) was searched using the MeSH terms "emergency medical services" and "communication barriers" with no further limits applied. ClinicalKey (2004–March 2015) was searched using the terms "prehospital and language barriers or EMS and language barriers" with source type restricted to Medline abstracts, full text articles, and clinical trials. Academic Search Complete (1965–March 2015) was searched using the subject terms "emergency medical services" and "language" with no further limits applied.

2. Web-based search*:* Google Scholar was searched using the terms "prehospital language barrier" and then searched again using the terms "EMS language barrier" with the additional restriction of excluding patents. The first 150 results as ranked by relevance were evaluated for each search term.

3. Citation searches*:* Each individual citation within the reference lists of reviewed publications was searched in Thomson Reuters' Web of Science for related citations.

4. Review of conference proceedings: Three annual conferences were identified as the most likely locations for presentations of research on prehospital language barriers that may not have yet been published. PubMed/Medline includes the indexed abstracts for the American College of Emergency Physicians annual conference. Abstracts from the annual conference proceedings for the Society of Academic Emergency Medicine and National Association of EMS Professionals were reviewed from 2010 to 2014 to identify research that may be too recent to have been published in peer-reviewed journals.

Study Selection

Titles and abstracts of publications were reviewed to determine whether publications met initial inclusion and exclusion criteria. After an initial screening of the abstract, publications that were potentially eligible were then reviewed in their entirety for inclusion and exclusion criteria (Figure 1). For publications that did not have abstracts available, the complete publications were reviewed to ascertain eligibility. If full publications were not available even after attempting to contact the primary author, they were excluded from the review. There were no exclusion criteria by language of publication or by date of publication.

Data Extraction and Quality Assessment

The data extraction tool included the following fields: unique study identifier, author, date of publication, research design, study sample characteristics, EMS stakeholder groups studied (minority language speaking communities, EMS providers, or health system), country of study, key results, key limitations, and eligibility for inclusion in review. All publications that met potential eligibility criteria after abstract review were included in the data extraction tool on review of the full publication. We reviewed eligible studies using the Critical Appraisal Skills Framework Programme appraisal tools for qualitative studies, cohort studies, and case-control studies.[14] Survey studies were reviewed using the Center for Evidence-Based Management critical appraisal tool.[15] The Mixed Methods Appraisal Tool was used to review mixed methods studies.[16] Results and methods are reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses recommendations.[17,18]

Outcomes of Interest and Data Synthesis

A narrative synthesis of the results was planned prior to implementation of the literature search due to anticipated heterogeneity of outcome measures.[19] Language-related outcomes from each publication were categorized as 1) community-specific outcomes, defined as measures of LEP community members' knowledge about EMS, trust in EMS, or confidence in their ability to activate EMS; 2) EMS provider-specific outcomes, defined as measures of stress, provider self-efficacy, training, or decision-making; 3) patient-specific outcomes, defined as measures of patient satisfaction or specific

Inclusion criteria:

- Publication type: research investigations, case series, short/preliminary communications, theses, abstracts, presentations (including posters), systematic review articles or meta-analyses;
- Study population specific to prehospital setting: EMS providers, current or former EMS patients or their caregivers, EMS systems, focus groups or individual interviews with specific prehospital care content domains;
- Sample selection criteria or outcome measure specific to language discordance.

Exclusion criteria:

- Publications that were not specific to prehospital setting;
- Publications that dealt with communication barriers other than language discordance (cultural barriers, physical disabilities, etc.);
- Unavailable full publication despite attempts to contact the primary author;
- Publication type: Expert opinion, personal essay, single case report, non-systematic review articles, preliminary reports;
- Publications that reported incidence of language barriers but did not include any language-related outcome;
- Publications exclusively describing methodology.

Figure 1. Inclusion and exclusion criteria of publications reviewed with regard to language barriers and use of emergency medical services in the United States.
EMS, emergency medical services

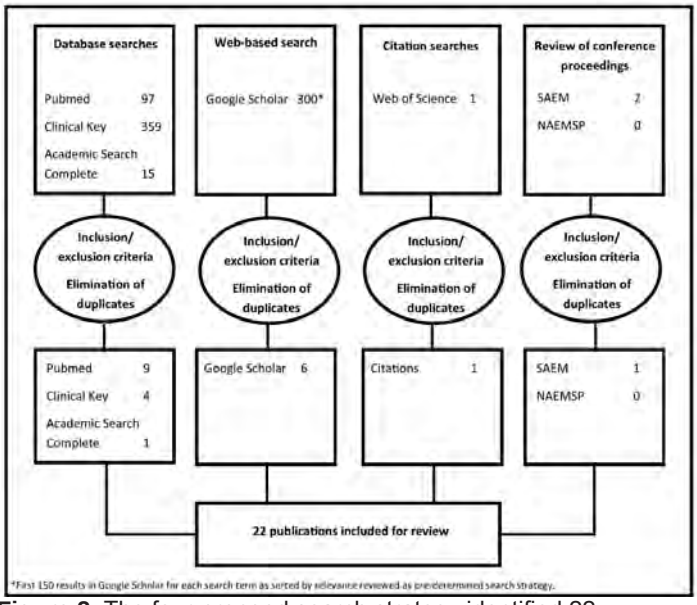

Figure 2. The four-pronged search strategy identified 22 publications for review.

clinical outcome measures; or, 4) health system-specific outcomes, defined as measures of cost, quality, or efficiency.

RESULTS

A total of 22 publications were identified as meeting inclusion and exclusion criteria and are reviewed in the results.[8-12,20-36] (Figure 2 and Table) A single prior systematic review of the literature was identified.[20] However, this review of the barriers and facilitators of EMS utilization by minority ethnic communities was broader than the specific question of the impact of language barriers on prehospital care. This review was unpublished outside of a poster presentation, unable to be replicated from the methodology, and a full list of citations was unavailable.

The remaining 21 publications offer insight into the mechanisms by which language barriers impact EMS care and provide an outline for future research in prehospital language barriers.

Language Barriers Impede Minority-Language Speaking Community Engagement with EMS

Language discordance is a perceived barrier to using EMS in the United States, the only country in which studies of engagement of minority-language speaking communities with EMS have been conducted. Focus group interviews of LEP Chinese speakers in King County, Washington, found that Chinese adults are more likely to rely upon themselves and their community in an emergency rather than on EMS. Participants in these focus groups identified language barriers as a negative factor impacting their likelihood of using EMS for emergencies while awareness of interpreter services was a potential facilitator.[28,36] When members of this Chinese community were presented with hypothetical emergency scenarios, non-English speaking Chinese adults reported lower likelihood of activating EMS than Chinese adults who could speak some English.[35] Spanish-speaking parents participating in focus groups in Kansas City, Missouri, reported awareness of 9-1-1, but uncertainty around when it is appropriate to call 9-1-1. Amongst the 49 parents who participated in these focus groups, language discordance was cited as a key barrier to calling 9-1-1.[11] Similarly, Sasson and colleagues found that Latinos in Denver, Colorado, neighborhoods with high rates of out-of-hospital cardiac arrest but poor rates of bystander CPR also identified language discordance as a barrier to calling 9-1-1 in focus group interviews.[29] Subramaniam et al. surveyed LEP, English proficient but non-native speaking and native English speaking caregivers in a pediatric emergency department (ED) in Detroit. They reported that LEP caregivers were less aware of EMS and reported fewer activations of EMS than both non-native English-proficient and native English speakers. Nearly a third of the LEP caregivers in this study cited inability to communicate with 9-1-1 as a barrier to using EMS.[33]

These studies reflect intentions and attitudes but are not linked to EMS utilization data. Only two studies reported EMS utilization by language group. Smith and co-investigators found that, in an adult Mexican-American population in Nueces County, Texas, who presented to an ED with

Table. Reviewed literature concerning language barriers and use of emergency medical services.

First author (Year)	Design	Location	Sample	Results
Review publications				
Phung (2013)	Systematic review		Studies published in English between 2003 and 2013 with barriers/ facilitators for minority populations accessing prehospital emergency medical services	• 16 studies included, 2 from Europe and 14 from US (only 5 of the 16 studies provided in references) • Single uncited study specific to language barriers
Publications describing minority language speaking community engagement with EMS				
DuBard (2006)	Survey	US (Florida, Nebraska, North Carolina, Oklahoma)	Heart Attack and Stroke Module of the 2003 Behavioral Risk Factor Surveillance System population survey administered in English or Spanish	• Spanish-speaking Hispanics have less recognition of stroke or heart attack symptoms than English-speaking Hispanics (p<0.001) • No difference between Spanish-speaking Hispanics and English-speaking Hispanics in intent to call 911 for suspected heart attack or stroke (p=0.17)
King (2009)	Retrospective cohort	Canada (Calgary, Alberta)	406 patients discharged with a diagnosis of acute myocardial infarction (AMI) and ethnicity determined by surname of Caucasian, Chinese, South Asian, Southeast Asian, or First Nations	• Only 34% of Chinese patients, 46% of South Asian patients, and 51% of Southeast Asian patients were fluent in English compared to 99% of Caucasian patients and 92% of First Nations patients (p<0.001) • Caucasian patients were more likely to present to the ED by ambulance than other ethnic groups (p<0.001)
Meischke (2012)	Survey	US (King County, Washington)	667 Cambodian adults as identified by surname	• Increased measures of acculturation correlated with increased likelihood of calling 911 in an emergency and correlated with increased likelihood of prior CPR training
Ong (2012)	Focus group interviews	US (King County, Washington)	36 adult Chinese speakers with self-identified limited English proficiency recruited from a community center (same sample as Yip 2013)	• Chinese LEP adults identified language as an barrier to accessing 911, as well as lack of familiarity with EMS and concerns about delays • Knowledge that telephonic interpretation is available was cited as a facilitator to accessing 911 • Strategies used to overcome language barriers include finding an English speaker to call 911 and using simple words in English
Sasson (2015)	Focus groups and interviews	US (Denver, Colorado)	64 Latinos in neighborhoods with high rates of cardiac arrest and low rates of bystander CPR	• Language barriers were cited as one of six key thematic barriers to calling 911 • Participants cited frustration with being placed on hold as a particular barrier and identified bilingual dispatchers as a facilitator

EMS, emergency medical services; *CPR,* cardiopulmonary resuscitation; *LEP,* limited-english proficiency

Table. Continued. Reviewed literature concerning language barriers and use of emergency medical services.

First author (Year)	Design	Location	Sample	Results
Smith (2010)	Secondary analysis of cohort study	US (Nueces County, Texas)	1,134 Mexican-American and non-Hispanic White adults with ischemic stroke	• Spanish-only language was not associated with time to presentation in ED (OR 0.8, CI 0.5-1.3, p=0.4) or arrival via EMS (OR 1.1, CI 0.7-1.7, p=0.7)
Subramaniam (2010)	Survey	US (Detroit, Michigan)	50 limited English proficiency, 50 proficient but non-native English, and 100 native English speaking caregivers in a pediatric emergency department	• LEP caregivers were less aware of EMS than native English speaking caregivers (40% unaware of EMS vs. 7% unaware of EMS, p<0.01) • LEP caregivers reported less EMS use than native English speaking caregivers (16% had ever called EMS vs. 58% had ever called EMS, p<0.01) • 32% of LEP caregivers reported language as a barrier to calling 911
Watts (2011)	Focus group interviews	US (Kansas City, Missouri)	49 Spanish-speaking parents	• Familiarity with 911 was high, but parents reported uncertainty about when to access EMS • Language was cited as a key barrier to accessing 911, as was fear of repercussions for undocumented immigrants utilizing the services • Perceptions of 911 and understanding of EMS logistics was overall good, but Spanish-speaking parents opted to take children directly to an ED
Yip (2013)	Focus group interviews	US (King County, Washington)	36 adult Chinese speakers with self-identified limited English proficiency recruited from a community center (same sample as Ong 2012)	• Chinese LEP adults identified reliance on self and community in emergency situations • Language barriers and lack of familiarity with 911 were identified as barriers to 911 utilization
Yip (2014)	Survey	US (King County, Washington)	517 Chinese adults as determined by surname and who self-identified as limited English proficiency	• When presented with hypothetical scenario of an emergent medical condition for a family member, non-English speaking Chinese adults reported lower likelihood of calling 911 than some-English speaking Chinese adults (p < 0.01)
Publications describing the impact of language barriers on EMS dispatch				
Bradley (2011)	Secondary analysis of randomized controlled trial	US (King County, Washington)	971 cardiac arrest calls	• Dispatchers took longer to recognize cardiac arrest with LEP callers compared to non-LEP callers (median 84 seconds vs. 50 seconds, p<0.001) • Receipt of bystander CPR was poorer among LEP callers compared to non-LEP callers (OR 0.52, CI 0.29-0.97, p=0.02) • Survival to hospital discharge not statistically significantly different (OR 0.49, CI 0.15-1.24, p=0.12)
Heward (2004)	Cross-sectional analysis	UK (London, England)	100 cardiac arrest calls	• 49% of calls had barriers to performance of dispatcher-assisted CPR and 2% of encounters with barriers was due to language discordance

ED, emergency department; *OR,* odds ratio; *CI,* confidence interval; *LEP,* limited-english proficiency; *EMS,* emergency medical services

Table. Continued. Reviewed literature concerning language barriers and use of emergency medical services.

First author (Year)	Design	Location	Sample	Results
Lindström (2014)	Qualitative analysis of recorded calls	Sweden (Stockholm County)	100 general 911 calls, 50 of which had agreement on priority level between dispatcher and on-scene providers, 50 of which were determined to be under-triaged by on-scene providers	• One-third of calls were by non-native language speakers (22% of calls with agreement on priority level and 10% of calls with under-triage), but language not identified as a barrier to accurate call assessment
Meischke (2010)	Mixed methods	US (King County, Washington)	129 EMS dispatchers; 86 recorded calls with life-threatening complaints and dispatcher-identified LEP callers	• 70% of dispatchers reported encountering LEP callers almost daily or daily • 88% of dispatchers experience these calls as somewhat stressful, stressful, or very stressful • 78% of dispatchers believe that language barriers sometimes, often, or always affect medical care • While 55% of dispatchers reported that telephonic interpretation is the primary communication strategy that they use with LEP callers, telephonic interpretation was used for only 13% of abstracted calls • LEP callers less likely than non-LEP callers to have BLS and ALS resources simultaneously dispatched despite similar chief complaints (20% vs. 38%, p=0.01)
Meischke (2013)	Case-control study	US (King County, Washington)	272 EMS calls with a language barrier as identified by dispatcher matched to 272 calls without a language barrier during a 4-month period	• Increased time to dispatch of BLS resources (p<0.001) and ALS resources (p=0.008) with language barrier • Increased likelihood of on-scene change in resources for calls with language barrier (OR 2.36, CI 1.29-4.33, p=0.006) • Connecting to a telephonic interpreter required a mean of 158 seconds
Meischke (2014)	Randomized-controlled trial	US (King County, Washington)	139 self-identified limited-English proficient adults with primary languages of Mandarin, Cantonese, or Spanish	• In a cardiac arrest simulation in which participants called a simulated 911 dispatcher for assistance, including bystander CPR instructions, use of a telephonic interpreter increased time to first compressions by nearly 2 minutes compared to a standardized language protocol or a protocol in which the telecommunicators could rephrase the protocol language (mean 288 s vs. means 176 s and 168 s, p<0.001) • Participants reported better understanding of dispatcher instructions with interpreter use, but there was no improvement in quality of CPR with interpreter use • There was no difference in time to first compressions or quality of CPR for the protocol in which telecommunicators could rephrase the protocol language as compared to a standardized language protocol

EMS, emergency medical services; *LEP,* limited-english proficiency; *BLS,* basic life support; *ALS,* advanced life support; *OR,* odds ratio; *CI,* confidence interval; *CPR,* cardiopulmonary resuscitation

Table. Continued. Reviewed literature concerning language barriers and use of emergency medical services.

First author (Year)	Design	Location	Sample	Results
Publications describing the impact of language barriers on EMS care in the field				
Cottrell (2014)	Focus group interviews	US (Multnomah County, Oregon)	40 paid and volunteer EMS providers	• Language barriers cited as one child and family-level factor contributing to prehospital pediatric safety events
Grow (2008)	Cross-sectional analysis	US (Minnesota)	15,620 reports that identified a prehospital delay in the Minnesota State Ambulance Reporting system database during 18-month period	• Language barriers were the second most commonly cited cause of prehospital delay (13% of delays) • Time on-scene for encounters identified as delay due to language barrier was actually shorter than the no delay encounters (mean time on scene of 16.00 minutes vs. 21.98 minutes)
Shaw (2014)	Focus groups	UK (East Midlands region, England)	17 paramedics	• Patient language identified as one type of communication barrier to adherence to prehospital asthma guidelines
Sterling (2013)	Cross-sectional analysis	US (New Jersey)	11,249 EMS encounters for chest pain excluding cardiac arrest	• Language discordance associated with shorter on-scene times for chest pain encounters (mean 8.93 minutes for language discordant vs. 9.78 for language congruent, $p<0.0001$)
Weiss (2014)	Retrospective double cohort study	US (Albuquerque, New Mexico)	59 limited-English proficiency patients and 100 English-proficient patients as determined by ability to sign an English-only form	• Language barriers not associated with differences in on-scene times, transport times, number of interventions, medications, or pain scores when corrected for age and gender

EMS, emergency medical services

stroke, language was not associated with arrival by EMS.[31] Conversely, a single Canadian hospital's data for patients discharged with a diagnosis of acute myocardial infarction and a recorded ethnicity of Caucasian, Chinese, South Asian, Southeast Asian, or First Nations was analyzed. The investigators found that Caucasian patients were statistically significantly more likely to present to the ED by ambulance than other ethnic groups with lower English fluency.[24] These studies are too limited to allow generalizations about the impact of language barriers on utilization of EMS by minority language speaking communities.

A few studies suggest that increased acculturation, or adopting the values and practices of the new culture in which immigrant minority language speakers settle, may moderate negative impacts of language barriers on EMS engagement. Smith and co-authors note that most Mexican-Americans in Nueces County, Texas, are second or third generation immigrants and this Hispanic population may be more acculturated than other minority language populations.[31] Another study of Hispanics in four states also found no difference in intent to call 9-1-1 for suspected heart attack or stroke for English-speaking Hispanics compared to Spanish-speaking Hispanics, suggesting that language may not be a significant factor in EMS engagement in acculturated Hispanic communities.[22] In specifically assessing the effects of acculturation, Meischke and colleagues found in a 2012 survey of Cambodians in King County, Washington, that increased measures of acculturation were associated with increased likelihood of calling 9-1-1 in an emergency.[26]

Future Research Opportunities

Although minority-language speaking communities in the U.S. are consistent in describing language discordance as a disincentive to EMS activation, further research on actual EMS utilization by minority language speaking communities is needed to bridge the gap between perception and outcomes. Additionally, the existing body of literature suggests an opportunity to improve engagement with EMS at the community level through developing evidence-based, linguistically-appropriate outreach educating minority-language speaking communities on how and when to activate EMS for an emergency.

Language Barriers Impede Accurate and Efficient EMS Dispatch and Current Language-Assistance Resources May Not Be Well-Adapted for EMS Use

Much of the research on the impact of language barriers on EMS care has focused on dispatch, with an association described between language barriers and delayed and inaccurate dispatch. Meischke and colleagues surveyed EMS telecommunicators in King County, Washington, and found that dispatchers reported increased stress with LEP callers, as well as perceived negative impacts on the overall care delivered by the EMS system for these callers. This study also suggested that language barriers impact dispatch by demonstrating that resources were dispatched differently (Advanced Life Support vs Basic Life Support) for calls with language barriers despite similar acuity of the complaint.[8] Meischke and colleagues further investigated the impact of language barriers on EMS dispatch in a 2013 study that demonstrated that calls with language barriers were more likely to require changes in the on-scene resources that were initially dispatched, particularly downgrades from Advanced Life Support to Basic Life Support, suggesting that dispatchers are less accurate in dispatching resources when confronted with language barriers.[9]

The impact of delayed and less accurate dispatch on patient outcomes is unclear. The only study that reported patient-specific outcomes related to language barriers at the level of dispatch was a secondary analysis of the data from a randomized controlled trial of dispatcher-assisted CPR for cardiac arrest in King County, Washington. Dispatchers took longer to recognize cardiac arrest and initiation of bystander CPR was less common if a language barrier was present. Survival to hospital discharge was also poorer among patients in which the call to EMS involved a language barrier but did not rise to the level of statistical significance.[12] Although not tied to outcomes, a retrospective analysis of 100 cardiac arrest calls to a London EMS dispatch center also identified language barriers as one reason that dispatcher-assisted CPR was not initiated prior to the arrival of on-scene providers.[23]

Third-party telephonic interpreter services are the language assistance technology used by most EMS dispatch centers and the primary strategy that dispatchers in the King County, Washington, studies reported using to overcome language barriers. However, these studies suggest that third-party telephonic interpretation may not be an efficient tool to aid dispatch. On review of a subset of recorded calls for life-threatening conditions that featured language barriers, Meischke and colleagues found that actual use of a telephonic interpreter was less common than self-reported by dispatchers in the survey.[8] It is possible that dispatchers are less likely to use telephonic interpreters for life-threatening complaints and only high acuity calls were reviewed by researchers. Another possible explanation is that dispatchers do not perceive that their ability to effectively dispatch is impacted by language discordance and prefer to avoid the delay associated with interpreter services. A Swedish study reviewed calls with both on-scene and dispatch provider agreement and disagreement in the priority of calls. Dispatchers in this study had a large proportion of calls with language barriers, but dispatchers specifically indicated that language barriers were not a barrier to effective dispatch and interpreter services were not used.[25] Another review of calls with language barriers, as compared to matched language-concordant calls, found longer dispatch times with much of the difference in dispatch times attributable to connecting to the telephonic interpreter service. However, the subset of calls with language barriers in

which telephonic interpretation was used was not analyzed to measure whether use of telephonic interpreters was associated with more accurate dispatch.[9] Further investigating the role of telephonic interpretation, Meischke and co-investigators enrolled LEP adults in a randomized controlled trial of different communication strategies for providing dispatcher-assisted CPR instructions. Participants reported better understanding of CPR instructions with telephonic interpreter use, but interpreter use delayed onset of CPR by nearly two minutes and there was no improvement in quality of CPR with interpreter use.[27]

Future Research Opportunities

The clinical significance of statistically significant differences in the time to dispatch and the accuracy of dispatched resources has not yet been demonstrated, signaling a key gap in the existing research. Prior research has been conducted in two-tier response systems, meaning dispatchers have the capacity to choose basic or advanced resources to be dispatched to a call, and it is unclear that these findings can be extrapolated to single-tier EMS systems in which a single level of resource is available for dispatch. In two-tier EMS systems, erring on the side of dispatching advanced resources may provide a safer response to calls with language barriers. However, the impact of language barriers on the dispatch strategies of single-tier systems is unknown. Additionally, both over-triage and under-triage of prehospital resources have cost and quality of care implications in two-tier systems that are undefined, as is the cost-effectiveness of third-party telephonic interpreters. Third-party telephonic interpretation is a time-consuming and costly strategy for overcoming language barriers and the current body of evidence demonstrates an unclear benefit to the use of telephonic interpreters. Given that third-party telephonic interpretation is the most commonly provided language assistance technology for dispatchers, further research in outcomes for calls using interpreter services, the cost-effectiveness of telephonic interpreter services, and alternative language assistance strategies is warranted.

Language Barriers Have Unclear Impacts on EMS Field Care

The impact of language barriers on treatment and transport decisions in the field has not been directly studied. However, a pair of studies suggests that EMS provider decision-making may be different for language-discordant patients. Grow et al. reviewed prehospital encounters featuring a delay in the Minnesota State Ambulance Reporting System and found that language barriers were identified as the second most common cause of delay.[10] Intriguingly, however, the on-scene times for calls with a reported delay due to language barrier were actually *shorter* than the on-scene times for calls with no delay. A significant limitation of the study was that the "no delay" comparison group did not come from the general pool of all EMS encounters and it is unclear if these calls had atypical features that prompted EMS providers to specifically notate "no delay" in the report. Nonetheless, the shorter on-scene time hints that, in the presence of a language barrier, EMS providers may perceive more threats to timely treatment and transport at the scene and opt to rapidly transport patients to a receiving healthcare facility, a practice known colloquially as "scoop and run." Shorter on-scene times in the presence of a language barrier were also described by Sterling and colleagues in a retrospective review of EMS encounters in New Jersey with a complaint of chest pain.[32] Just under 2% of encounters featured a language barrier and these encounters were statistically significantly shorter than chest pain encounters without a language barrier. In contrast to these two studies finding shorter on-scene times with language barriers, a retrospective double-cohort study of EMS encounters with LEP and English-speaking patients in Albuquerque, New Mexico, did not find a statistically significant difference in on-scene times, transport times, pain scores, number of EMS interventions, or number of medications administered.[34] The small sample size may have limited the ability to detect differences as, in this study, there was a trend towards longer on-scene and transport times for LEP patients. A significant limitation of this study was that the LEP and English-speaking patients had marked demographic differences, with LEP patients being older and more female.

No studies that directly address patient-specific or health system-specific outcomes were identified for review. However, in the development of a theoretical framework for pediatric prehospital safety events based on focus groups of EMS providers in Multnomah County, Oregon, Cottrell and co-investigators identified language barriers as a factor that contributes to pediatric prehospital safety events.[21] Focus groups of paramedics in the United Kingdom also identified language discordance as a barrier to adherence to asthma treatment guidelines.[30] Collectively, these studies provide indirect suggestions that EMS care differs when confronted with language barriers, but do not allow for more nuanced analysis or conclusions.

Future Research Opportunities

There is a paucity of research on the impact of language barriers on on-scene treatment and transport decisions, the majority of the interaction between a patient and EMS. The dearth of studies on treatments received by language-discordant patients relative to language-concordant patients and their subsequent patient-related outcomes is a glaring opportunity for future inquiry. Indeed, the targets by which to evaluate quality of prehospital care in the context of language barriers do not appear to be well-defined. Is a shorter on-scene time for language discordant patients, as demonstrated in two studies,[10,32] advantageous or disadvantageous to patients? Prehospital medicine is riven by controversy regarding whether patient care is improved by shorter on-scene times as compared to more prolonged on-scene

initiation of care. Furthermore, do on-scene or transport times have differential impacts depending on the acuity or type of medical complaint? In the context of this broader uncertainty about optimal strategies for patient care, it is unclear whether language discordant patients experience better or worse quality of care. Language barriers have been associated with harmful outcomes to patients and inefficient uses of healthcare resources in a variety of other medical care settings.[2-7] Despite the unique challenges of providing prehospital care, it is unlikely that EMS care is unaffected by language discordance given such broadly documented disparities. However, the existing research on the impact of language barriers on prehospital care is unable to answer questions of clinical significance or healthy equity.

DISCUSSION

In this narrative review of the impact of language barriers on prehospital care, three domains of existing research were identified related to community-specific and EMS-provider specific outcomes. Firstly, studies of minority-language speaking communities indicate that language discordance is a perceived barrier to activating EMS. Secondly, studies of EMS dispatchers describe less accurate and delayed dispatch of resources when confronted with language discordant callers, as well as limitations in the ability to provide medical direction to callers. Thirdly, studies of on-scene EMS care hint that treatment and transport decisions may differ when EMS providers are confronted with language barriers. No studies were identified that addressed patient-specific or health system-specific outcomes. The existing literature raises provocative questions about the potential impact of language barriers on the quality of prehospital care that have yet to be studied and which facilitate the development of a future research agenda. In 2006, Jacobs and colleagues presented a proposed research agenda for language barriers in healthcare, highlighting the need for research that delineates the mechanisms by which language barriers affect healthcare, evaluates the efficacy of language assistance strategies, and defines the costs of language barriers in healthcare.[37] All three of these questions remain unanswered for prehospital medicine and, in the context of the existing literature, outline an agenda for prehospital research.

LIMITATIONS

A key limitation to review of the literature on prehospital language barriers is the lack of consistent terminology to identify prehospital literature. The definition of "prehospital" varies in some databases and in some countries to mean emergency medical care delivered prior to hospital care or any care delivered outside of a hospital, including outpatient care. Similarly, "emergency medical services" may refer narrowly to institutions and agencies that are organized specifically for the delivery of emergency care prior to hospital care or may index more broadly to emergency medical care delivered in or out of hospital. The lack of consistent terminology may have led to the exclusion of relevant literature. Additionally, the limitations of keyword-based searching on this topic may have biased towards U.S.-based publications that use similar terminology. Alternatively, U.S.-based publications may be over-represented due to more active research in this area.

A second limitation to interpreting the existing literature is the lack of consistent reporting of the methodology for identifying minority language speakers as well as the heterogeneity of sampling approaches. The sampling strategies of the reviewed studies included self-identification, provider identification, optional documentation fields, and proxy identifiers, such as being unable to sign an English-only form. Additionally, the measures by which to identify language proficiency are not agreed upon and may vary at different points along the series of interactions between EMS and a language-discordant patient. For example, should an interaction with a caller who can communicate the patient's location and chief complaint to a dispatcher but who lacks the language fluency to answer questions for on-scene providers be considered to have a language barrier? This hypothetical encounter would be categorized differently using the various approaches in the existing literature. The validity and generalizability of sampling strategies to identify language barriers is unclear in the EMS context in which care is delivered along a series of interactions.

An unexpected finding of this review is the predominance of a single research group, the Northwest Preparedness and Emergency Response Research Center (NWPERRC) at the University of Washington. Eight (36%) of the publications reviewed were generated from research in King County, Washington.[8,9,12,26-28,35,36] All EMS systems practice in multi-cultural and multi-lingual communities, but the generalizability of single-site research in EMS is unclear. Themes that emerged from studies of Chinese and Cambodian communities in King County have good concordance with studies from other minority-language speaking communities in Denver, Detroit, and Kansas City. However, Meischke and colleague's studies of dispatchers were performed in an EMS system that has a two-tier response. Many EMS systems, in contrast, are single-tier response and the findings of differential delays based on the type of dispatched resources are difficult to interpret in the context of a single-tier response system. Likewise, the training and resources available to dispatchers in King County may not be comparable to those available to dispatchers in other EMS systems. Multi-site EMS research and research in different types of EMS systems is needed to better understand the impact of language barriers on prehospital care.

CONCLUSION

As minority-language speaking communities grow, EMS will be increasingly confronted with language barriers. This review, the first of the literature on the impact of language

barriers on prehospital care, demonstrates the heterogeneity of existing research and the substantial gaps in understanding the interaction between language barriers and prehospital care that have yet to be addressed. Future research elucidating the mechanisms by which language barriers impact the care received by minority language speakers, the effect of language barriers on patient-level or health system-level outcomes, and the cost implications of addressing language barriers is needed.

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A Delphi Method Analysis to Create an Emergency Medicine Educational Patient Satisfaction Survey

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Introduction: Feedback on patient satisfaction (PS) as a means to monitor and improve performance in patient communication is lacking in residency training. A physician's promotion, compensation and job satisfaction may be impacted by his individual PS scores, once he is in practice. Many communication and satisfaction surveys exist but none focus on the emergency department setting for educational purposes. The goal of this project was to create an emergency medicine-based educational PS survey with strong evidence for content validity.

Methods: We used the Delphi Method (DM) to obtain expert opinion via an iterative process of surveying. Questions were mined from four PS surveys as well as from group suggestion. The DM analysis determined the structure, content and appropriate use of the tool. The group used four-point Likert-type scales and Lynn's criteria for content validity to determine relevant questions from the stated goals.

Results: Twelve recruited experts participated in a series of seven surveys to achieve consensus. A 10-question, single-page survey with an additional page of qualitative questions and demographic questions was selected. Thirty one questions were judged to be relevant from an original 48-question list. Of these, the final 10 questions were chosen. Response rates for individual survey items was 99.5%.

Conclusion: The DM produced a consensus survey with content validity evidence. Future work will be needed to obtain evidence for response process, internal structure and construct validity.
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INTRODUCTION

The quantification of patient satisfaction (PS) data has become its own industry. Physicians' pay, promotion and job satisfaction may be influenced by PS scores. Residents will be expected to practice independently in this environment, yet they are given little objective patient feedback on the care they provide. This limits the opportunities they have for improvement while in training.

The Council of Residency Directors for Emergency Medicine (CORD-EM) created a taskforce with the mission of creating a database of PS education and evaluation resources. This includes creation of a free, open-source survey instrument to provide resident feedback. Emphasis was placed on behavioral traits that affect patient satisfaction scores which are amenable to remediation. Importance was also placed on its validity.

The concept of psychometric validity is itself a controversial subject in survey development. There is no single reliable measure of validity; it is instead the sum of multiple facets that provide evidence of what has been deemed

'construct validity.' These include content validity: "whether [the survey] covers a representative sample of the behavior domain to be measured."[1] The goal of this project was to create and provide content validity evidence for an emergency medicine-based, educationally grounded PS survey.

METHODS

We used a method of survey development created by the RAND Corporation, called the Delphi Method (DM) analysis. This process involves gathering experts and using iterative, anonymous surveying to determine consensus. It has been used by others to create PS surveys.[2,3] The goal of the method is to achieve consensus through rounds of advocacy and opposition, hopefully minimizing the influence of strong but prejudiced or ill-informed opinions. This study was reviewed by the institutional review board and found to be exempt.

Given the differences in geographic practice patterns, experts were solicited from across the United States. Our goal was to recruit a diverse expert group of educators, residents and administrators with PS-oriented careers (see Appendix I). These include national emergency medicine leadership (the 2014-2016 American Academy of Emergency Medicine President and 2013-2015 CORD PS taskforce chair), emergency physician PS researchers and educators, residents with interest and experience in PS research and hospital administrators with PS expertise. These 12 hail from seven states (Colorado, Wisconsin, Michigan, Tennessee, Georgia, New York and New Jersey) and include three residency program directors and three assistant program directors. The average clinical experience of the attending physician experts was 8.6 years post residency training with a median of 9.5 years.

Potential survey items included in the analysis were chosen from four patient satisfaction tools (see Appendix II).[4-7] Qualitative questions were taken from the author's previously published work.[8] Six additional questions were also suggested by the experts themselves given concerns that some essential aspects were not represented on the initial question list. Given the desire for readability, small grammatical changes were made so that all items followed the same syntax.

Left undefined by the DM analysis is the definition of expert consensus. The seminal works in this field are by Lynn and Lawshe.[9-10] Both advocated for four-point scales, with low values denoting disagreement with the content, high values infer the opposite. Lynn recommended three or more experts with decreasing benefit from very large numbers. Lawshe created a table of critical values of agreement depending on the number of participants (up to 40 experts). For Lynn, content validity is defined as agreement by ≥80% of experts, Lawshe required lower rates for groups >8 members (for instance, a 12-member panel would require 56% agreement[10]). Given the more stringent requirements of Lynn's criteria, they were chosen to define consensus and establish content validity for our survey.

The surveying itself was performed using the online, anonymous survey service Survey Monkey. Surveying was split into three series. The "initial series" surveys were focused on determining the tool's structure and individual question content validity (relevance). The "second series" surveys chose which items from the "initial series" made it into the final product. Finally, a single survey was sent following the completion of the process to evaluate for expert approval with the final product.

The data was analyzed by the authors using Microsoft Excel and the built-in tools from the SurveyMonkey website.

RESULTS

The experts chose a single-page, 10-item survey. Demographic questions about the patient's age and gender were included. Additional questions about global satisfaction with the physician's care as well as the satisfaction with the other facets of the patient's visit were chosen for comparison. Both patients themselves as well as family members were allowed to participate. Given concern for consent, it was decided only patients and family members aged 18 or older would be eligible for participation. A second optional page, with qualitative questions and additional demographic data was recommended for inclusion. The tool was entitled BOOST: Behaviorally Oriented, Open Satisfaction Tool.

Forty-two items were chosen from the initial sources.[4-8] From expert comments, six additional items were added. Of these 48, 31 were found relevant in the "initial series." During the initial "second series" survey, three items tied for tenth place. Two sets of two similarly themed items were present in those 13. Therefore two redundant items were dropped and the three items that tied for tenth place were all included.

Seven surveys were required to complete the Delphi Method analysis. These included four "initial series" (which took place from 9/14-12/14), two "second series" (12/14-1/15) and the final affirmation survey (4/15). All experts participated in every survey, giving a 100% overall response rate. There was a 99.5% individual response rate for each survey item.

DISCUSSION

With the increasing influence of the PS industry, educating the next generation of physicians on effective practice habits is integral to their success. Furthermore, high PS score have been shown to improve rates of patient compliance,[12] a goal of all physicians. PS scores also inversely correlate with rates of litigation, another important aspect of a successful clinical career.[13] Finally, PS techniques can provide comfort and minimize suffering of patients, a core tenet of medicine.[14]

Central to the idea of skill improvement is the ability to receive feedback. This survey's content validity and focus on behavioral traits can provide actionable data and allow for

credible improvement or remediation plans. Before this survey is ready for use we anticipate the need for two further steps: 1) Evaluation of survey readability and comprehensiveness from the patient perspective using focus groups; and 2) In situ investigation of BOOST in use with patient/resident dyads to determine inter-item agreement and correlation of multiple patient ratings of individual residents. This future work will further establish response process, internal structure and construct validity.

LIMITATIONS

Two major limitations stand out. One was the relatively low number of experts, 12. With a larger number of experts for the DM, we may have elicited a different set of questions, or included additional survey items touching on different areas. There is some evidence, however, to indicate that a larger sample of experts may not lead to further response diversity once a threshold is reached and our threshold of validity (80%) was higher than Lawshe would require (56%) for a group of 12 experts.[9,10] The second is that our list of items did not include questions on timeliness of care or pain management as mentioned in a comprehensive review.[11] The former was left off secondary to concerns that timeliness is more of a systems issue than the responsibility of a resident. The latter was left off given concerns of how opioid utilization has fueled an epidemic of addiction that left some experts uncomfortable using pain control as a quality metric. Two authors also participated as experts (Finefrock and Simmons) but did not take part in data analysis and only helped create the research protocols and write the final manuscript.

CONCLUSION

We developed a draft survey with content validity evidence using a DM analysis. It was based on initial questions with high content validity as many had been developed from literature review of patient-preferred behaviors or been validated in prior studies. Our group of experts spanned a large geographic and professional spectrum, increasing the generalizability of the study results. The questions are largely behavioral, creating practical data for educational purposes. Qualitative questions were provided on an optional basis. These can provide context and other data that quantitative analyses sometimes miss, though require greater patient effort and time utilization. Further work is needed to attain the high level of construct validity required for use in educational settings.

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The Physiologically Difficult Airway

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Airway management in critically ill patients involves the identification and management of the potentially difficult airway in order to avoid untoward complications. This focus on difficult airway management has traditionally referred to identifying anatomic characteristics of the patient that make either visualizing the glottic opening or placement of the tracheal tube through the vocal cords difficult. This paper will describe the physiologically difficult airway, in which physiologic derangements of the patient increase the risk of cardiovascular collapse from airway management. The four physiologically difficult airways described include hypoxemia, hypotension, severe metabolic acidosis, and right ventricular failure. The emergency physician should account for these physiologic derangements with airway management in critically ill patients regardless of the predicted anatomic difficulty of the intubation. [West J Emerg Med. 2015;16(7):1109-1117.]

INTRODUCTION

The "difficult airway" has traditionally been used to describe intubations that have anatomic characteristics that make visualization of the vocal cords and placement of the tracheal tube challenging. Although scoring systems and prediction rules to identify the potentially difficult airway may be helpful, the performance of these prediction methods is only moderately successful. Additionally, the last decade has seen an incredible expansion of devices available to successfully ventilate, visualize the vocal cords, and place a tracheal tube leaving these prediction methods less useful.[1] However, even with the expansive armamentarium available for emergent airway management, contextual factors such as operator experience, time pressures, and the patient's underlying physiologic alterations still often result in difficulty with optimizing gas exchange, which is the primary goal of airway management.[2]

Critically ill patients represent the highest risk patients to intubate because of these contextual factors that increase the incidence of adverse events leading to dangerous hypoxemia, hemodynamic collapse and cardiac arrest.[3-11] This baseline physiologic risk is exaggerated when intubations require more than one attempt,[12-15] with difficult intubations being an independent predictor of death.[16] As a result of the higher risk of these untoward events at intubation, first pass success has become the goal. Research in airway management has lead to advances that have greatly improved the management of the anatomically difficult airway, yet critically ill patients remain high-risk patients due to underlying pathophysiologic abnormalities. While the anatomically difficult airway is one in which obtaining a glottic view or passing an endotracheal tube is challenging, the physiologically difficult airway is one in which physiologic derangements place the patient at higher risk of cardiovascular collapse with intubation and conversion to positive pressure ventilation. These physiologic derangements should be accounted for in the intubation plan even if one does not predict anatomic difficulty with intubation. This paper will review four clinically important physiologically difficult airways that the emergency physician will encounter: hypoxemia, hypotension, severe metabolic acidosis, and right ventricular failure. Unfortunately, the physiologically difficult airway is not well described and there are very limited data available on management methods. In this paper we will provide physiologically and experience-based recommendations and, where available, evidence-based recommendations to decrease the risk of hemodynamic

collapse when faced with one of these four high-risk airway management scenarios.

Hypoxemia

Hypoxemic respiratory failure (Type I) in which there is failure to maintain adequate arterial oxygenation is a relatively common indication for intubation and invasive mechanical ventilation in the emergency department (ED). The mechanism of acute hypoxemic respiratory failure is most commonly due to any etiology that disrupts optimal alveolar-capillary gas exchange, such as pneumonia, acute respiratory distress syndrome (ARDS), and cardiogenic or non-cardiogenic pulmonary edema. In each of these instances a portion of the blood passing through the pulmonary circulation shunts past the remaining functional alveoli without the opportunity to participate in gas exchange. This hypoxemia is different than that which occurs with hypercapneic respiratory failure (Type II), which is due to decreased alveolar ventilation or an increase in dead space. Hypoxemia from Type II respiratory failure is relatively easily corrected with supplemental oxygen or an increase in minute ventilation. Hypoxemic respiratory failure patients are at high risk for rapid desaturation during intubation, which may result in hemodynamic instability, hypoxic brain injury, and potentially cardiopulmonary arrest.[7,17-19] Identification of patients at risk for desaturation, such as the patient with limited reserve from acute hypoxemic respiratory failure or obesity, and utilization of all techniques available to prolong this time to desaturation, or safe apnea time, regardless of one's assessment of the anatomic difficulty of the intubation is critical for the emergency physician.

Preoxygenation is an important step in every intubation with the goals of achieving the following: 1) maximal hemoglobin saturation and, 2) maximal partial pressure of arterial oxygen.[20,21] The current standard method of preoxygenation includes the use of a non-rebreather (NRB) mask with tidal breathing for 3-5 minutes. This standard was extrapolated from studies in the operating room that used tight-fitting facemasks that prevented any air leak from the anesthesia circuit.[22-25] Safe apnea time is prolonged with preoxygenation, but variable depending on factors that change the rate of oxygen consumption or functional residual capacity (FRC) such as critical illness and obesity.[26,27] While a NRB provides an oxygen reservoir designed to breathe a higher fraction of inspired oxygen (FiO_2), the rigid mask does not create an adequate seal and thus ambient air is entrained around the mask and decreases the effective FiO_2 to much less than 100%. The higher the minute ventilation, the more this ambient air dilutes the FiO_2 by admixing with the oxygen reservoir from the NRB. This relationship of FiO_2 with underlying minute ventilation makes preoxygenation with a NRB less effective in critically ill patients. Noninvasive positive pressure ventilation (NIPPV) has been shown to improve oxygenation beyond usual preoxygenation methods, particularly in patients with obesity and shunt physiology.[28,29] NIPPV increases mean airway pressure with the benefit of alveolar recruitment, temporarily decreasing shunt fraction and improving oxygenation.[28,30-33] Indications and contraindications for the use of NIPPV may not apply when the sole purpose of applying NIPPV is preoxygenation for intubation as the intubating clinician is physically present and prepared to intervene during this short period of time. When hypoxemic patients preoxygenated with NIPPV are removed from positive pressure for the intubation procedure, there is a risk of derecruitment of alveoli causing rapid desaturation. Maintaining continuous positive pressure during the intubation with the use of a nasal mask has been shown in the operating room to be beneficial in patients with hypoxemic respiratory failure and may be useful in the ED.[34]

Occasionally NIPPV is inadequate due to anatomic characteristics that make obtaining or maintaining an adequate mask seal difficult. In these patients that have significant mask leaks, or when higher pressures are required for preoxygenation, such as in patients with pulmonary edema or morbid obesity, supraglottic airways may be an option for preoxygenation. Current data for the use of supraglottic airways for preoxygenation in the ED are limited to a case report; however, there are some limited data showing success with prolonging safe apnea time in morbidly obese patients in the operating room.[35,36] Limiting insufflation pressures to a maximum of 20cmH20 should not result in increased gastric distention or aspiration events.[28,37,38]

Pharmacologic assistance to decrease anxiety or even induce sedation may be useful if chosen carefully to improve patient tolerance of either the NIPPV mask or supraglottic airway. A recent observational study formalized a protocol, termed delayed sequence intubation (DSI), in which ketamine was administered to induce a dissociated state to allow preoxygenation with a NRB mask or NIPPV prior to the administration of a neuromuscular blocking agent, and showed most patients had improved preoxygenation.[39]

Apneic oxygenation, also known as "diffusion respiration" or "aventilatory mass flow," occurs because oxygen removal from the aveoli by circulating blood brings alveolar pressure to slightly subatmospheric levels, generating a negative pressure gradient, drawing oxygen from the upper airway into the lungs.[40] Nasal oxygen administration as a method of apneic oxygenation has repeatedly been shown to prolong safe apnea time, including in obese patients.[41-43] Apneic oxygen supplementation has been found to prevent desaturation for as long as 100 minutes at the expense of severe hypercapnea and decreased pH in operative patients. However, the effects of hypercapnea during apnea can be deleterious leading to ventricular arrhythmias, neurologic compromise, and even death.[44-48] Transnasal humidifed rapid-insufflation ventilatory exchange (THRIVE) has recently been shown to not only increase apnea time by delivering high-flow humidified

oxygen via nasal cannula at 70L/pm, but also reduce the rate of carbon dioxide increase by gaseous mixing and flushing of dead space.[49]

Recent evidence with the use of a high-flow nasal cannula (HFNC) capable of delivering a humidified, adjustable FiO_2 up to 60Lpm for preoxygenation and apneic oxygenation is mixed. Vourc'h and colleagues found no difference in desaturation rates when HFNC for preoxygenation and apneic oxygenation was compared to high-flow facemask in hypoxemic patients.[50] However, Miguel-Montanes et al. found that preoxygenation and apneic oxygenation with the same HFNC reduced desaturation compared to NRB in patients intubated in the intensive care unit. HFNC resulted in higher O_2 saturation after preoxygenation, during intubation, and at 5- and 30-minutes post-intubation.[51] A benefit of HFNCs is varying amounts of continuous positive airway pressure achieved at higher flow rates.[52] A low-cost, low-risk application of apneic oxygenation is via standard or wide-bore nasal prongs at 10-15L/pm. This flow rate is well tolerated,[53] provides near 100% FiO_2 to the nasopharynx during the apneic period and may prevent desaturation in some patients. For a more detailed description of preoxygenation and apneic oxygenation, see Weingart and Levitan's comprehensive review.[54]

Recommendations

1. Preoxygenation and apneic oxygenation should be performed in all critically ill patients. Despite mixed data, apneic oxygenation is a low-risk intervention that may provide significant benefit in prolonging the safe apneic period. If a HFNC system is not available, a wide-bore nasal cannula or standard nasal prongs should be used to augment preoxygenation and provide apneic oxygenation.
2. In patients with shunt physiology due to atelectasis or alveolar filling from pneumonia, ARDS or pulmonary edema, NIPPV can improve alveolar recruitment and oxygenation. In select patients, supraglottic airways may be considered when higher pressures are needed or a mask seal with NIPPV cannot be achieved. One must balance this potential benefit of a supraglottic airway with the risk of aspiration or upper airway injury. Nasal continuous positive airway pressure with a nasal mask may be useful to maintain alveolar recruitment during intubation in patients at high risk.
3. For patients who cannot tolerate the NIPPV mask (e.g. delirium), analgesia, anxiolysis, or DSI may be considered to optimize preoxygenation. If procedural sedation for preoxygenation is performed, one must be prepared to intubate at the onset of DSI, even with ketamine, due risk of cardiac arrest, laryngospasm and apnea, which have all been reported with ketamine.[55,56]

Hypotension

Peri-intubation hypotension is common and roughly one-quarter of patients develop transient hypotension after emergent intubation and transition to positive pressure ventilation.[57] A recent report shows that nearly 30% of critically ill patients had cardiovascular collapse after intubation.[11] Peri-intubation hypotension is a major risk factor for adverse events, including cardiopulmonary arrest related to airway management, longer intensive care unit stays and increased hospital mortality.[10,58-62] Griesdale and colleagues report that a SBP<70mmHg complicates 10% of intubations in critically ill patients[6] and pre-induction shock index (heart rate/systolic blood pressure) >0.8 and hypotension have been shown to predict patients at risk for post-intubation hypotension.[58,59,62]

Venous return to the heart is driven by the difference between venous pressure (i.e. mean systemic pressure) and right atrial pressure. During spontaneous respiration, the negative intrathoracic pressure augments this pressure gradient, which in essence "pulls" blood back to the right heart. Any physiologic disturbance that disrupts this driving pressure gradient will decrease venous return. Transition to positive pressure ventilation increases intrathoracic pressure and thus right atrial pressure, decreasing the pressure differential driving venous return.[63-66] Common causes of shock such as volume depletion, capillary leak, or a loss of systemic vascular resistance will decrease the mean systemic pressure and venous return making these patients particularly susceptible to positive pressure ventilation induced hypotension.

Fluid resuscitation is important in critically ill patients, as an increase in circulating volume will increase mean systemic pressure and venous return.[65,67] If the right heart can accommodate the increased venous return, the patient will be a "volume responder" and cardiac output will increase. Volume responsiveness is typically defined as an increase in cardiac output by >15% in response to a fluid challenge. Rapid evaluation of volume responsiveness is easily performed at the bedside by a number of techniques evaluating cardiopulmonary interactions, such as respiratory changes in inferior vena cava diameter, arterial waveform analysis, or Doppler assessment of aortic flow velocities.[68] Not all patients will be volume responsive, in which case vasopressors may be helpful for maintaining vascular tone and perfusion pressure and norepinephrine is preferred vasopressor in critically ill patients.[69,70] Pure vasoconstrictors such as phenylephrine will increase vascular resistance and blood pressure, but will depress the cardiac output and decrease venous return. In patients who are in shock, or under-resuscitated, this decrease in venous return and depressed cardiac output may actually worsen hemodynamics despite improved blood pressure.[64] In patients with transient hypotension during intubation from vasodilation or a positive pressure induced decrease in venous return, peripherally administered vasopressors may be useful for maintaining adequate end-organ perfusion pressure until adequate fluid resuscitation is achieved. Diluted phenylephrine boluses may be useful for ameliorating the decrease in vascular tone induced by anesthetic agents and maintain

systemic vascular resistance and diastolic perfusion of the coronary arteries until the transient hypotension resolves or fluid resuscitation can be optimized.[79-82] When given for a short duration, peripherally administered vasopressors have been shown to be low risk.[71]

The choice of induction agents can contribute to peri-intubation hypotension as many have adverse hemodynamic effects. Benzodiazepines and propofol have a sympatholytic effect, leading to myocardial depression and a decrease in vascular tone.[72] Etomidate is a non-benzodiazepine sedative, which has been shown to be relatively hemodynamically neutral.[73,74] Ketamine is also an attractive choice for an induction agent given its sympathomimetic properties,[75] although there have been reports of cardiac arrest after ketamine administration.[55] Jabre and colleagues compared etomidate and ketamine for emergency intubation in septic patients and found no difference in serious complications.[76] Although generally considered hemodynamically neutral, some neuromuscular blocking agents have indirect cardiovascular effects through histamine release and parasympathetic activity.[77,78] Thus, pre-intubation fluid resuscitation and thoughtful pharmacologic intervention will optimize the hemodynamic stability with airway management in the hypotensive patient.

Recommendations

1. Patients with conditions that reduce venous return are particularly susceptible to hypotension and patients at risk are suggested by pre-intubation hypotension or an elevated shock index >0.8. These patients should be hemodynamically optimized prior to intubation. This includes aggressive volume resuscitation if the patient is likely to be a volume responder. Hemodynamically stable induction agents should be used when possible.
2. For patients unresponsive to volume resuscitation, a norepinephrine infusion should be initiated.
3. If pre-intubation resuscitation is not feasible due to impending cardiopulmonary arrest in patients with shock, peripherally administered vasopressor boluses can be prepared quickly at the bedside and may maintain blood pressure during intubation and resuscitation. This intervention has not been studied in critically ill adults; however, diluted epinephrine (given as 10-50mcg boluses with a concentration of 1-10mcg/mL) may be preferred due to its inotropic effect.
4. For patients without shock who have a transient drop in blood pressure after intubation due to the vasodilatory effects of induction agents or transition to positive pressure ventilation, diluted phenylephrine (given as 50-200mcg boluses with a concentration of 100mcg/mL) may be useful.

Severe metabolic acidosis

When acidemia develops from a respiratory acidosis, rapid correction of that acidemia can occur by increasing the alveolar ventilation. Doubling the alveolar ventilation will reduce the $PaCO_2$, roughly by half. Respiratory acidosis is then usually corrected easily by interventions that increase the alveolar ventilation such as bag-valve mask ventilation, NIPPV, or mechanical ventilation. When acidemia develops from a metabolic acidosis, maintenance of acid-base homeostasis depends on a compensatory respiratory alkalosis from alveolar hyperventilation.[83] Unlike the rapid decrease in $PaCO_2$ possible during hypoventilatory states, when hypocapnia is already present due to a compensatory respiratory alkalsosis, further hyperventilation results in incrementally smaller decreases in $PaCO_2$ and eventually reaches a plateau at which point there is no effect of further increasing alveolar ventilation.[83] Thus, in severe metabolic acidosis from diseases such as diabetic ketoacidosis (DKA), salicylate toxicity, and even severe lactic acidosis, the organic acid production demands an alveolar ventilation requirement that sometimes cannot be met and patients can subsequently develop profound acidemia. In the event that patients with severe acidemia require intubation, even a brief apneic period can lead to a precipitous drop in pH given the loss of the already inadequate respiratory compensation. Further, the pre-intubation alveolar ventilation sometimes cannot be matched by the mechanical ventilator, which has physical limits on the volume and rate that can be delivered. For example, a patient with DKA and Kussmaul respirations may have a minute ventilation of >40L due to a respiratory rate of 40 breaths per minute and a tidal volume of >1L. Mechanically ventilating this patient with a set rate of 30 and tidal volume of 1L will result in an inadequate minute ventilation of 30L. Consequently, even if lung protective ventilation strategies are abandoned, the maximal attainable minute ventilation may be less than the pre-intubation minute ventilation, leading to a precipitous drop in pH and a high risk of hemodynamic deterioration after intubation. Patients with extremely high minute ventilation requirements are at high risk of developing relative hypoventilation, flow starvation, patient-ventilator dysynchrony and worsened acidosis. In these situations, a pressure-targeted mode, such as pressure support ventilation or pressure control, may allow better patient-ventilator synchrony and maintenance of the minute ventilation, especially in the spontaneously breathing patient.

Recommendations

1. Intubation should be avoided, if possible, in patients with severe metabolic acidosis who have a minute ventilation requirement not likely to be met by the mechanical ventilator, despite a low pH. A short trial of NIPPV may adequately support the respiratory work of breathing until correction of the underlying metabolic acidosis can occur and will provide an estimate of the patient's intrinsic minute ventilation by measuring the patient's respiratory rate and tidal volume delivered with each breath.

2. If intubation is necessary, maintaining spontaneous respiration becomes the critical action both during intubation and with mechanical ventilation. This will allow the patient to maintain their own high minute ventilation and includes using sedative agents that are less likely to reduce the patient's respiratory drive. Rapid sequence intubation should be avoided if possible, and if one is deemed necessary, a short-acting neuromuscular blocker such as succinylcholine should be used.
3. After intubation, we recommend choosing a ventilator mode that allows the patient to set and maintain their own minute ventilation in order to best maintain their respiratory compensation. A pressure-targeted ventilator mode such as pressure support ventilation or pressure control mode will allow the patient to set the rate and tidal volume received. Special care should be taken to monitor for air trapping given the high rates and tidal volumes reached as well as monitor for respiratory muscle fatigue, which will result in a loss of compensation.

Right Ventricular Failure

Under normal circumstances, the right ventricle is a low-pressure, high-compliance, flow-based chamber geared to propel venous blood returning to the heart into the pulmonary circulation.[84,85] However, any process that increases right ventricular (RV) afterload, such as chronic pulmonary hypertension from lung or left ventricular disease, pulmonary arterial hypertension, or acute pulmonary embolism strains the RV, which adapts by increasing both contractility and preload.[86,87] The critical action for the emergency physician is to determine if the patient has RV dysfunction, where the RV has some reserve and is able to perform some of its pumping function, or overt RV failure, in which the RV is unable to meet increased demands leading to RV dilation, retrograde flow, decreased coronary perfusion, and ultimately systemic hypotension and cardiovascular collapse.[85]

Intrathoracic pressure changes with respiration have an exaggerated effect on hemodynamics in the patient with RV failure, worsening cardiopulmonary interactions and making intubation extremely risky. Unlike left ventricular function, which improves with positive pressure ventilation, RV function worsens with the increase in intrathoracic pressure induced by positive pressure ventilation. This occurs because the intrathoracic pressure is transmitted to the alveolar capillary bed, leading to collapse of these small vessels and increases the pulmonary vascular resistance against which the RV must pump.[88] When patients with RV failure require intubation, the increased RV afterload and decreased preload associated with invasive mechanical ventilation can often lead to cardiovascular collapse.[89] When possible, work of breathing and gas exchange should be supported with medications, oxygen, and if positive pressure ventilation is needed then NIPPV and low positive end-expiratory pressure with the goals of decreasing work of breathing, limiting atelectasis, and reducing hypoxic vasoconstriction. These methods of support allow the patient to breathe spontaneously, resulting in a smaller rise in intrathoracic pressure than control modes.

Patients with increased RV afterload often present with varying degrees of RV strain on bedside echocardiography, including a dilated RV and inferior vena cava, septal flattening during systole in pressure overloaded states, and septal flattening during diastole in volume overloaded states. While patients with RV dysfunction may respond to small fluid challenges or an inotropic agent, further increasing preload with a fluid challenge in patients with RV failure is unlikely to be fruitful, and may be deleterious as volume overloading a pressure overloaded RV increases diastolic wall tension and left ventricular diastolic dysfunction, directly worsening left ventricular filling and stroke volume.[87] Thus, determining volume responsiveness is quite challenging and critically important as the volume-starved left ventricle will always appear volume responsive when using the usual techniques such as pulse pressure variation (PPV) or stroke volume variation (SVV). The tricuspid valve regurgitation jet velocity, tricuspid annular plane systolic excursion (TAPSE), tricuspid annular peak velocity or isovolumetric contraction velocity (IVV) and RV outflow tract velocity-time integral are easy to perform and useful methods of determining the degree of RV strain, volume responsiveness, and contractile reserve on bedside echocardiography.[90,91] Hemodynamic optimization, including RV afterload reduction with inhaled pulmonary artery vasodilators such as inhaled nitric oxide (iNO) or inhaled epoprostenol (Flolan), should be performed in patients with RV failure prior to intubation to avoid cardiovascular collapse with positive pressure ventilation. For a more detailed review of hemodynamic assessment methods, see Dalabih et al. and Krishnan et al.[90,91]

Recommendations

1. Bedside echocardiographic assessment of RV function should be performed to assess RV dysfunction versus RV failure. If the patient has some contractile reserve (RV dysfunction), cautious fluid resuscitation should be performed.
2. Preoxygenation is essential despite the difficulties resulting from intracardiac shunt and ventilation-perfusion (V/Q) mismatch, which commonly occur in right heart failure.[28]
3. Apneic oxygenation should be performed given the potential for benefit.[54] INO at low concentrations (<30ppm), delivered in-line continuously through the nasal cannula, can augment oxygenation by improving V/Q matching in the hypoxemic patient but may worsen V/Q mismatch at higher concentrations. In the RV failure patient without hypoxemia, 30-80ppm of iNO delivered

through the nasal cannula, or inhaled epoprostenol during preoxygenation and apneic oxygenation can reduce pulmonary vascular resistance.[90]

4. Induction agents should be considered carefully. Hemodynamically neutral sedatives such as etomidate should be used for induction. Intravenous fentanyl premedication may be useful to blunt the hypertensive response to laryngoscopy.
5. Continuous norepinephrine infusion should be started prior to induction in hypotensive patients with the goal of increasing mean arterial pressure higher than pulmonary artery pressure, which can be determined by bedside echocardiography. For patients without hypotension, norepinephrine should be primed and "in-line" in the event of post intubation or sedative induced hypotension.
6. The goals of mechanical ventilation include maintenance of a low mean airway pressure and avoidance of hypoxemia, atelectasis, and hypercapnea, which increase RV afterload.[92-95]

CONCLUSION

The difficult airway is well recognized as a clinical entity and is classically based on anatomic considerations. In this paper we describe another aspect of the difficult airway that involves physiologic abnormalities that must be considered in developing an intubation plan. These physiologic abnormalities must be considered and addressed prior to intubation. If they are not, significant untoward outcomes can result. We present four physiologic disturbances that must be considered carefully when planning for and performing tracheal intubation in the ED to avoid complications from the very procedure intended to be life saving. Many of the recommendations presented are based on clinical experience and physiologic principles and thus represent opportunities for formal investigation.

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Lactate Clearance Predicts Survival Among Patients in the Emergency Department with Severe Sepsis

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Introduction: Lactate clearance has been implicated as a predictor of mortality among emergency department (ED) patients with severe sepsis or septic shock. We aimed to validate prior studies showing that lactate clearance during the ED stay is associated with decreased mortality.

Methods: Retrospective dual-centered cross-sectional study using patients identified in the Yale-New Haven Hospital Emergency Medicine sepsis registry with severe sepsis or septic shock who had initial lactate levels measured in the ED and upon arrival (<24 hours) to the hospital floor. Lactate clearance was calculated as percent of serum lactate change from ED to floor measurement. We compared mortality and hospital interventions between patients who cleared lactate and those who did not.

Results: 207 patients (110 male; 63.17±17.9 years) were included. Two reviewers extracted data with 95% agreement. One hundred thirty-six patients (65.7%) had severe sepsis and 71 patients (34.3%) had septic shock. There were 171 patients in the clearance group and 36 patients in the non-clearance group. The 28-day mortality rates were 15.2% in the lactate clearance group and 36.1% in the non-clearance group (p<0.01). Vasopressor support was initiated more often in the non-clearance group (61.1%) than in the clearance group (36.8%, p<0.01) and mechanical ventilation was used in 66.7% of the non-clearance group and 36.3% of the clearance group (p=0.001).

Conclusion: Patients who do not clear their lactate in the ED have significantly higher mortality than those with decreasing lactate levels. Our results are confirmatory of other literature supporting that lactate clearance may be used to stratify mortality-risk among patients with severe sepsis or septic shock. [West J Emerg Med. 2015;16(7):1118-1126.]

INTRODUCTION

The incidence of severe sepsis in the United States has increased steadily over the past two decades, with an estimated 3.1% of all patients who present with infection to the emergency department (ED) meeting criteria for severe sepsis.[1] Over half of all septic patients require intensive care unit (ICU) admission,[2] and among those with organ dysfunction, overall mortality rate may approach up to 70 percent.[2-4] The advent of protocolized care has ushered in an era of ED outcomes research among patients with severe sepsis and septic shock with an objective of optimizing physiologic derangements occurring during the sepsis cascade. Direct mortality benefits have been shown in several studies.[4-6] However, there are a limited set of methods to risk-stratify

patients with severe sepsis and septic shock,[7-11] and current tools require complex sets of variables or invasive monitoring, which may not be immediately available in the ED setting.[12-14] There similarly remains a need for non-invasive endpoints to resuscitation that could tell providers they are successfully reversing physiologic derangements.

Serum lactic acid levels have long been identified as a diagnostic tool for global tissue hypoxia and therefore can serve in identifying patients with severe sepsis;[15-17] however, in recent years there has also been recognition of the prognostic value of serum lactate measurement.[18-20] Increased initial lactate values have been associated with mortality among all-comers with sepsis,[20-22] as well as specifically in ED patients with sepsis.[19] Based upon these findings, international sepsis guidelines now suggest routine measurement of lactate among patients with severe sepsis and immediate resuscitation for septic patients whose serum lactate measurement is greater than 4 mmol/L.[23]

Relatively few studies, however, have examined the role of lactate clearance or serial lactate measurements as endpoints among patients with severe sepsis or septic shock patients presenting in the ED.[18,24-26] Several hospitals are now incorporating sepsis bundles into standard practice, and these bundles often suggest repeat lactate measurement,[27-29] yet there are limited data available to show what clinical significance the serial measurement has. Our aim was to evaluate the predictive value of lactate clearance on 28-day in-hospital mortality and to investigate secondary outcomes such as need for particular treatments and interventions. We hypothesized that patients with severe sepsis or septic shock who present to the ED and have evidence of lactate clearance upon admission to the hospital would have lower in-hospital mortality rates than those who did not clear initial lactate levels.

METHODS

The study was performed at a dual-site teaching hospital ED with nearly 100,000 patient visits annually. It was a retrospective cross-sectional study using patients identified prospectively in the Yale-New Haven Hospital Emergency Medicine registry. The study was approved by the Yale Human Investigation Committee for the review of medical records by study personnel. The registry is comprised of a patient list created between July 1, 2005, and July 31, 2008. In a systematic and standardized fashion, we prospectively and consecutively identified sepsis registry patients during predefined time periods at two EDs as a quality improvement initiative tracking sepsis outcomes (i.e., short-term mortality) and quality measures (i.e.–lactate measurement, time to antibiotics, resuscitative endpoints) for ED patients in the Yale Health System. Inclusion criteria were age greater than 18 years and a diagnosis of severe sepsis or septic shock. In addition, for all included patients, the time between the initial ED serum lactate measurement and the lactate measurement on the floor needed to be 24 hours or less. Patients were excluded from the study if they were discharged to home or were documented as desiring only comfort care measures prior to or during the ED admission.

We based definitions of systemic inflammatory response syndrome (SIRS) criteria, presumed or documented source of infection, end-organ dysfunction, and classification of a patient's sepsis category upon the model proposed by the International Sepsis Definitions Conference's consensus statement.[17] End-organ dysfunction was defined as any one of the following findings: transient systolic blood pressure less than 90 mmHg that responded to fluid resuscitation; lactate level greater than or equal to 2mmol/L; altered mental status from baseline; elevation of any coagulation factor (in the absence of heparin or warfarin therapy); unexplained acidosis marked by an arterial pH less than 7.35 or a serum bicarbonate level less than 21mEq/L; elevation of bilirubin (direct or indirect) from baseline; hypoxemia marked by a pulse oximetry reading less than 90 percent or presence of a significant oxygen requirement; acute kidney injury defined as a creatinine greater than 0.5mg/dL from baseline level or abnormal if no baseline was available; and/or any troponin elevation from baseline.

We collected baseline demographic information for all patients. Data were recorded in a standardized fashion onto a data collection form by medical student investigators under the supervision of a faculty investigator. We entered data from the chart review into an Excel (Microsoft Corp., Redmond, Washington) database. Weekly meetings were conducted to review progress and the data extraction process. Lactate data collected in the database included the time and measured value for the initial ED, peak ED, initial admission, and peak admission serum lactate levels. For data points that were not present in the chart, labs other than serum lactate levels were considered to be normal and were not calculated into the mean value; Glasgow Coma Scale (GCS) scores that were not explicitly recorded were interpreted from the documented neurologic exam or excluded from the mean value if an exam was not documented. There were no missing vital signs or lactate values among our sample. The two chart extractors collected overlapping data points with 95% agreement.

We calculated lactate clearance as a percentage of lactate cleared between the initial ED lactate blood draw and the initial admission lactate level by modeling after previously developed formulas: (Initial ED lactate level - Admission ED lactate level) / Initial ED lactate level[18,25]. Patients who had a negative value for lactate clearance based upon this formula were considered to have not cleared lactate; all other patients (i.e., those that had a zero or positive value) comprised the lactate clearance group. The time period over which clearance occurred was calculated using the date and time information for each lab draw. We compared the 28-day in-hospital mortality rate among all-comers who cleared lactate with those who showed an increase in lactate levels at the time of admission.

We also calculated Acute Physiology and Chronic Health Evaluation II (APACHE II) and Mortality in Emergency

Department Sepsis (MEDS) scores,[8,11] For MEDS calculations, because "rapidly terminal comorbid disease" data was not explicitly available in the registry, we used patients with cancer receiving chemotherapy as a surrogate of terminal disease. Secondary analyses were performed to determine differences between the lactate clearance group and the patients with negative clearance for variables related to baseline characteristics, disease severity, and ED treatments. In addition, we assessed markers of morbidity outcome between the two groups by comparing rates of vasopressor use, steroid administration, mechanical ventilation, and source control between the two groups.

We completed statistical analysis using SPSS 11.0 (Chicago, IL, USA) and GraphPad (La Jolla, CA, USA). For all categorical variables, relationships were determined using two-tailed Fisher's exact tests or a chi-squared test. If the data contained continuous variables, independent samples, 2-tailed t-tests were used. Findings were deemed statistically significant for all values of $p<0.05$. Unless otherwise specified, all reported values in the manuscript, tables, and figures present mean±standard deviation (SD).

RESULTS

Of the 245 patients in the registry with serial lactate levels obtained both in the ED and on the floor, 207 met inclusion criteria for our study. We excluded 38 patients (15.5%) for having greater than 24 hours between lactate levels in the ED and the floor. The sample consisted of 110 males (53.1%) with a mean age of 63 years±17.9 years. Overall patient characteristics are summarized in Table 1. One hundred thirty-six patients (65.7%) met criteria for severe sepsis and 71 patients (34.3%) met criteria for septic shock. Patients' mean total number of organ dysfunction signs was 3.63±2.0 with 95 patients (45.9%) having four or more organs with dysfunction.

A summary of ED interventions is described in Table 2. One hundred ninety-four patients (93.7%) in the study received antibiotics in the ED. Fifty-two patients (25.1%) received some form of vasopressor support in the ED and nearly 40% of patients required vasopressor support within 72 hours of admission to the hospital. Eighty-six patients required mechanical ventilation either in the ED or at some point during their hospitalization. One hundred sixty-one patients (77.8%) were admitted to an ICU setting. The overall 28-day in-hospital mortality rate for our cohort was 19% (39 patients).

The mean initial ED lactate in the clearance group was 3.2±2.1mmol/L and the mean for the non-clearance group was 3.1±3.7mmol/L (95% CI, [-1.2 to 1.4]; p=0.861). In contrast, admission lactate levels differed significantly between the non-clearance group's mean level of 4.7±4.8 mmol/L and the clearance group's mean lactate of 1.7±1.2 (95 % CI, [-4.6 to -1.4]; $p<0.001$). Table 3 compares demographical and clinical variables between the clearance and non-clearance groups.

The percentages of patients receiving vasopressor support in the ED were 24% (n=41) and 30.6% (n=11) for the clearance and non-clearance groups, respectively (p=0.405). As shown in Figure 1, the non-clearance group had a rate of overall hospital vasopressor use of 61.1% (n=22) whereas only 36.8% (n=63) in the clearance group received vasopressors after admission (p=0.009). There was also a difference in the rate of hospital use of mechanical ventilation between the lactate clearance group and the patients who did not clear lactate (36.3% (n= 62) vs. 66.7% (n=24), p=0.001). Rates of corticosteroids and source control procedures were similar among the two groups. The mean ED length of stay for the clearance group was 6.5±3.33 hours contrasted to 5.98±3.93 hours for the Non-clearance group (p=0.41).

In hospital 28-day mortality rates were 12.7% (8 of 63 patients) for patients who had initial lactates less than 2.0mmol/L, compared with mortality rates of 19.5% (17 of 87 patients) among patients with an initial lactate between 2.0 and 4mmol/L and 24.6% (14 of 57 patients) for those with lactates greater than 4.0mmol/L (p=0.246).

For our cohort, the mean time between the initial ED lactate measurement and the second-floor lactate blood draw was 9 hours and 8 minutes±4 hours and 46 minutes. As shown in Figure 2, the mortality rate was 36.1% (13 of 36 patients) among those who did not clear their lactate level after admission compared with the mortality rate of 15.2% (26 of 171 patients) for those in the lactate clearance group (p=0.008). Further, among the subgroup of 144 patients with an initial ED lactate of 2 mmol/L or higher, 28-day mortality rates were 62.5% for the non-clearance group (10 of 16 patients) compared with 16.4% (21 of 128 patients) in the clearance group ($p<0.001$).

DISCUSSION

We have shown in a real-world cross-sectional study that 28-day in-hospital mortality rates are significantly higher among patients who have no lactate clearance upon admission to the hospital compared with those who have clearance. Our findings complement a growing body of literature, consisting of both retrospective studies and prospective and randomized clinical trials that demonstrate the non-invasive variable of lactate clearance can be used to predict 28-day mortality among patients in the ED with severe sepsis or septic shock.[18,25,30,31,32]

Bakker et al. found that among the septic shock population, a shorter "lac-time" (defined as the total duration of elevated blood lactate levels) could predict survivability but also could predict lower organ failure scores, lending credence to the emerging concept of serial lactate measurement.[15] Specific application to the ED setting came with Nguyen's novel use of the formula for lactate clearance during the first six hours of care, and these authors showed a statistically and clinically significant difference in outcome.[18] They found that although there is often no statistical difference among patients' initial lactate levels, those patients who were unable to improve their lactic acidosis were more likely to develop organ failure and had higher 24-hour and 60-day mortality

Table 1. Patient characteristics (n=207) in study of lactate clearance as predictor of survival in patients with severe sepsis.

Patient characteristics	n (%)
Male	110 (53.1%)
Mean age ± SD (years)	63.17 ± 17.9
Diagnosis	
Severe sepsis	136 (65.7%)
Septic shock	71 (34.3%)
Diagnostic criteria	
Mean number of SIRS criteria ± SD	2.99 ± 0.77
Documented source of infection	
Genito-urinary	24 (11.6%)
Intra-abdominal	27 (13.0%)
Pneumonia	54 (26.1%)
Soft tissue	16 (7.7%)
Other[†]	19 (9.2%)
Mean number of organ dysfunctions ± SD	3.63 ± 2.0
Transient hypotension	86 (41.5%)
Lactate level ≥2mmol/L	144 (69.6%)
Unexplained acidosis	97 (46.9%)
Altered mental status	72 (34.8%)
Low platelet count	31 (15.0%)
Elevated bilirubin level	81 (39.1%)
Coagulopathy(without prior anticoagulation)	31 (15.0%)
Acute renal failure	98 (47.3%)
Hypoxemia	64 (30.9%)
Troponin elevation	52 (25.1%)
Past medical history	
Alcohol abuse	26 (12.6%)
Asthma	10 (4.8%)
Cancer	54 (26.1%)
Cancer with chemotherapy	22 (10.6%)
Congestive heart failure	45 (21.7%)
Coronary artery disease	47 (22.7%)
Chronic altered mental status	25 (12.1%)
Chronic obstructive pulmonary disease	38 (18.4%)
CVA/transient ischemic attack	29 (14.0%)
Diabetes	74 (35.7%)
End stage renal disease	25 (12.1%)
HIV or HIV/AIDS	9 (4.3%)
Hypertension	108 (52.2%)
Immunosuppression	22 (10.6%)
Liver disease	15 (7.2%)
Residing in extended care acility	59 (28.5%)
Mean MEDS score ± SD[§]	9.05 ± 4.09

SIRS, systemic inflammatory response syndrome; *CVA*, cerebrovascular accident; *HIV*, human immunodeficiency virus; *AIDS*, acquired immune deficiency syndrome
[†]e.g., central nervous system infection or line infection.

MEDS, mortality in emergency department sepsis
[§]N = 206.

Table 2. Interventions and treatment (n=207).

	n (%)
Mean length of ED stay ± SD (hours:minutes)	6:25 ± 3:26
Mean intravenous fluid amount ± SD (L)	3.43 ± 2.33
Antibiotic treatment	
Received	194 (93.7%)
Mean time ± SD (hours:minutes)	2:34 ± 2:12
Type of antibiotic[†]	
Acyclovir	4 (2.1%)
Ampicllin	4 (2.1%)
Ceftazadime	8 (4.1%)
Ceftriaxone	45 (23.2%)
Ciprofloxacin	45 (23.2%)
Doxycycline	33 (17.0%)
Metronidazole	22 (11.3%)
Gentamicin	8 (4.1%)
Ampicillin/sulbactam	8 (4.1%)
Vancomycin	122 (62.9%)
Piperacillin/tazobactam	112 (57.4%)
Other[§]	9 (4.6%)
Cultures	
Blood culture drawn	199 (96.1%)
Urine culture drawn	139 (67.1%)
Other culture drawn[‡]	63 (30.4%)
Any culture positive[Δ]	140 (34.9%)
Hospital vasopressors	
Less than 72 hours after admission	81 (39.1%)
Greater than 72 hours after admission	7 (3.4%)
Hospital use of dobutamine	15 (7.2%)
Hospital use of corticosteroids	75 (36.2%)
Source control[†]	40 (19.3%)
Hospital use of mechanical ventilation	86 (41.5%)

ED, emergency department
[†]N=194 (of those patients receiving antibiotics).
[§]amoxicillin, clindamycin, meropenem, moxifloxacin, trimethoprim-sulfamethoxazole.
[‡]e.g., sputum, wound, or cerebrospinal fluid cultures.
[Δ]N=401 (of those cultures drawn).
[†]abscess drained, line pulled, endoscopic or operative management.

Table 3. Baseline characteristics and therapies for clearance and non-clearance groups.

Variable	Clearance group (N=171)	Non-clearance group (N=36)	p-value
Age (years)	63.3 ± 18.0	62.53 ± 17.52	0.814
Diagnostic variables			
Severe sepsis (%)	67.3	58.3	0.337
Number of SIRS criteria	3.03 ± 0.75	2.78 ± 0.80	0.073
Source of infection (%)			
Genito-urinary	11.1	13.9	0.577
Intra-abdominal	14.0	8.3	0.429
Pneumonia	25.7	27.8	0.835
Soft tissue	7.6	8.3	1.00
Other[†]	9.4	8.3	1.00
Number of organ dysfunctions	3.54 ± 1.87	4.03 ± 2.50	0.187
Past medical history (%)			
Alcohol abuse	13.5	8.3	0.581
Cancer	26.9	22.2	0.678
Cancer with chemotherapy	8.8	19.4	0.074
Congestive heart failure	19.3	33.3	0.076
Coronary artery disease	23.4	19.4	0.669
Chronic obstructive pulmonary disease	15.2	33.3	0.017[a]
Diabetes	37.4	27.8	0.340
End stage renal disease	11.7	13.9	0.778
Hypertension	49.7	63.9	0.144
Immunosuppression	9.9	13.9	0.550
Liver disease	7.0	8.3	0.729
Residing in extended care facility (%)	26.9	36.1	0.310
Glasgow coma scale score[Ψ]	13.6 ± 2.8	13.2 ± 3.5	0.431
MEDS score	8.78 ± 3.96	10.40 ± 4.48	0.032[a]
APACHE II score	18.6 ± 7.0	21.1 ± 8.6	0.069
Laboratory values			
WBC (per mm^3)[‡]	13.99 ± 8.10	16.71 ± 18.57	0.168
Hematocrit (%)[‡]	37.72 ± 7.41	35.60 ± 8.01	0.130
Platelet count (per mm^3)[‡]	260.8 ± 124.4	222.1 ± 129.8	0.097
Creatinine (mg/mL)	2.4 ± 2.1	2.4 ± 1.9	0.942
Blood cultures drawn (%)	97.1	91.7	0.145
Urine cultures drawn (%)	70.2	52.8	0.052
Initial ED lactate (mmol/L)	3.26 ± 2.14	3.14 ± 3.73	0.804
Initial admission lactate (mmol/L)	1.76 ± 1.25	4.76 ± 4.81	<0.001[a]

SIRS, systemic inflammatory response syndrome; *MEDS,* mortality in emergency department sepsis; *APACHE II,* Acute Physiology and Chronic Health Evaluation II; *WBC*, white blood cell; *ED,* emergency department

[†]e.g., line infection or central nervous system infection.

[Ψ]N=165 for clearance group.

[‡]N=35 for non-clearance group.

[Δ]N=169 for clearance group.

N=34 for non-clearance group

Table 3. Continued.

Variable	Clearance group (N=171)	Non-clearance group (N=36)	p-value
Therapy (%)			
Intravenous fluid administered in ED	98.8	86.1	0.002[a]
Amount of intravenous fluid (L)[Δ]	3.41 ± 2.26	3.57 ± 2.74	0.720
Antibiotics administered in ED	95.3	86.1	0.054
Central line placement in ED	45.0	61.1	0.099
ED vasopressor use	24.0	30.6	0.405

ED, emergency department
[a]Statistically significant, p<0.05.

rates.[15,18] Nguyen et al. did not find a significant difference in the use of ED vasopressors or fluid among survivors and non-survivors in their sample, and our cohort similarly revealed no differences between clearance and non-clearance groups for ED vasopressor usage. In addition, we found no significant difference in antibiotic administration rates between the two groups. In an analysis using data from prospectively collected registries from three urban hospitals, Arnold et al., showed similar results to Nguyen's work, suggesting that lactate clearance of 10% or greater from initial values was associated with significant mortality benefits.[25] Our study shows comparable results using a slightly different definition of "clearance" in that we examined a binary distinction (i.e., decrease or no change in lactate versus any increase in lactate), which we feel can be easily calculated by the clinician.

Our results are also similar to work from other arenas, including the trauma literature, that supports the notion of lactate clearance as a marker for ongoing tissue hypoxia and a predictor of mortality. The use of normalized lactate clearance has been associated with improved outcomes in several critical illness settings, including both trauma patients[33,34] and patients with circulatory arrest.[35-37] Our findings also show a significantly higher requirement for hospital vasopressors within 72 hours of admission for the non-clearance group and further revealed a significantly higher rate of mechanical ventilation among the non-clearance group, a finding that was not seen in the prior work by Nguyen et al. but has been demonstrated in a recent study among trauma patients in which impaired 24-hour lactate clearance increased the likelihood of requiring mechanical ventilation.[38]

Among our sample, fewer patients in the non-clearance group received fluids compared with those patients who had clearance of lactate suggesting that under-resuscitation with intravenous fluids, independent of receipt of antibiotics, may correlate with impaired lactate clearance; the patients in the non-clearance group likely had sustained global tissue hypoxia due to ongoing physiologic derangements. Therefore, it appears that patients who are not clearing lactate are sicker in spite of having similar severity of illness scores to the control group. This could be because a proportion of patients didn't receive adequate ED fluid resuscitation, or it could illustrate that lactate is a better prognostic variable for the ED setting. Furthermore, extrapolation from our results suggests that lactate clearance might be a useful endpoint for ED resuscitation, but further investigation will undoubtedly be needed to assess its exact potential.

Currently, lactate clearance is not readily identified as a variable that can be used to determine the therapeutic endpoint for patients with sepsis.[23] However, a recent study has shown lactate clearance may be used as a surrogate for invasive central venous oxygen saturation when implementing resuscitative strategies.[26] If lactate clearance continues to be associated with improved outcome, as in our study and other recent work,[18,25,26] it may suggest that normalized lactate values can be used as a therapeutic endpoint among this patient population, should be incorporated into sepsis bundles, and might dictate safe disposition from the ED or ICU to a general medical floor.

LIMITATIONS

Limitations of our study include its retrospective extraction from a prospective registry and chart abstractors were not blinded to the study hypothesis. Several data points were unavailable in the sepsis registry, and calculation of GCS, for example, relied upon use of documented neurologic status at triage or during the physical exam. Despite this limitation, our cohort included 207 patients, which is among the highest in any study of lactate clearance and ED sepsis to date, and we had strong agreement between the two investigators recording overlapping data points. The study was also prone to a length bias as there was not a specific protocol guiding the intervals lactate levels were drawn (i.e., time to initial and time to repeat lactate level) —this was left at the discretion of the treating teams and could have been delayed for various reasons, thus confounding results. However, there is still potential merit in assessment at variable time-periods. What is perceived as "lactate clearance" may also be interpreted, given the short duration of elevation seen in other patient populations (i.e., grand mal seizure patients), as a decrease in lactate production.[39] This interruption in lactate production likely ensues from resuscitative procedures reversing global tissue hypoxia and oxygen delivery and

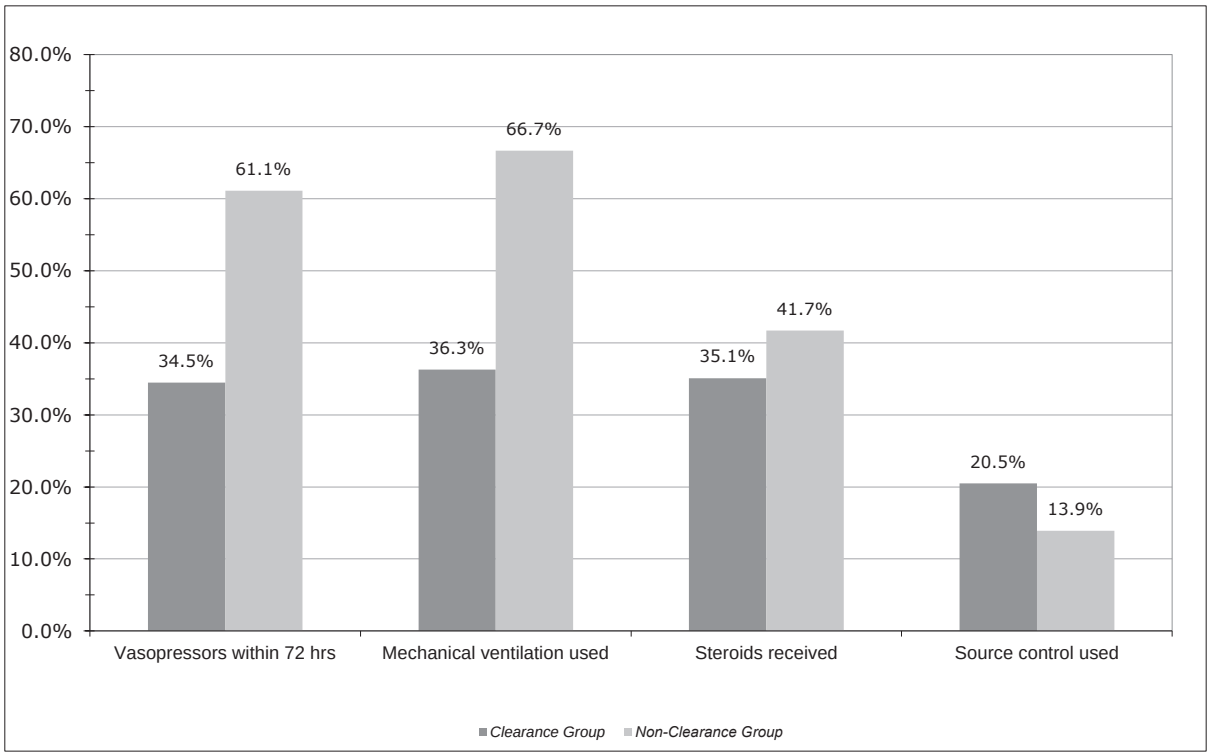

Figure 1. Hospital interventions for clearance and non-clearance groups.
A significantly higher ratio of patients in the non-clearance group required vasopressor support within 72 hours of admission compared with the rate of vasopressor use in the clearance group (p<0.01). A greater percentage of patients in the non-clearance group required mechanical ventilation for any point during the hospitalization (p=0.001). There were no significant differences in the rates of steroid use or source control between clearance and non-clearance groups.

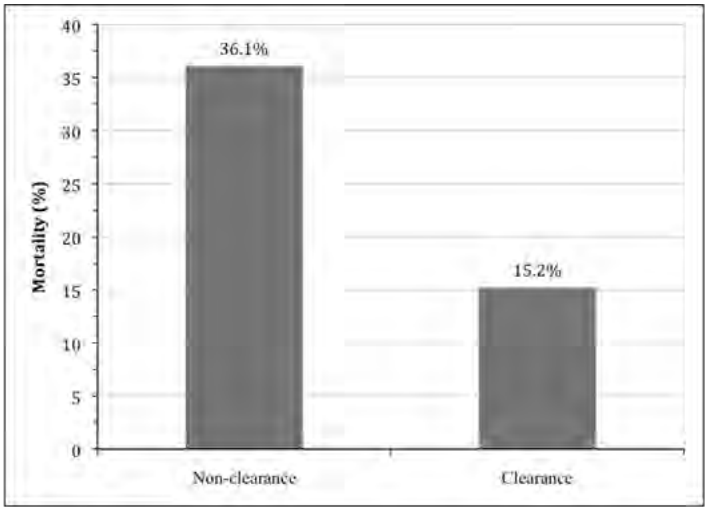

Figure 2. Mortality rates by lactate clearance group.
28-day in-hospital mortality rates were significantly lower among patients who cleared lactate (15.2% mortality) compared with those who did not (36.1% mortality, p<0.01).

consumption mismatches. It is feasible that the termination of lactate production reflected by lactate clearance formulas may perhaps better confer prognostic information in the early (<24 hours) phase of ED and inpatient care. Despite these considerations that merit further investigation, in our study the mean time over which lactate clearance was measured was only three hours greater than the study by Nguyen et al. and there was no significant difference in the mean time over which lactate clearance was calculated between our clearance and non-clearance groups.

Similarly, our results could be affected by selection bias, in that sicker patients may have been prone to getting lactate levels checked more frequently. However, we found no significant differences between the clearance and non-clearance group for initial lactate level and also found no significant difference in APACHE II score between the two groups, suggesting that the overall population had similar disease severity at the time of presentation and initial lactate draw. However, the proportion of patients who received antibiotics or IVF in the ED was higher in the clearance group (p=0.002 for IVF, p=0.054 for antibiotic administration). This confounder could account for the observed differences in mortality, and perhaps underscores the importance of administering these key interventions in a time-sensitive fashion in the ED.

Additionally, selection bias may have been why some patients were excluded because an initial lactate was not

measured, but this group was small. Our overall sample population had even distribution by gender, had a mean age of 63 years which is similar to the mean age of the sample used by Nguyen et al., and also had similar characteristics between the clearance and non-clearance groups for initial laboratory parameters, SIRS presentations, ED length of stay, and lactate levels. Thus we feel our "real world" findings can be compared with those of prior studies and are applicable to the broader population of patients presenting to the ED with severe sepsis or septic shock.

CONCLUSION

Based on our findings, we conclude that lactate clearance appears to correlate with short-term survival among patients with severe sepsis or septic shock. Lactate clearance could serve as an efficient tool for mortality risk-stratification similar to more complex scoring systems and could potentially provide critical information about response to treatment. Despite the need for further prospective validation studies, this study reveals that the ability to clear lactate or halt lactate production could have potential as a predictor of mortality among patients presenting to the ED with severe sepsis or septic shock, in aiding with disposition, or in recognizing patients who require additional resuscitation.

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Conflicts of Interest: By the *West*JEM article submission agreement, all authors are required to disclose all affiliations, funding sources and financial or management relationships that could be perceived as potential sources of bias. The authors disclosed none.

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Evidence-based Comprehensive Approach to Forearm Arterial Laceration

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Introduction: Penetrating injury to the forearm may cause an isolated radial or ulnar artery injury, or a complex injury involving other structures including veins, tendons and nerves. The management of forearm laceration with arterial injury involves both operative and nonoperative strategies. An evolution in management has emerged especially at urban trauma centers, where the multidisciplinary resource of trauma and hand subspecialties may invoke controversy pertaining to the optimal management of such injuries. The objective of this review was to provide an evidence-based, systematic, operative and nonoperative approach to the management of isolated and complex forearm lacerations. A comprehensive search of MedLine, Cochrane Library, Embase and the National Guideline Clearinghouse did not yield evidence-based management guidelines for forearm arterial laceration injury. No professional or societal consensus guidelines or best practice guidelines exist to our knowledge.

Discussion: The optimal methods for achieving hemostasis are by a combination approach utilizing direct digital pressure, temporary tourniquet pressure, compressive dressings followed by wound closure. While surgical hemostasis may provide an expedited route for control of hemorrhage, this aggressive approach is often not needed (with a few exceptions) to achieve hemostasis for most forearm lacerations. Conservative methods mentioned above will attain the same result. Further, routine emergent or urgent operative exploration of forearm laceration injuries are not warranted and not cost-beneficial. It has been widely accepted with ample evidence in the literature that neither injury to forearm artery, nerve or tendon requires immediate surgical repair. Attention should be directed instead to control of bleeding, and perform a complete physical examination of the hand to document the presence or absence of other associated injuries. Critical ischemia will require expeditious surgical restoration of arterial perfusion. In a well-perfused hand, however, the presence of one intact artery is adequate to sustain viability without long-term functional disability, provided the palmar arch circulation is intact. Early consultation with a hand specialist should be pursued, and follow-up arrangement made for delayed primary repair in cases of complex injury.

Conclusion: Management in accordance with well-established clinical principles will maximize treatment efficacy and functional outcome while minimizing the cost of medical care. [West J Emerg Med. 2015;16(7):1127-1134.]

INTRODUCTION

Upper extremity arterial injuries constitute up to 50% of peripheral vascular injuries.[1-2] Penetrating injury to the forearm is a less common subset of upper extremity trauma. Lacerations of the forearm and wrist by knife, glass or machinery (often from occupational injury), are frequent to both the radial and ulnar arteries. Musculotendinous and nerve structures are also commonly injured (complex laceration). Emergency physicians and trauma surgeons constitute the front-line providers who direct initial management, where availability of hand subspecialty provides an additional level of expert care. The literature is replete with operative management strategies with hard signs, but sparse on conservative management without surgical intervention, a service often not available at rural emergency facilities. Conservative nonoperative management of lacerated forearm arterial injuries in accordance with well-established clinical principles will maximize treatment efficacy and functional outcome while minimizing healthcare costs.

A bleeding forearm involving arterial laceration presents dramatically and demands prompt attention. The presence of pulsatile bleeding is a hard sign of arterial injury. The first step in the management of this condition is to provide active hemorrhage control. Knowledge of vascular anatomy as well as the mechanisms of bleeding and coagulation will aid the treating physician in the management of arterial bleeding. The purpose of this review is to provide a thorough and systematic approach to management of forearm arterial laceration without emergent or urgent operative intervention. Inherent is the need for good communication and understanding between the treating emergency or trauma physician and the hand specialist consultant.

DISCUSSION

Arterial Anatomy

In the proximal forearm, the brachial artery bifurcates at the level of the radial tuberosity into the radial and ulnar arteries. These arteries have recurrent branches that anastomose with the upstream brachial artery branches to form a network of rich collaterals around the elbow. The ulnar artery gives off the common interosseous artery, which immediately gives rise to the anterior (volar) and posterior (dorsal) interosseous branches that run on either side of the interosseous membrane. In the forearm the radial artery lies in proximity and medial to the superficial branch of the radial nerve, and the ulnar artery is joined in its course by the ulnar nerve. At the wrist, the radial artery traverses the anatomical snuffbox, gives off a superficial palmar branch that contributes to the superficial palmar arch, then winds dorsally around the wrist across the carpal bones (scaphoid and trapezium). In the hand, the radial artery travels dorsally through the first interosseous webspace and across the palm deep to the adductor pollicis muscle to join the deep palmar arch. The ulnar artery courses superficial to the transverse carpal ligament and deep to the palmar carpal ligament at the wrist, gives off a deep palmar branch and then continues on superficial to the flexor tendons to form the superficial palmar arch, the dominant arterial arcade supplying the hand. The hand has a robust collateral network comprised of the deep and superficial palmar arches, which derive their main contributions from the radial and ulnar arteries respectively (Figure 1). Approximately 20% of the population has an incomplete or interrupted superficial or more rarely deep palmar arch, with an absence of communication or anastomosis between the arterial branches of the arch. However, in the majority the superficial and deep palmar arches interconnect with each other and with the radial and ulnar circulations.[3] The superficial palmar arch gives rise to the common palmar digital arteries, which in turn branch into the proper digital arteries to supply the fingers.

Initial Patient Assessment

In a multi-trauma patient or a trauma patient in extremis, priority is given to initial resuscitation, stabilization, and identifying life-threatening injuries, according to the Advanced Trauma Life Support (ATLS) guidelines.[4] Arterial hemorrhage may constitute such an injury. Further assessment must also be made of the viability and perfusion of the distal limb as described below.

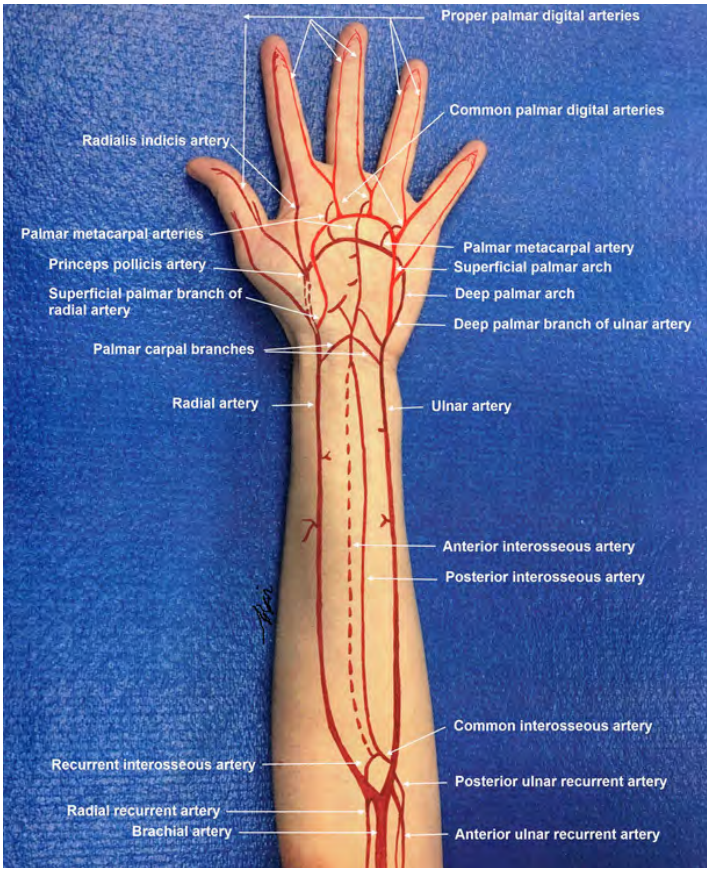

Figure 1. Arterial circulation in the forearm and hand.

METHODS OF HEMORRHAGE CONTROL

Manual Direct Digital Compression

Of the various methods for achieving hemostasis in a briskly bleeding wound, manual direct digital pressure over the bleeding artery is safe and effective.[5] However, this method requires investment of sufficient time to obtain hemostasis, ranging from five to 15 minutes or more of consistent application of pressure without interruption and is often successful.[6] Disturbance of the wound by manipulation or additional inspection will destabilize forming clot and contribute to additional blood loss and time to hemostasis. Heavy dressings will be ineffective if the point of bleeding is not precisely compressed.

Temporary Tourniquet Application and Wound Closure

The next optimal method of achieving hemostasis is by temporarily applying an antebrachial pneumatic tourniquet for distal forearm laceration or brachial tourniquet for proximal forearm laceration. The correct pressure is the minimum amount required to produce a bloodless field. In an adult, upper extremity pressure 30-70mmHg higher than the systolic pressure may be sufficient to suppress arterial flow. An appropriate tourniquet pressure is around 250mmHg in adults and between 100 to 200mmHg in children, and adjusted for patient size and systolic pressure.[7] If a pneumatic tourniquet is not readily available, a standard blood pressure cuff can be used, with clamping of the cuff with hemostats to maintain pressure. Ideally, before the cuff is inflated the arm is exsanguinated by elevation and distal-to-proximal centrifugal wrapping with an Esmarch bandage or tight ACE wrap. Tight compressive dressings should be applied over the wound. When the bleeding is adequately controlled under tourniquet pressure, the lacerated wound should be promptly inspected, debrided of foreign material, irrigated with normal saline, and promptly closed with running non-absorbable monofilament suture under local anesthesia. After wound closure, a compact compressive gauze dressing should be applied and reinforced with elastic bandage wrap and the tourniquet released. This method effectively achieves hemostasis by way of tissue tamponade. Inflation time should be kept to a minimum. Accurate tourniquet pressure monitoring avoids excessive pressure to nerve structure underneath, which is the major source of tourniquet-related pain. Although, as a generally accepted safe limit, the normal forearm and hand can withstand a tourniquet time of up to two hours without ischemic sequelae,[8,9] bleeding control solely by tourniquet is discouraged. Prolonged tourniquet use defeats the rich collateral network that maintains perfusion of an already compromised circulation to the distal forearm and hand.[9] Moreover, when a tourniquet is used in an awake patient, pain may limit the duration of application and utility.

Arm elevation, for example by a cast stockinette sleeve rolled onto the arm with the other end tied to an elevated support such as an IV pole, may be used to stabilize the wound and decrease intravascular hydrostatic pressure, minimizing residual bleeding.

The close anatomic relationship between artery and nerve especially on the ulnar aspect of the wrist results in a high probability of nerve injury when attempts are made to place clamps or suture ligature on the bleeding artery. Blind application of clamps and ligatures in the bleeding wound risks iatrogenic injury to nerves including the superficial branch of the radial nerve, palmar cutaneous branch of the ulnar nerve and the ulnar nerve itself. Distally, intimacy between the common and digital arteries and nerves guarantees cross ligation. Therefore, clamps and suture ligature on bleeding points are not a recommended method of achieving acute hemostasis in this setting. Similarly, wound exploration should be performed cautiously to avoid iatrogenic injury to adjacent structures.[10]

Other causes of wound bleeding include injury to veins and tributaries, as well as tearing of small vessels between tissue planes. These bleeding sources can be easily controlled with the same above-mentioned principles and methods of achieving hemostasis, with the exception that venous ligation may be considered in safe anatomic locations.

Comprehensive Physical Examination

After control of arterial hemorrhage, a thorough and systematic physical examination in the injured forearm and hand should be performed including comparison made to the uninjured hand, to evaluate perfusion and neurological status, as well as for concomitant bone, nerve or tendon injury. This assessment directs the subsequent treatment and management. The duration and pressure of a tourniquet, as well as use of local anesthetics must be documented to avoid compromise of subsequent examinations and inadvertent prolonged ischemia.

Vascular Examination

A complete vascular examination involves assessing for any clinical evidence of ischemia or vascular insufficiency to the hand. This includes palpation of the radial and ulnar pulses. The radial artery, in its superficial location, is easily palpable at the wrist, while the ulnar artery may not be as easily detected. If pulses are not palpable, interrogation with a hand-held Doppler device should be performed seeking brisk, triphasic Doppler signals. It is important to compare the pulse or Doppler examination to the non-injured hand. An asymmetric pulse is almost always abnormal. Documentation of an intact radial or ulnar artery is important in a lacerated forearm.

An ischemic hand is painful and the symptom of pain should raise suspicion of vascular insufficiency. Motor and sensory deficits can also result from arterial insufficiency, ranging from paresthesia to weakness and paralysis. Use skin color, turgor, temperature, backflow and distal fingertip or nail bed capillary refill time to assess perfusion to the hand. Inspection and palpation of an ischemic hand will reveal paleness or pallor, bluish discoloration or cyanosis, skin mottling and coolness as compared to the rest of the body. A

delayed or asymmetric finger capillary refill time >2 seconds signifies decreased perfusion. Assessment of tissue oxygen saturation with pulse oximetry, using a pulse oximeter sensor is an important additional perfusion assessment method. It is quick and reliable, and should be measured in more than one digit (Figure 2). Asymmetry or values significantly less than alternate sites of measurement would suggest hypoperfusion. Serial readings can be helpful for continuous assessment to detect any deterioration from the baseline assessment. Finger pulp skin temperature can be measured with a temperature probe. A reading <30^{0}C (<86^{0}F) may indicate decreased perfusion. It is reliable, widely available and simple.

Adjunct Vascular Examination

While not a priority exam, the Allen's test, originally described in 1929, can be performed to evaluate the integrity of the palmar arch and palmar collateral circulation.[11] A variation of this technique exists and is known as the modified Allen's test.[12,13] To perform the Allen's test, the examiner will first occlude the radial artery with one hand, followed by occluding the ulnar artery with the other hand. The patient's hand is then clasped in a tight fist to exsanguinate the palmar arch. The hand is then relaxed. To assess the integrity of the palmar arch circulation, either one of the radial or ulnar artery compression is released while the other remains occluded. If the uncompressed artery and palmar arch is intact, the hand will blush with return of circulation. An Allen's test is said to be positive when the blush occurs, demonstrating patency of the artery tested and integrity of the palmar arch circulation. A delay in filling time >6 seconds is widely used as a cut-off to imply an incomplete or interrupted arch. However, this is not an absolute discriminatory test as controversy exists surrounding its reliability in predicting hand ischemia.[14]

Alternatively, Doppler signal interrogation of the palmar arch and digital arteries can be performed with a hand-held Doppler (Figure 2). The Doppler Allen's test can also be conducted to evaluate continuity of the palmar arch.[15,16] In theory, an intact palmar arch circulation is required for maintaining adequate vascular perfusion to the hand in the setting of an injury to one of the two forearm arteries. Common sense would dictate that repair of an injured artery is mandatory with an incomplete palmar arch. The presence of intact palmar arch communication, however, is seldom documented in a traumatic setting. Therefore, the presence of a warm and well-perfused hand without evidence of acute ischemia on physical examination is often used in-lieu of an objective finding to imply an intact arch.

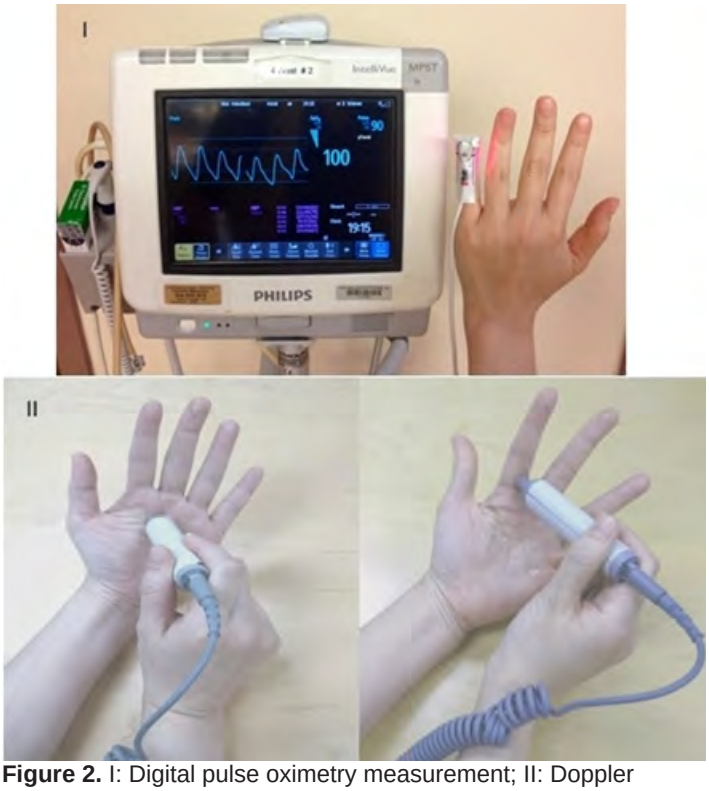

Figure 2. I: Digital pulse oximetry measurement; II: Doppler interrogation of palmar arch and digital artery.

Neurological Examination

A complete neurological examination of the hand should assess the integrity of the major peripheral nerves, both sensory and motor function. This includes the radial nerve (branch posterior interosseous nerve), median nerve (branch anterior interosseous nerve) and ulnar nerve. A thorough, systematic approach should be routine on every injured forearm and hand, and can be done rapidly in an awake and cooperative patient.

Motor Examination of the Hand

Focused motor examination includes evaluation of extrinsic forearm and intrinsic hand muscle innervation. Evaluation of median nerve integrity includes thumb opposition with little finger, and flexion of thumb interphalangeal (IP) joint with index finger proximal IP (PIP) joint to form an "OK" sign. Ulnar nerve evaluation includes abduction of fingers by spreading them apart, and criss-crossing the index and third finger. Radial nerve evaluation includes thumb extension to make a "thumbs-up" sign, dorsal wrist extension and extension of fingers at the metacarpophalangeal (MCP) joint (Figure 3). The radial nerve innervates the forearm muscles that provide extension of the wrist, thumb, and all finger MCP joints. The median nerve has dual intrinsic and extrinsic innervation. In the hand, the motor branch of the median nerve provides innervation for thumb palmar abduction. In the forearm, it innervates the muscles that flex the thumb, wrist, and all the PIP and DIP joints of the index and middle fingers. The ulnar nerve also has dual innervation. It provides the dominant innervation to the intrinsic muscles of the hand, flexion of the MCP joints and extension of the IP joints of the fingers and adduction of the thumb. In the forearm, it innervates the muscles that flex the wrist and DIP joints of the ring and little fingers.

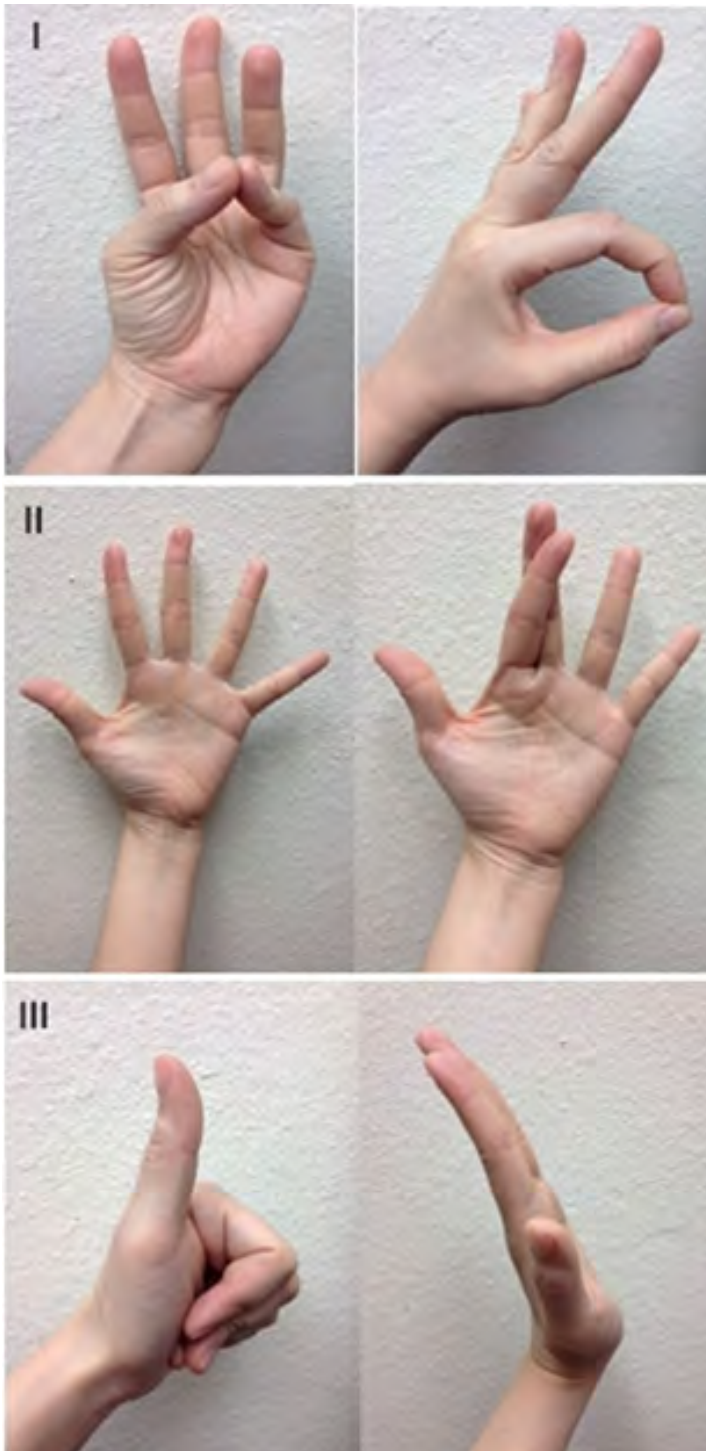

Figure 3. Motor examination of the hand. I: Median nerve. II: Ulnar nerve. III: Radial nerve.

Sensory Examination of the Hand

Focused sensory examination includes assessment of sensation to light touch and pin-prick as well as two-point discrimination test, with ≤5mm as normal.[17] The median nerve sensory distribution includes the volar aspect of hand from the thumb to the radial half of the ring finger; and the dorsal aspect of index, middle, and radial half of the ring finger from the PIP joint to the tip of the finger. The ulnar nerve sensory distribution includes the dorsal and volar sides of the ulnar aspect of the hand and medial half of the ring finger and the entire little finger. The radial nerve sensory distribution includes the dorsal aspect of the radial two-thirds of the hand and thumb; and the dorsal aspect of the thumb, index, middle, and radial half of the ring finger to the PIP joint (Figures 4 and 5). Sensations of numbness or tingling should also be elicited to disclose subtle subjective signs of nerve injury or early compartment syndrome.

Musculoskeletal Examination

Wrist joint and skeletal stability through palpation and gentle manipulation, as well as active and passive range of

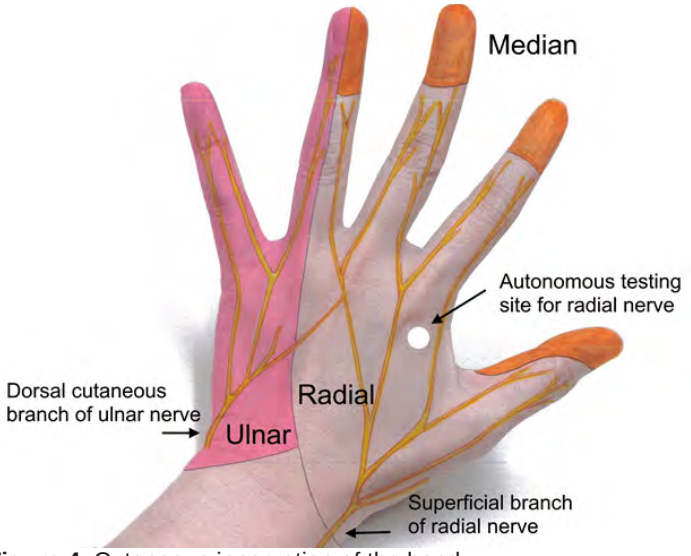

Figure 4. Cutaneous innervation of the hand.

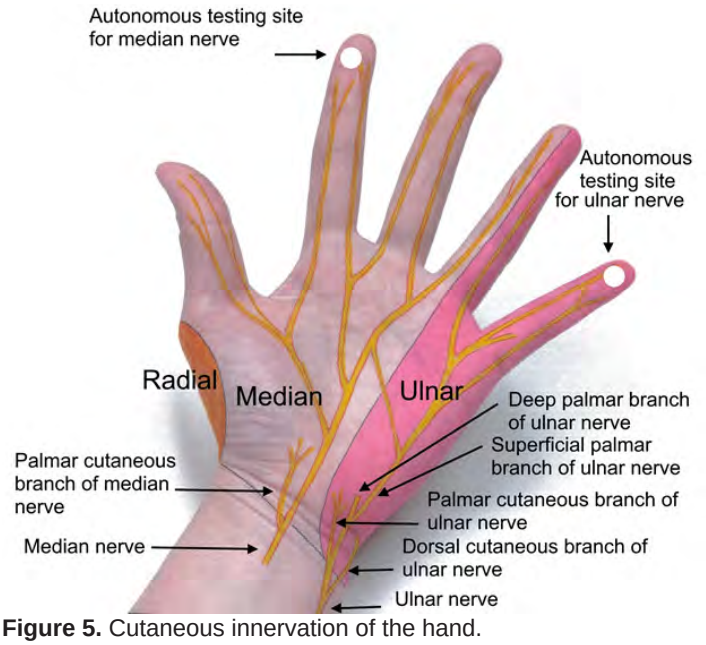

Figure 5. Cutaneous innervation of the hand.

motion, should be assessed to evaluate for concomitant bone, muscle, tendon or ligament injury. Tendon integrity and muscle function examination includes extensors of the wrist, thumb and digits on the dorsal aspect, and similarly flexor mechanisms on the volar aspect. In addition, ulnar and radial deviation of the wrist should be assessed. Knowledge of local anatomy will permit a limited direct assessment of the identity and integrity of local structures. Documentation of nervous, myotendinous or ligamentous injury is important, and will be helpful for completion of possible later reconstructive procedures. Focused physical exam and identification of associated dysfunction will corroborate anatomic findings. Clinically appropriate suspicion of compartment syndrome should exist during examination and is discussed further below.

OTHER CONSIDERATIONS

Operative Repair or Ligation?

Operative management is required in the case of persistent bleeding after exhaustion of conservative methods of hemorrhage control. This may occur where hemodynamic instability persists despite adequate resuscitation. The decision to perform a surgical ligation or repair of the artery is at the surgeon's discretion. It is well-established in the literature that nerve injury determines the long-term functional disability of the hand, not arterial injury, which may be associated with non-debilitating exercise or work-induced hand claudication, cold intolerance, or presence of other disabling ischemic symptoms.[18-26] Isolated laceration of either the radial or ulnar artery is usually not critical, given the rich collateral anastomoses found in the hand. It is safe and acceptable in a well-perfused hand to ligate, if necessary, a distal forearm artery as long as there is one remaining patent artery and the palmar arch circulation is intact. Attempts at vessel repair have been documented at 50-77% patency rate.[27,28] Ligation, however, is only safe in the operating room with adequate exposure and control. It is not to be attempted in an emergent or urgent setting in an uncontrolled environment, as to avoid iatrogenic nerve injury. Rather, hemostasis should be attempted with utilization of the proper techniques described above. Arterial repair is mandated if both the radial and ulnar arteries are injured, or if suspicion of an incomplete arch exists.

Complex Laceration Injury

A large body of evidence-based literature exists to affirm the safe clinical practice of delayed primary repair involving traumatic injuries to nerves and tendons of the forearm and wrists.[29-31] Priority should be centered on control of hemorrhage. Delayed primary repair can be performed at an outpatient setting for any associated injuries by a hand specialist consultant, when proper staff equipment and operative time may be more effectively available.

Diagnostic Imaging Studies

Imaging work-up is dictated by clinical assessment of history, physical exam and/or mechanism of injury. Plain radiographs will assist in identification of associated fracture or foreign body. Advanced imaging techniques such as computed tomography angiography or magnetic resonance angiography are not indicated.[32,33] Invasive contrast arteriography is unnecessary.[34]

Acute Compartment Syndrome

Although a rare occurrence in an isolated arterial laceration injury, acute compartment syndrome in the forearm may occur, especially in the setting of associated injuries involving fractures, extensive soft tissue injury or crush injury.[35] The forearm comprises three separate fascial compartments: volar, dorsal, and the lateral mobile wad. The hand has 10 fascial compartments: four dorsal and three volar compartments, an adductor pollicis compartment as well as the thenar and hypothenar compartments. The diagnosis of acute compartment syndrome is a clinical one. Cardinal signs of compartment syndrome include swollen and taut muscle compartment(s), pain out of proportion to injury or severe pain on passive muscle stretch with digital extension. Neurological deficit is an important clinical feature with paresthesias indicating early nerve ischemia, and paresis or paralysis being late features of nerve and muscular dysfunction. The clinical diagnosis may be substantiated with intracompartmental pressure measurements. A finding of measured intracompartmental absolute pressure at ≥30mmHg, or delta-pressure (muscle perfusion pressure) with a differential between systemic diastolic pressure and compartment pressure ≤20mmHg, is an indication for fasciotomy in patients with a supporting physical examination or who are unable to be adequately examined for any reason.[36] Emergent forearm fasciotomy is indicated for decompression of fascial compartments to prevent irreversible muscle and nerve damage. Surgical techniques for volar compartment decompression include the ulnar approach, or the radial (Henry) approach and its modified version. The dorsal compartment and mobile wad can be decompressed with a single midline dorsal longitudinal incision. A carpal tunnel release should be considered at the time of fasciotomy.[37-40]

Relevant Medical Conditions

Patients with advanced hepatic disease, or taking anticoagulants such as warfarin may have an elevated international normalized ratio (INR) and will exhibit impaired hemostasis. These patients should have their INR normalized. However, in rare situations involving patients on warfarin therapy, the risk benefit ratio of decreasing the INR should first be considered. Such patients include those with a history of vascular graft thrombosis or those with a mechanical heart valve. This decision should be made on an individual basis with sound clinical judgment. Discussion with appropriate specialists may be helpful.

Patients with hypotension due to volume depletion should first be adequately resuscitated with isotonic fluid. Findings of

low hemoglobin or hematocrit level may be treated with blood transfusion. Patients presenting with hypertension should be treated with anti-hypertensive medications to normalize their blood pressure in order to facilitate hemostasis.[41]

Tetanus Prophylaxis and Prophylactic Antibiotics

Tetanus prophylaxis should be considered. A booster dose of the tetanus toxoid is given to previously immunized individuals, and tetanus toxoid plus tetanus antitoxin containing human tetanus immune globulin to non-immunized individuals.

Broad spectrum antibiotics may be considered in extensive or contaminated wounds. One intravenous dose, followed by several days of oral administration may reduce the risk of wound infection. Clean or minimally contaminated lacerated wounds may only require orally administered antibiotics. Systemic antibiotics effective against skin flora such as a first-generation cephalosporin is typically used (e.g. Cephalexin 500mg p.o. QID).[42]

Expert Consultation and Hand Immobilization

Consultation with a hand specialist should be obtained immediately following determination of the extent of injury to discuss further management. Application of a forearm and hand splint is recommended for those with concomitant tendon or bone injury to reduce swelling, provide stabilization and relative comfort, and allow early mobilization of uninvolved joints. The wrist may be splinted in 0° to 30° of extension (dorsiflexion).[43] Outpatient follow up with a hand specialist should be arranged for dressing change, wound inspection and suture removal in the setting of an isolated arterial injury or complex injury for delayed primary repair.

CONCLUSION

An optimal management of forearm arterial laceration is based on basic principles of achieving hemostasis. Operative treatment algorithms are widely practiced and remain the current trend in management at urban trauma centers. However, the need for emergent or urgent surgical intervention is not justified based on the available evidence and from a cost-effectiveness standpoint. Furthermore, trauma and hand surgery specialists are not widely available in the rural settings. Emergency clinicians can be confident in the evidence-based nonoperative approach when faced with an arterial injury involving a forearm laceration. This includes isolated or complex laceration with concomitant nerve and/or tendon injury. Attention must first be given to the presence of other life-threatening injury, and to the initial resuscitation and hemodynamic stabilization of the patient. Concomitantly, measures are taken to stop additional blood loss. This can be accomplished most effectively by a combination of direct manual pressure, temporary pneumatic tourniquet inflation for proximal control, followed by prompt wound debridement and rapid wound closure. The sole or prolonged use of tourniquet is discouraged, as is blind clamping or attempted ligation of an artery. A complete and thorough assessment of the hand should include neurovascular status and musculoskeletal integrity. Documented critical ischemia must be addressed expeditiously with surgical restoration of arterial perfusion. In a well perfused and non-ischemic hand, the presence of one intact artery is adequate to sustain viability. Long-term functional disability will not be compromised, provided the palmar arch circulation is assessed to be intact. Concomitant injuries to nerves and tendons in a complex laceration can be safely repaired in a delayed fashion. Immediate surgical exploration is not mandatory if bleeding can be stopped with conservative compressive maneuvers and a complete physical examination of the hand is performed. The appropriateness and safety of an outpatient strategy is validated with evidence-based literature. The evolution of an acute compartment syndrome must be monitored in the presence of suggestive clinical signs. A hand specialist consultation should be obtained early after adequate control of bleeding to guide subsequent therapeutic requirements. Adherence to these basic principles of management will not only streamline patient management but will also decrease cost and optimize clinical outcome.

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A Simulation-based Randomized Controlled Study of Factors Influencing Chest Compression Depth

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Introduction: Current resuscitation guidelines emphasize a systems approach with a strong emphasis on quality cardiopulmonary resuscitation (CPR). Despite the American Heart Association (AHA) emphasis on quality CPR for over 10 years, resuscitation teams do not consistently meet recommended CPR standards. The objective is to assess the impact on chest compression depth of factors including bed height, step stool utilization, position of the rescuer's arms and shoulders relative to the point of chest compression, and rescuer characteristics including height, weight, and gender.

Methods: Fifty-six eligible subjects, including physician assistant students and first-year emergency medicine residents, were enrolled and randomized to intervention (bed lowered and step stool readily available) and control (bed raised and step stool accessible, but concealed) groups. We instructed all subjects to complete all interventions on a high-fidelity mannequin per AHA guidelines. Secondary end points included subject arm angle, height, weight group, and gender.

Results: Using an intention to treat analysis, the mean compression depths for the intervention and control groups were not significantly different. Subjects positioning their arms at a 90-degree angle relative to the sagittal plane of the mannequin's chest achieved a mean compression depth significantly greater than those compressing at an angle less than 90 degrees. There was a significant correlation between using a step stool and achieving the correct shoulder position. Subject height, weight group, and gender were all independently associated with compression depth.

Conclusion: Rescuer arm position relative to the patient's chest and step stool utilization during CPR are modifiable factors facilitating improved chest compression depth. [West J Emerg Med. 2015;16(7):1135-1140.]

INTRODUCTION

Following the First National Conference on Cardiopulmonary Resuscitation in 1966, the Journal of the American Medical Association published the initial iteration of "Standards for Cardiopulmonary Resuscitation (CPR) and Emergency Cardiac Care (ECC)" in 1974.[1] Multiple periodic updates of these standards shifted emphasis toward a systems approach credited with helping some programs achieve significantly higher-than-average resuscitation rates by developing a comprehensive structure addressing each of the links in the chain of survival.[2] The 2005 update of the guidelines stressed the importance of high-quality CPR with defined standards for compression rate, depth, recoil, and maximal acceptable time for interruptions in compressions.[3] Supported by additional research,[4-8] the 2010 guidelines further emphasized high-quality CPR as the "cornerstone of a system of care that can optimize outcomes beyond return of spontaneous circulation."[9] Recent studies support the relationship of high-quality CPR to improved clinical outcomes.[10,11] These changes require a refocusing of priorities

during resuscitation to assure that high-quality CPR is being provided. Resuscitation team leaders can track the time-dependent CPR standards with relative ease, but monitoring compression depth and recoil is more subjective. The quality of compressions during training can be assessed with various indicator devices incorporated within training mannequins. However, real-time feedback devices, both stand alone and attachments to newer monitor/defibrillators,[12-15] are not currently available in many clinical settings. The demands of advanced life support interventions (e.g. medication doses, energy levels, and algorithms) can distract the attention of resuscitation teams away from chest compression quality. This was evident when our group recently assessed the impact of a backboard on compression depth achieved with CPR performed on a mannequin positioned on an emergency department (ED) gurney (manuscript in preparation). Although the subjects all successfully completed an Advanced Cardiac Life Support (ACLS) course in the previous six months, we found that the majority of subjects in both control and treatment groups failed to routinely lower the bed, use a step stool, focus attention on compression quality, or achieve the 50 mm compression depth advocated in the 2010 guidelines. Consistent with our experience, other researchers have identified that a significant percent of healthcare providers fail to achieve the recommended compression depth.[16,17]

Variables that may influence compression depth include bed height, step stool utilization,[18-20] the rescuer's height,[18] weight,[21-23] and gender,[23,24] and team focus on compression depth as an important aspect of resuscitation. One additional factor we observed was the position of the rescuer's arms and shoulders relative to the point of compression over the chest. Ideally, the rescuer should position his/her shoulders directly over the point of compression so that the rescuer's arms form a 90º angle to the patient's chest (Figure 1). To assess these variables we conducted a high-fidelity mannequin study. Our research hypotheses included the following: 1) Using a stepstool and lowering the bed will significantly increase the mean compression depth; 2) Rescuers attaining a 90º angle with their arms and the mannequin's chest (placing the shoulders directly over the point of compression) will achieve a greater mean compression depth; 3) Males will achieve a greater mean compression depth than females; and 4) Mean compression depth will increase with the rescuer's height and weight.

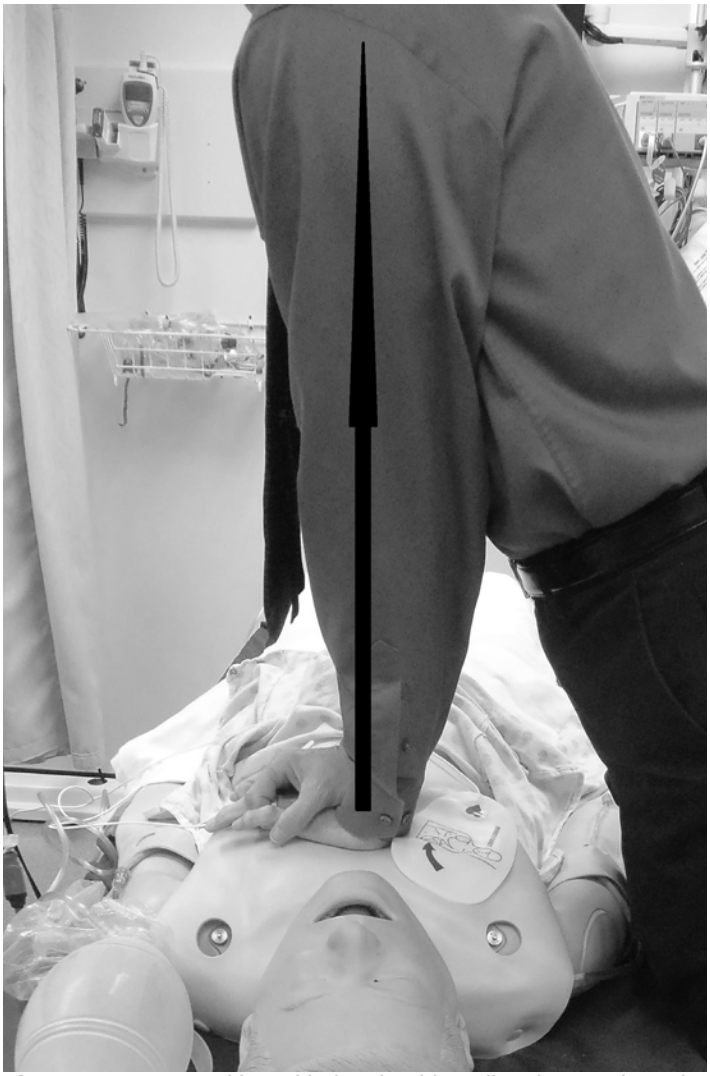

Figure 1. Proper position with the shoulders directly over the point of compression and the rescuer's arms forming a 90° angle with the patient's chest.

METHODS

Following approval by our university's institutional review board, we recruited subjects from a cohort of 56 trainees including physician assistant (PA) students and first-year emergency medicine residents completing resuscitation practice as a required part of their respective curricula following completion of an ACLS course within the previous month. Each resuscitation scenario required at least one two-minute segment of CPR per American Heart Association (AHA) guidelines. Subjects were informed that automatically-recorded data from the SimMan Essential™ (Laerdal, Norway) mannequin would be evaluated as part of a research project, but the nature of the data being assessed was not revealed to subjects.

We solicited the entire class of PA students and first-year emergency medicine residents to avoid selection bias. The condition for the subjects in the experimental group included setting the bed in the lowest position (64cm from the floor to the top of the mattress) with a step stool (23cm height) prominently placed next to the bed. For the control group, we placed a locking device in the bed, which elevated the lowest bed setting by 10cm (from 64cm to 74cm) and placed the stool under an IV cart at the foot of the bed so that it was available, but not prominently exposed. Ten cm elevation provided about 30% of the maximum bed height without making the

modification readily apparent. We mounted a web camera on the wall at the foot of the bed in alignment with the center of the mannequin to record each subject's shoulder position/arm angle relative to the compression point. The mannequin was placed on top of a CPR backboard on a standard 10cm foam mattress on an ED bed (Stryker Medical, Portage, MI).

Using a random number generator, we allocated groups of four subjects each to either the control or intervention condition. We used block randomization since the subjects completed the sessions in sets of four simulations. Prior to each session, we reviewed the Institutional Review Board-approved cover letter with all subjects, gave them a written copy and obtained their verbal consent for inclusion in the study. As each group entered the simulation lab, we recorded demographic data on an Excel spread sheet (Microsoft, Redmond, WA) including gender, height, and an estimation of each subject's weight in one of three groups (<150lbs., 150-200lbs., or >200lbs.). We assessed the height using a measuring tape attached to the control room one-way mirror. Each height was a consensus measure by two of the investigators in the control room. The weight groups were arbitrarily selected to represent low, intermediate, and heavy weight ranges in a population of healthcare workers and each subject's group was estimated by a consensus of the same two investigators. We instructed the subjects to complete all resuscitations in accordance with ACLS standards and to do everything they would do with an actual cardiac arrest patient. During the two-minute episodes of chest compressions, the mannequin software automatically recorded mean compression depth in 10-second segments.

A screen shot from each resuscitation video was captured during the beginning of the 2-minute compression period to assess each subject's arm angle during compression. The screen shots were cropped providing a view from the top of each compressor's shoulders to the mannequin's chest without including facial or other identifying features. The screen shots were evaluated independently by two investigators who assessed the angle of the rescuer's arm position relative to the mannequin's chest as either 90° or less than 90°. The identity of the subject, the subject's group, and their compression data was concealed. A third investigator served as the tiebreaker when the initial two assessments did not agree. Prior to the start of the study, the investigators were shown screen shots of compressors at a 90° angle and others at less than 90°.

Statistics

We analyzed the results from the intervention and control groups and the arm angle of 90° and less than 90° groups with a 2-tail t-test for samples with equal variance using Excel™ (Microsoft, Redmond, WA) and reported these results as a mean with 95% confidence intervals. Using SAS version 9.4 (Cary, NC), the correlation between mean depth of compression and the subject's height was assessed using a Pearson correlation coefficient (for two continuous variables), the correlation between compression depth and the subject's weight group was assessed with a Spearman Rho correlation coefficient (for continuous and ordinal variables), and for gender with a point biserial correlation (for continuous and binary variables). We considered a p-value of <0.05 to be significant. We assessed the inter-rater reliability for assessing arm angle of 90° or less than 90° using Cohen's kappa.

RESULTS

Fifty-six healthcare trainees verbally consented to participate in the study. Twenty-eight were randomly allocated to the intervention group and the other 28 to the control group. A complete data set was not recorded for one subject in the control group due to malfunction in the recording program and all reported results were derived with the data from the remaining 55 subjects (Figure 2).

Thirty-five of the subjects were female and 20 were male. Twenty-six were in weight group 1, 21 in group 2, and 8 in group 3 (Table). Subject height ranged from 63 to 76 inches (Figure 3).

Primary End Point

We compared the mean compression depth achieved in the intervention group and the control group using an intention to treat analysis. The intervention group achieved a mean compression depth of 39.3 (95% CI [35.4-43.2])mm compared to the control group 34.6 (95% CI [30.2-39.0])mm ($p = 0.11$).

Pre-positioning the step stool next to the bed in line with the mannequin's chest was not associated with its use. Only two of 28 subjects in the intervention group used the step stool. Conversely, 10 of the 27 subjects in the control group found and used the step stool.

Secondary End Points

The Cohen's kappa for interrater agreement regarding arm angle/shoulder position was 0.87 indicating very good agreement between the two raters. The group of 29 subjects (18 from the intervention group and 11 from the control group) forming a 90° angle between their arms and the mannequin's chest wall achieved a mean compression depth of 41.4 (95% CI [37.5-45.2])mm compared to 32.2 (95% CI [28.6-35.8]) mm achieved by the 26 subjects in the group compressing at an angle less than 90° ($p<0.003$) (Figure 4). Post hoc analysis of the correlation between proper shoulder angle and the use of a step stool, using a Chi-squared test, revealed a significant correlation between using a step stool and achieving the correct shoulder position ($p<0.02$).

The correlations between compression depth and subject height, weight group, and gender were all statistically significant. The height and compression depth were strongly, positively correlated (Pearson correlation coefficient -$r=0.560$, $p<0.0001$). As height increases, compression depth also increases. The weight category and compression depth are

strongly, positively correlated (Spearman Rho correlation coefficient -r=0.499, p=0.0001). As weight increases by category, compression depth also increases. Gender and compression depth are strongly correlated (point biserial correlation -r=0.499, p=0.0001). Mean compression depth for males is greater than that for females.

DISCUSSION

Increased emphasis on quality chest compressions over the last 10 years has not translated to full compliance with current AHA recommendations. ACLS providers dedicate a great deal of mental energy to recalling algorithm sequences and drug doses, along with orchestrating the multiple time-sensitive, critical actions required from a frequently *ad hoc* team. Thus, suboptimal cardiac compression can potentially go undetected by a task-saturated team leader. When teams monitor chest compressions, they frequently focus on rate since it is the most readily detectable parameter to monitor. Various groups actively promote adjuncts like a metronome or a song rhythm (e.g. Stayin' Alive) to support the recommended rate of at least 100 compressions per minute. Monitoring compression depth is more difficult. Devices providing immediate compression depth feedback are commercially available, but are currently not widely employed in clinical practice. In addition, most ACLS courses cannot provide the amount of chest compression practice needed for each learner to develop the conscious proprioception required to consistently recognize compression depths of >50mm. Each of the variables in our secondary end points correlated with improved compression depth. The height, weight, and gender of any particular rescuer cannot be modified, but the angle of the rescuer's arms to the patient's chest can easily be assessed during resuscitation and corrected, if needed, to achieve a 90° angle.

Even though the greater mean compression depth provided when the subject achieved a 90° angle was both statistically and clinically significant, the mean depth in this group was still nearly 9mm below the desired goal. However, of the 11 subjects attaining a mean compression depth of ≥50mm, 10 achieved a 90° angle. Increased emphasis on compression technique during training and testing sessions may be needed to reinforce the priorities advocated in current guidelines.

While we expected some of the intervention group subjects to ignore the step stool, we did not anticipate the higher utilization rate for the step stool in the control group. We concealed the step stool so it was not pre-positioned for use, but was available if sought in order to avoid drawing attention to the purpose of the study. In retrospect, some subjects performing chest compressions may have been motivated by the greater height of the bed in the control group to seek an adjunct to improve their position. Throughout the sessions, we rarely noticed the team leader or other team members addressing chest compression quality during a resuscitation scenario. The failure to consistently use adjuncts such as a step stool to improve chest compression mechanics suggests that ACLS providers do not prioritize chest compression depth relative to other cardiac arrest interventions.

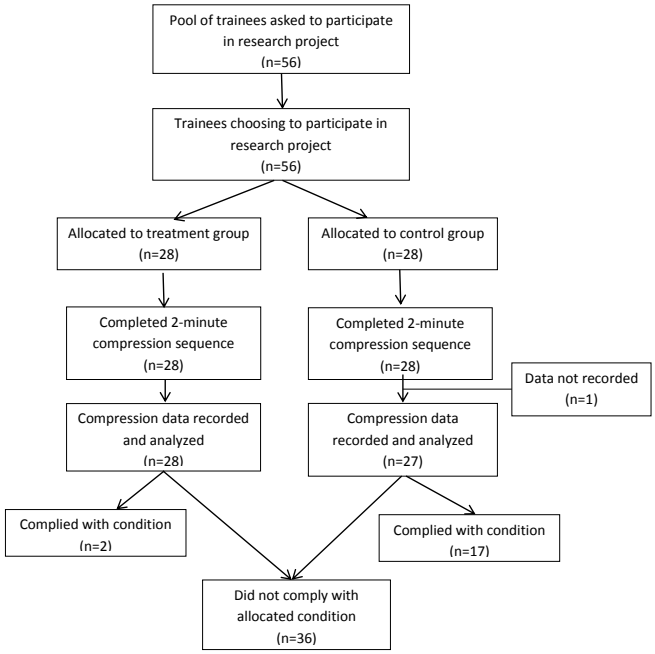

Figure 2. CONSORT flow diagram.
CONSORT, Consolidated Standards of Reporting Trials

LIMITATIONS

There were a number of limitations to our study. First, in an attempt to employ a randomized design while masking the purpose of the study, we allocated subjects to conditions that we could not fully control. The bed height was well controlled, but the majority of subjects did not comply with the allocated condition for step stool use. The paradoxical increased use of a step stool in the control group potentially nullified some of the impact of the increased bed height. Consequently, it is difficult to conclude anything from the intention to treat analysis. Second, we did not calculate a sample size, but enrolled the entire class of PA students and residents during our orientation period. The resulting sample size was small including only 55 subjects. Third, our subjects were relatively inexperienced in running resuscitations even though they had all completed an ACLS course within a month of the study. However, less experienced providers are often the initial responders to cardiac arrests outside the ED and are responsible for running the first few minutes of an arrest, which is the most critical time if return of spontaneous circulation and a good functional outcome can be achieved. Fourth, although the subjects came from two different institutions and had completed ACLS training in two different courses, we cannot generalize our results to the wide spectrum of healthcare personnel completing advanced cardiac life support training.

Table. Demographics (gender and weight).

Gender	Weight group	Number of subjects	Intervention group	Control group
Male	1	1	1	0
	2	13	6	7
	3	6	4	2
Female	1	25	11	14
	2	8	4	4
	3	2	2	0

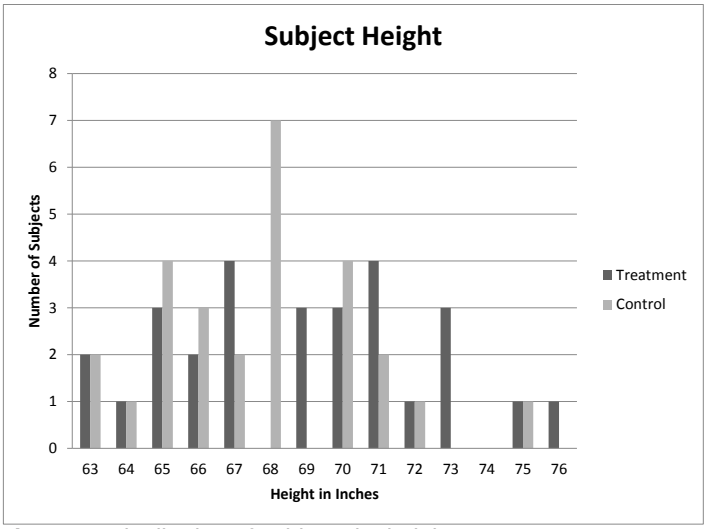

Figure 3. Distribution of subjects by height.

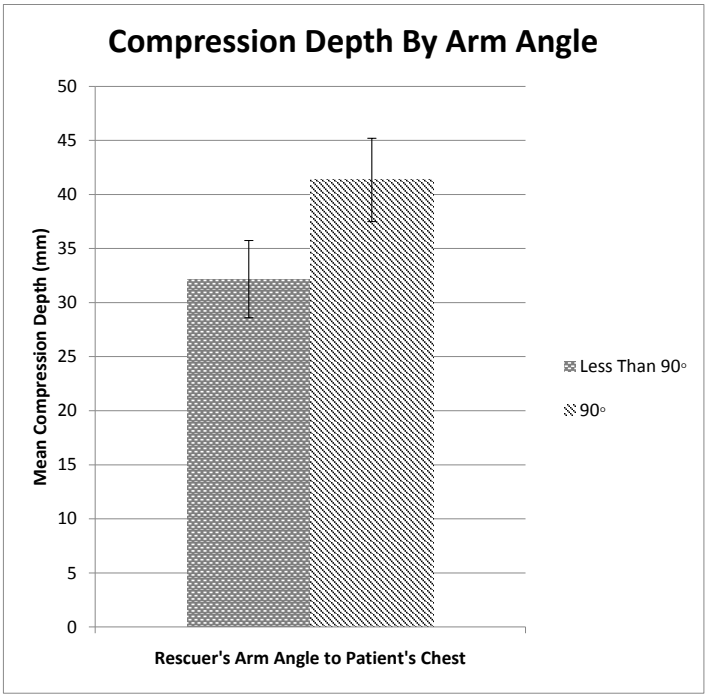

Figure 4. Mean compression depth, with 95% confidence intervals, of subjects who did and did not achieve a 90° arm angle.

CONCLUSION

The majority of ACLS providers in our sample did not achieve the 50mm compression depth recommended by the American Heart Association. Subjects with an arm angle of 90° to the mannequin's chest achieved significantly greater compression depth. The depth of compression was greater for males, as well as for taller and heavier subjects. We recommend ensuring a 90° arm angle during CPR to improve compression mechanics. Ensuring this arm angle provides a single simply-monitored factor that can be achieved by means of the rescuer's physical characteristics, lowering the bed, using a step stool or some combination of these factors.

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Staying in the Room

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The call from the nursing home relayed that an 85-year-old male was coming in by ambulance complaining of increased shortness of breath. The nursing home told us that he had an unknown code status. Once the patient arrived, it was clear that he was in the process of dying. While I was preparing for aggressive resuscitative efforts, my attending physician was shuffling through some paperwork that came with the patient and discovered a "do not resuscitate" order, signed by the patient. The paperwork also stated that he had advanced cancer. It was clear why the patient had previously decided he did not want any procedures to be done, which we were quickly prepping to perform. With this added information we put a stop to our efforts, followed the wishes of the patient, and made him as comfortable as possible in his final moments.

My attending asked the paramedics if the patient's family was coming, and they said they would be arriving in 5-10 minutes. At the time, I was the senior resident in charge, and I was feeling the increased pressure of wanting to see more patients and to get some charting done. A 5-10 minute wait may not seem like much, but in the shift of an emergency physician, it can feel like an eternity. However, my attending didn't leave the patient's side, and he held his hand the whole time.

After several long minutes, our patient's family arrived in the emergency department. We went over the care of the patient and the family quickly understood the entire situation. With tears in their eyes, they still had one request from us: they asked that my attending and I participate with their family in prayer. Of course, we could not refuse. So as we gathered around the bedside, all holding hands, we instantly felt for that brief moment as members of the family. The more we listened to the prayer, something incredible happened. The patient, whom we had no previous connection to and knew nothing about, quickly became very real to us. During the prayer the family described our patient as not only a wonderful, loving person, but also the rock and foundation of this entire family, and that this dying patriarch would be missed beyond measure. What an unforgettable moment that was, to instantly connect to our patient and his family during his last moments on earth.

Then I had an epiphany—what would it have looked like if the family had arrived and no one was at the bedside? It would have looked like their loved one was being abandoned in his final hour. But his family arrived to see my attending holding the hand of their loved one, and he was instantly able to explain the entire situation the moment they arrived. In emergency medicine, we train to save lives. We live for chest tubes, charged paddles, and difficult airways. In reality, the most important and meaningful thing we can do sometimes is as simple as staying in the room a few more minutes.

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Emergency Department Visits by Older Adults with Mental Illness in North Carolina

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Introduction: We analyzed emergency department (ED) visits by patients with mental health disorders (MHDs) in North Carolina from 2008-2010 to determine frequencies and characteristics of ED visits by older adults with MHDs.

Methods: We extracted ED visit data from the North Carolina Disease Event Tracking and Epidemiologic Collection Tool (NC DETECT). We defined mental health visits as visits with a mental health ICD-9-CM diagnostic code, and organized MHDs into clinically similar groups for analysis.

Results: Those ≥65 with MHDs accounted for 27.3% of all MHD ED visits, and 51.2% were admitted. The most common MHD diagnoses for this age group were psychosis, and stress/anxiety/depression.

Conclusion: Older adults with MHDs account for over one-quarter of ED patients with MHDs, and their numbers will continue to increase as the "boomer" population ages. We must anticipate and prepare for the MHD-related needs of the elderly. [West J Emerg Med. 2015;16(7):1142-1145.]

INTRODUCTION

Older patients with mental health disorders (MHDs) present to the emergency department (ED) with nursing, medical, environmental and social challenges. About 15% of those ≥60 years old have a MHD.[1] In the US, ED visits by patients ≥65 years old and ED visits by patients with MHDs are increasing.[2] The World Health Organization has identified the development of age-friendly services and settings as a treatment and care strategy for older adults with MHDs.[1] Quantifying ED visits by the elderly with MHDs is a first step in improving ED care for this group. Therefore, we analyzed ED visits in North Carolina from 2008-2010 to determine the types and frequencies of ED visits by those ≥65 years old with MHDs, compared with similar ED visits by all other age groups during the same time period.

METHODS

Data Collection and Variables

We extracted ED visit data from January 1, 2008-December 31, 2010 from the North Carolina Disease Event Tracking and Epidemiologic Collection Tool (NC DETECT). Over 99% of all civilian ED visits in NC were captured. Details of NC DETECT methodology are available in detail elsewhere.[3,4]

A MHD ICD-9-CM diagnostic code in any one of up to 11 positions classified that ED visit as a MHD-related ED visit. Each record was counted as one MHD-related visit if ≥1 MHD diagnosis code was captured for that visit. An MHD diagnosis code was the first listed code in 25% of MHD-related ED visits, and was second- or third-listed in an additional 30% of visits. Of these MHD-related ED visits,79.5% had only one MHD diagnosis code and 16.2% had two MHD codes.

We identified MHDs from ICD-9-CM[5] codes for Mental Disorders [290-299]: Symptoms, Signs, and Ill-Defined Conditions [787-789.9]; and Supplementary codes [V11-79]. We excluded ICD-9-CM codes for poisoning and overdose, metabolic or structural encephalopathies, which are classified

as psychiatric diagnostic codes by ICD-9-CM, tobacco use disorder and substance abuse disorders.

Using the first listed MHD diagnostic code for the ED visit, an expert team of epidemiologists and emergency physicians grouped the MHD diagnoses into 10 clinically similar categories. The following categories were defined using ICD-9-CM codes: stress, anxiety, and depression (300 (excluding 300.9), 306, 308, 309, 311, 313.1, V11.2, V69.8, V79.0); schizophrenia, delusional and paranoid disorders, and psychosis (294.0, 294.8, 294.9, 295, 297, 298, V11.0); bipolar disorder or manic depression (296, V11.1); dementia (290, 294.1, 294.2); suicidal or homicidal ideation (300.9 [often used for homicidal ideation before V62.85 was available], V62.84, V62.85); personality or conduct disorder (301, 312); specific non-psychotic mental disorders due to brain damage (310); pervasive developmental disorders originating in childhood (299); eating disorders (307.1, 307.5); and 'other' (302, 307 (excluding 307.1, 307.5, 307.8), V11.8, V11.9, V15.4 (excluding V15.41), V70.1, V70.2, V71.0).[5]

We characterized ED disposition as either admission or discharge from the ED. Admission to a hospital bed or unit (DEEDS codes 110-140) and transfers to another general hospital (DEEDS code 20) were counted as admissions.[6]

Data Analysis

Data were extracted and stratified for univariate and two-way descriptive analyses. We excluded from this analysis ED records that lacked any diagnosis codes (10.2% of 12,978,615 total ED records). Regression analysis tools implemented in SAS 9.2® were used in multivariable analyses to identify which factors increase the likelihood of hospital admission, after controlling for potential confounders. We calculated descriptive statistics and rates to determine proportions and changes in ED visits over time. Rates were calculated per 10,000 population.[7] Risk ratios were calculated for hospital admission from the ED. We computed risk ratios using log binomial regression with Poisson robust variances implemented in SAS 9.2 PROC GENMOD. Variables in the model include age (in years: 0-14, 15-24, 25-44, 45-64, ≥65); sex; insurance; day of week; time of day; number of comorbidities; whether the patient visited the ED more than once in the three years studied; year (2008, 2009, 2010); presence of any of 10 co-morbid conditions; and presence of any of 10 psychiatric diagnosis categories (stress, anxiety, and depression; schizophrenia, delusional and paranoid disorders and psychosis; bipolar disorder or manic depression; dementia; suicidal or homicidal ideation; personality or conduct disorder; mental disorders due to brain damage; developmental disorders; eating disorders; and other).

Study Approvals

The study was approved by the Institutional Review Board of the University of North Carolina School of Medicine and by the Data Use Agreement of the NC Division of Public Health, Epidemiology Division.

RESULTS

We extracted and analyzed 11,656,207 ED visits from 2008-2010, of which 9.8%, or 1,138,782 visits, had an MHD ICD-9-CM diagnostic code in any position 1-11. Thirty-three percent (33%) of ED visits by all age groups with an MHD diagnostic code were admitted to the hospital, compared to 14% of all ED visits in North Carolina from 2008-2010. The population-based rates of MHD-related ED visits increased progressively from 2008-2010, by 14.4%, while the rate of all NC ED visits increased by only 2.1% during the same time period.[4]

The total proportion of MHD-related ED visits for those age ≥65 years was 27.3% from 2008-2010, and over half of visits (51.2%) resulted in hospital admission, with a relative risk for hospital admission of 2.21, by far the highest proportion for any age group (Table).

The rate of the MHD 'Dementia' is highest in ED visits by those aged ≥65 years, an expected finding. However, high ED visit rates for the elderly with the MHD diagnoses 'Stress/Anxiety/Depressive Disorders' and 'Schizophrenia/Delusional Disorders/Psychosis' were unexpected and exceeded the rate for the MHD 'Dementia', and the rates for these three groups of MHDs were far greater in the elderly compared to all other age groups (Table).

DISCUSSION

In general, studies report that older adults have lower rates of major depressive disorder than younger-aged adults. For example, in one report, the prevalence of major depression was stated as 3.7-4.9% for patients aged 18-64 and only 2.1% for patients 65 and older.[8] The estimated prevalence of schizophrenia in older adults was also reported to be as low as 0.12% compared to an overall 12-month prevalence of 1.1%.[9,10] Anxiety disorders are reported to affect 3.8% of the elderly population.[1] Dementia and depression are thought to be the most common mental health [neuropsychiatric] disorders in the elderly.[1] In contrast, in our study the population-based rates of MHD-related ED visits due to 'Stress/Anxiety/Depressive Disorders' and for 'Schizophrenia/Delusional Disorders/Psychosis' were actually much higher than for 'Dementia.' This finding demonstrates a possible need for systematic ED assessment, and referral for appropriate treatment, for depression and anxiety in older adults. It also emphasizes the need for the appropriate use of non-pharmacologic and pharmacologic modalities to treat agitation and psychosis in those ≥65 in the ED. Furthermore, the high frequency of psychosis in older adults requires that clinicians have the skills to differentiate psychosis from delirium.

Admission to the hospital, especially in older adults with dementia, can be particularly dangerous given the frequency of delirium, falls, and agitation in this population.[11] Older adults with MHDs may be living longer, or they seek ED

Table. The average of rates for years 2008-2010 by age group and category of mental health disorder (MHD) diagnosis/10,000 population, North Carolina; and average proportions of MHD-related emergency department (ED) visits and hospital admissions for years 2008-2010, North Carolina*.

	Age group (years)				
Category of MHD diagnoses	0-14	15-24	25-44	45-64	65+
Stress/anxiety/depression	16.2	182.2	285.7	294.0	325.4
Schizo/delusions/psychoses	1.8	19.1	32.8	50.5	337.6
Bipolar	8.5	64.0	93.3	71.6	34.5
Suicidal/homicidal ideation	3.2	20.1	20.8	15.0	4.2
Dementia	0.2	0.3	0.3	3.7	153.9
Personality/conduct disorder	4.2	8.2	5.3	3.8	2.2
Mental disorders d/t brain damage (originating in childhood)	1.1	3.8	2.8	2.0	4.0
Eating disorders	1.2	1.1	0.8	0.4	0.7
Any MHD	47.3	312.1	450.9	448.3	870.5
% of MHD-related ED visits	2.3%	11.0%	31.1%	28.3%	27.3%
MHD-related hospital admission from ED %	14.0%	17.7%	22.2%	36.5%	51.2%
MHD-related relative risk for hospital admission (95% CI)**	1.00 (ref)	1.22 (1.18-1.26)	1.36 (1.31-1.40)	1.79 (1.73-1.86)	2.21 (2.13-2.28)

*Population estimates used as denominators for rate calculations are revised 2008, certified 2009, and projected 2010 estimates obtained 5/16/2011 from Jennifer Song, State demographer, Office of State Budget and Management (North Carolina). These are from North Carolina's 2010 estimate/projection series and don't incorporate the 2010 Census counts.
**Risk ratios computed using log binomial regression with Poisson robust variances implemented in SAS 9.2 PROC GENMOD. In addition to categorized number of diagnosis codes (6-11 versus 1-5), variables in model include age (in years: 0-14, 15-24, 25-44, 45-64, 65+); year (2008, 2009, 2010); presence of any of 11 psychiatric diagnosis categories (personality or conduct disorder; dementia; bipolar/manic-depressive; developmental disorder; eating disorder; mental disorder due to brain damage; stress, anxiety, depression; schizophrenic, delusional, psychotic; psychiatric exam or observation; suicidal or homicidal ideation; other mental disorder).

care and need hospital admission due to lack of access or resources for care in other ambulatory environments. Because the elderly population is growing, as is the proportion of ED visits for those with MHDs, we can expect that the elderly with MHDs will form an increasing proportion of the ED census. MHD issues in the elderly appear to represent a different pattern and require different approaches than younger patients. Expanded outpatient resources for older adults with MHDs may be needed. If current trends continue in North Carolina, and if other studies or states confirm similar results, then hospitals and EDs must improve the ED and hospital environment for those ≥65 with MHDs, and provide alternatives for ED visits and hospital admissions.

LIMITATIONS

Diagnostic coding of MHDs is challenging,[12-14] and the authors had no control over individual or institutional coding practices. We have no way of knowing if the order of the diagnosis codes received by NCDETECT is the order in which the clinician, or even the coder, assigned them. That said, we believe that most of the time the first listed diagnosis is probably the primary diagnosis. A previous study comparing the North Carolina Disease Event Tracking and Epidemiologic Collection Tool with the National Hospital Ambulatory Medical Care Survey demonstrated similar rates and proportions of disease groups.[3]

The investigators in this study used face validity in categorizing diagnosis codes into clinically coherent groups. While such groups are somewhat arbitrary, a study reviewing ED visits for MHDs in New South Wales, Australia, using a similar database methodology, resulted in almost identical ICD-9-CM categorization and frequencies of disorders.[15]

NC DETECT captures up to 11 diagnostic codes. In order to capture all relevant MHD codes, especially in the elderly who are likely to have multiple comorbidities, we analyzed all 11 codes. The goal of medical coders is to provide a complete picture of the ED encounter,[16] and coders do not attach a mental health [psychiatric] code unless it was specifically stated in physician documentation.[17] Thus, it is reasonable to include a MHD if it was a coded diagnosis in any position, because an MHD can affect the ED differential diagnosis, treatment, or disposition. However, it is possible that many ED visits were not primarily made for mental health issues. We analyzed ED data from only one state, North Carolina. States with different ED mental health or geriatric services

could demonstrate different results.

CONCLUSIONS

The NC population-based rates of ED visits for many MHDs have generally increased from 2008-2010, and the rates of older adult visits mirror this trend.[4] However, of all age groups, those ≥65 with MHDs accounted for nearly a third of all MHD ED visits, and 51% were admitted. The most common MHDs in the elderly were psychosis and stress/anxiety/depression. Because the elderly population is growing, we anticipate that such ED visits will continue to rise. The needs of the elderly with MHDs must be anticipated, and further research can better predict those needs.

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Alcohol Use as Risk Factors for Older Adults' Emergency Department Visits: A Latent Class Analysis

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Introduction: Late middle-aged and older adults' share of emergency department (ED) visits is increasing more than other age groups. ED visits by individuals with substance-related problems are also increasing. This paper was intended to identify subgroups of individuals aged 50+ by their risk for ED visits by examining their health/mental health status and alcohol use patterns.

Methods: Data came from the 2013 National Health Interview Survey's Sample Adult file (n=15,713). Following descriptive analysis of sample characteristics by alcohol use patterns, latent class analysis (LCA) modeling was fit using alcohol use pattern (lifetime abstainers, ex-drinkers, current infrequent/light/moderate drinkers, and current heavy drinkers), chronic health and mental health status, and past-year ED visits as indicators.

Results: LCA identified a four-class model. All members of Class 1 (35% of the sample; lowest-risk group) were infrequent/light/moderate drinkers and exhibited the lowest probabilities of chronic health/mental health problems; Class 2 (21%; low-risk group) consisted entirely of lifetime abstainers and, despite being the oldest group, exhibited low probabilities of health/mental health problems; Class 3 (37%; moderate-risk group) was evenly divided between ex-drinkers and heavy drinkers; and Class 4 (7%; high-risk group) included all four groups of drinkers but more ex-drinkers. In addition, Class 4 had the highest probabilities of chronic health/mental problems, unhealthy behaviors, and repeat ED visits, with the highest proportion of Blacks and the lowest proportions of college graduates and employed persons, indicating significant roles of these risk factors.

Conclusion: Alcohol nonuse/use (and quantity of use) and chronic health conditions are significant contributors to varying levels of ED visit risk. Clinicians need to help heavy-drinking older adults reduce unhealthy alcohol consumption and help both heavy drinkers and ex-drinkers improve chronic illnesses self-management. [West J Emerg Med. 2015;16(7):1146–1158.]

INTRODUCTION

Older adults (65+ years of age) consistently account for the largest proportion of emergency department (ED) visits/repeat visits, and they are expected to become an even larger presence in the ED when the "baby boomers" swell the ranks of older adults.[1-4] Between 2006 and 2011, older adults' ED visits increased by 2.3%, and visits by the 45-64 age group increased by 8.3%,[5] signaling a steep increase in visits by older adults in the coming years. Data also show that ED visits by individuals with substance use disorders have been increasing (a 34% increase for alcohol-related disorders and 48% increase for other substance-related disorders between 2006 and 2011).[5] Given that the boomers have had higher rates of substance use/misuse than their predecessors,[6,7] the growing numbers of older adults who use/misuse substances are likely to crowd EDs, requiring the examination of substance use/

misuse's impacts on ED visits by late middle-aged and older adults. Using nationally representative data on individual health status and healthcare utilization, this study sought to identify subgroups of individuals aged 50+ for their ED visit risk based on alcohol use patterns, chronic health and mental health conditions, and previous ED visits.

People aged 50+ have lower rates of heavy alcohol use and alcohol abuse/dependence than younger adults, because both alcohol use and drinking quantity tend to decline with age and increasing chronic disease burden.[8-13] However, even low-to-moderate alcohol use in late life can predispose older adults to adverse health outcomes, as aging- and disease-related physiological changes (e.g., smaller body mass and lower total body water content) lead to higher and longer-lasting blood alcohol content and neurotoxicity in older than in younger adults.[14,15] Despite general findings of the beneficial health effects of low-to-moderate drinking, the overall net effect of alcohol consumption on health outcomes is detrimental, owing to the negative effect on cancers; infectious disease; cardiovascular, hepatic, endocrine, and gastrointestinal diseases; neuropsychiatric disease including alcohol-use disorders; and intentional and unintentional injuries.[16-19]

Epidemiologic data from the 2008-2012 National Survey on Drug Use and Health (NSDUH) showed that 11% of the 50-64 age group and 20% of the 65+ age group were lifetime abstainers, and 21% of the 50-64 age group and 28% of the 65+ age group were ex-drinkers (i.e., did not use alcohol in the preceding 12 months).[20] Compared to lifetime abstainers and current drinkers, ex-drinkers have been found to have more physical and mental health problems and are likely to include "sick quitters" who stopped drinking heavily due to health problems that are caused by or deteriorated because of long-term alcohol use.[21,22]

In reality, a substantial proportion of those aged 50+, with or without chronic medical conditions, continue to engage in at-risk/harmful/hazardous drinking. The 2013 NSDUH show that 23% of the 50-54 years old, 16% of the 55-59 years old, 14% of the 60-64 years old, and 9% of the 65+ years old were binge (but not heavy) alcohol users (i.e., defined as 5+ drinks on the same occasion on at least 1 day in the past 30 days); and 6%, 4%, 5%, and 2% in each respective group were heavy users (5+ drinks on the same occasion on each of 5 or more days in the past 30 days).[8] A study based on the 2005-2007 NSDUH data also found that among alcohol users, 20% of those aged 50-64 and 15% of those aged 65+ endorsed alcohol abuse or dependence symptoms.[23] Another study, based on the 2005-2008 National Health and Nutrition Examination Survey data and using the alcohol-related risk assessment algorithm, also found that in the context of their medical problems, functional status, and other health risks, 37% of drinkers aged 65+ were classified as engaging in harmful consumption (based on both frequency and amount of alcohol intake), and 53% engaged in either harmful or hazardous consumption.[24] The study also found that male drinkers and Black drinkers had significantly greater odds of hazardous/harmful consumption than female and White drinkers.[24]

Other studies based on Medicare beneficiaries or primary care patients corroborate these epidemiologic findings. That is, 31% of community-dwelling, fee-for-service Medicare beneficiaries aged 65+ with at least one of seven chronic conditions (i.e., Alzheimer's disease or other dementia, chronic obstructive pulmonary disease, depression, diabetes, heart failure, stroke, and hypertension) reported alcohol consumption, and 7% reported at-risk drinking (i.e., 30+ drinks per typical month or 4+ drinks in any single day).[13] Nearly 35% of current drinkers aged 60+ seen at primary care settings engaged in at-risk drinking behaviors that included any of the following: (1) alcohol use despite high-risk comorbidities (e.g., liver disease, pancreatitis, high blood pressure, gout, heartburn, stomach pain, falling, nausea, memory impairment, depression); (2) alcohol use despite high-risk medication use (medications that may cause bleeding, dizziness, sedation and those for hypertension, ulcer disease, gastroesophageal reflux, and depression); and (3) at-risk alcohol use alone (e.g., binge drinking, driving under the influence).[25]

Older adults who misuse alcohol have higher rates of ED visits than their age peers who do not misuse alcohol. The National Institute on Alcohol and Alcohol Abuse and American Geriatrics Society guidelines use lower guidelines than the NSDUH for defining heavy drinking among older adults, i.e., 4+ drinks in any single day during a typical month in the past year. Compared to their age peers who drink within these guidelines, older-adult heavy drinkers had a 1.91 greater odds (95% CI [1.11-3.30]) of acute care ED utilization for ambulatory-care sensitive conditions.[26] Regardless of age group, repeat ED users were also found to include a higher proportion of those with alcohol-related diagnoses than non-repeat users.[27,28]

Higher ED visit rates among older adults who misuse alcohol are attributable in part to alcohol's adverse effects on chronic medical conditions, falls and other accidents resulting in fractures, self-inflicted injuries including suicide attempts, delirium, gastrointestinal problems, alcohol/alcohol-withdrawal induced mood disorders and agitation, lower adherence to prescribed therapy for chronic medical conditions, and lower rates of primary care and preventive care visits.[4,26,29-35] Older-adult alcohol and/or drug users who take multiple prescription and nonprescription medications are also at a high risk for potentially dangerous interaction effects between these medications and substance use.[36,37] Those who concurrently use alcohol with opioid pain relievers (OPR) or benzodiazepines (BZD) are at an especially high risk for fatal/nonfatal overdose, more aberrant behaviors, accidents, and greater ED visits.[38,39] The 2010 Drug Abuse Warning Network data showed that alcohol was involved in nearly 13% of OPR abuse-related ED visits and nearly 25% of BZD abuse-related visits among patients aged 55+.[40]

ED visits have negative health and mental health

consequences for older adults.[41,42] A systematic review found that between one-third and one-half of ED patients aged 65+ are admitted to a hospital, which is 2.5-4.6 times higher than the hospital admission rates among younger ED patients.[31] One study also found that problem drinking was associated with worse self-perceived health among older patients in the year following an ED visit.[43] Frequent ED visits by increasing numbers of older adults are also likely to further increase healthcare costs and drain healthcare resources.[44] Since alcohol-related health crises can be prevented, identification of subgroups of late middle-aged and older adults who may be at a high risk of ED visits and frequent visits based on their health status and alcohol use/misuse patterns is important for helping older adults avoid such visits.

In this study, we used latent class analysis (LCA)[45,46] to identify unobservable subgroups of individuals aged 50+ who may be at risk of ED visits based on their alcohol nonuse/use patterns, chronic health and mental health conditions, and previous ED use. The study contributes to the ED literature by examining ED visit risk levels incorporating health status and alcohol consumption patterns among the population group that comprises the largest share of ED users.

METHODS

Data Source and Sample

Data came from the 2013 National Health Interview Survey (NHIS). The annual, cross-sectional NHIS series is the principal source of information on the health of the civilian noninstitutionalized population of the United States.[47] The 2013 NHIS public-use data file contains information on 41,336 households and 42,321 families, with 12,860 children and 33,557 adults interviewed as sample children and sample adults, respectively. All interviews were done face-to-face. Of the total 16,505 sample adults aged 50 years and older, the present study focused on 15,713 respondents, after excluding 619 (4.25%) who were not self-interviewed (i.e., proxy interviewed or interviewee status not known) and an additional 173 (1.01%) whose alcohol-use data were missing.

Measures: Latent Class Indicators

Alcohol nonuse/use pattern was categorized into lifetime abstainers, ex-drinkers, current infrequent/light drinkers, current moderate drinkers, and current heavy drinkers. The NHIS defines lifetime abstainers as those who have had less than 12 drinks of any alcoholic beverages (including liquor such as whiskey or gin, beer, wine, wine coolers, or any other type of alcoholic beverages) in their entire life. Ex-drinkers had had 12+ drinks in their lifetime but had not consumed any alcoholic beverages in the past year. Current drinkers had had 12+ drinks in their lifetime and at least one drink in the past year. Based on the frequency and number of drinks in the past year, current infrequent drinkers had 1-11 drinks total; current light drinkers had 3 or fewer drinks per week; current moderate drinkers had 4-14 drinks per week for men and 4-7 drinks per week for women; and current heavy drinkers had 15+ drinks per week for men or 8+ drinks per week for women.[47] Since our bivariate and multivariate analyses showed no significant difference in the numbers of diagnosed chronic illnesses and other reports of chronic health conditions among current infrequent, light, and moderate drinkers, we combined these three groups in the LCA in this study.

Chronic health and mental health conditions (yes=1; no=0 for each) included: (1) chronic illnesses (hypertension [HP], heart disease [coronary heart disease, angina pectoris, myocardial infarction, and/or other health disease or condition], stroke, diabetes, any lung problems [asthma, chronic obstructive pulmonary disease-COPD, emphysema], arthritis [arthritis, rheumatoid arthritis, gout, lupus, fibromyalgia], and cancer as diagnosed by a doctor or other health professional); (2) chronic (in the past three months) fracture, bone/joint injuries that caused functional limitations; (3) chronic (in the past three months) depression/anxiety/other emotional problems that caused functional limitations; (3) chronic (in the past three months) experience of pain in neck, low back, face/jaw muscles and joints, head/migraine, and generalized joint pain that lasted a whole day or more; and (4) whether or not the respondent needed help with activities and instrumental activities of daily living (ADL/IADL).

Number of ED visits in the past 12 months was measured with the question, "…how many times have you gone to a hospital emergency room about your own health (this includes emergency room visits that resulted in a hospital admission)?" The response categories were 0, 1, 2-3, 4-5, 6-7, 8-9, 10-12, 13-15, 16 or more."

Measures: Sample and Latent Class Membership Characteristics

Sample and latent class membership characteristics included demographics, self-rated health and mental health status, health-related behaviors, and healthcare service use (in the past 12 months).

Demographics were chronological age and age group (50-59, 60-69, 70-79, & 80+ years); gender (male vs. female); race/ethnicity (non-Hispanic white, non-Hispanic Black, Hispanic, non-Hispanic Asian, other); marital status (married/cohabiting vs. not married/cohabiting); education (college degree vs. no college degree); employment status (employed vs. not employed); and region of residence (Northeast, Midwest, South, and West).

Self-rated health was measured on a 5-point scale (1=poor, 5=excellent); and mental health status was measured with the six-item K6 for psychological distress ("feeling nervous; feeling hopeless; feeling restless or fidgety; feeling so sad or depressed that nothing could cheer you up; feeling that everything was an effort; and feeling down on yourself, no good, or worthless" during the past 30 days; 0=none of the time, 4=all of the time).[48] Cronbach's alpha for the study sample was .88. Due to

individual item missing values, K6 scores were grouped into no symptoms (=0), any symptoms (≥1), and missing.

Health-related behaviors included (1) body mass index (BMI) calculated from the respondent-reported height and weight, without shoes, at the time of the survey (underweight, healthy weight, overweight, obese, missing); (2) leisure time physical activities (exercise, sports, physically active hobbies…) referring to engagement at least once a week in vigorous, low/moderate, or strength activities; and (3) any tobacco product use (current daily or some-day user, former user, never user) including cigarette smoking and/or other tobacco product use.

Healthcare service utilization in the past 12 months (yes=1; no=0 for each) included (1) insurance status (private insurance, Medicare, and Medicaid); (2) visit with a general doctor/primary care physician (general practice, family medicine, or internal medicine); (3) visit with a mental health service provider (psychiatrist, psychologist, psychiatric nurse, or clinical social worker); and (4) whether or not the ED was the respondent's usual source of healthcare.

Data Analytic Approach

LCA is a method for identifying unobserved subgroups (latent classes) that consist of individuals that share similar characteristics across a variety of measures .[45,46] In this study, we used LCA to identify latent subgroups of older adults based on alcohol consumption patterns, chronic physical and mental health conditions, and past-year ED visits. The LCA models were fit using Mplus 7.13[49] using full information maximum likelihood estimation with robust standard errors, which makes use of all available data.[50] The first step in fitting an LCA model is to determine the optimal number of classes that underlie the population. This was done by fitting a series of models beginning with a one-class model in which all respondent were treated as a single population, then sequentially increasing the number of classes until there was no improvement gained by adding an additional class. Simulation studies that examined the properties of fit indices[51,52] and null hypothesis significance tests[52] concluded that the Bayesian information criterion (BIC) and the sample-adjusted BIC were the best indicators of class recovery; however, the Lo-Mendell-Rubin (LMR) likelihood ratio test[53] and the bootstrap likelihood ratio test performed similarly well. In another LCA simulation study, Clark and Muthén[54] demonstrated that true parameter values are more likely to be in the 95% confidence when entropy, a measure of classification accuracy, was greater than .80. For this study, a series of models were fit and evaluated using LMR likelihood ratio test; entropy (>0.80)[54]; average class probabilities (>0.80)[55]; a scree plot of the BIC; and inspection of latent classes' descriptive statistics. After fitting the LCA model, LCA membership was used as an independent variable in a series of generalized linear models using an identity link function for continuous outcomes and a logit link function for binary outcomes to assess class differences in demographic and other characteristics. All estimates presented in this study are weighted, with the exception of sample sizes.

RESULTS

Sample Characteristics by Alcohol Nonuse/Use Patterns

As alcohol consumption pattern was one of the key indicators for LCA, data in Tables 1 and 2 describe the characteristics of the five alcohol nonuse/use groups. Table 1 shows sociodemographic and health behavior characteristics of the study sample by alcohol nonuse/use pattern. It shows that 20% were lifetime abstainers, 20% were ex-drinkers, 26% were current infrequent/light drinkers, 14% were current moderate drinkers, and 19% were current heavy drinkers. Lifetime abstainers and ex-drinkers were older than the three current drinker groups; however, of all five groups, lifetime abstainers had the highest proportion of women, racial/ethnic minorities, and never smokers.

Table 2 shows health status and healthcare use characteristics by alcohol nonuse/use pattern. Ex-drinkers had the poorest health and mental health indicators. A significantly higher proportion of lifetime abstainers (the oldest of the five groups) than current infrequent/light drinkers and current moderate drinkers also had chronic illnesses and needed help with ADL/IADL, but they were least likely of all five groups to report any psychological distress symptoms. Current infrequent/light drinkers and current moderate drinkers were similar to each other in health and mental health indicators and had the fewest chronic illnesses of all groups. Compared to these two groups of current drinkers, a larger proportion of current heavy drinkers had reported chronic illnesses, needed help with ADLs/IADLs, and reported psychological distress symptoms. Heavy drinkers were also mostly likely (8.17%) to have reported functional limitations due to chronic bone/joint fractures or other injuries.

With respect to past-year healthcare use, 77% of lifetime abstainers and about 80% of the other groups visited a general doctor/primary care physician. Lifetime abstainers had the smallest portion of mental health service users. Almost 25% of ex-drinkers, about 20% of lifetime abstainers and current heavy drinkers, and about 16% of current infrequent/light drinkers and current moderate drinkers visited an ED in the past 12 months.

Determination of Number and Interpretation of Latent Classes

Fit indices, entropy, LMR, and average class probabilities for models with two through five classes are presented in Table 3. After evaluating all five LCA models (i.e., models with 1 through 5 latent classes), a four-class model was selected for subsequent analyses as the LMR test indicated no significant difference between the 4-class and 5-class models which indicates that the additional complexity of a 5-class model relative to a 4-class model did not improve the model fit; other indices did not appreciably differ across models. The Figure shows item proportions for each of the four latent classes (i.e., the proportions of individuals in a putative class

Table 1. Sociodemographic characteristics and health-related behaviors by alcohol nonuse/use pattern.

N (%)	All 15,713 (100)	Lifetime abstainer 3,505 (20.02)	Ex-drinker 3,474 (20.37)	Current infrequent/ light drinker 3,759 (26.18)	Current moderate drinker 2,069 (14.37)	Current heavy drinker 2,906 (19.05)
Sociodemographics						
Chronological age (M,SE)	63.58 (0.11)	66.40$_a$ (0.25)	65.50$_b$ (0.22)	61.32$_c$ (0.19)	61.97$_d$ (0.24)	62.89$_e$ (0.24)
Age group (%)						
50-59 years	41.49	32.72	33.97	49.27	47.93	43.21
60-69 years	31.51	28.99	32.40	32.13	31.22	32.56
70-79 years	17.58	22.69	20.34	13.41	15.14	16.83
80+ years	9.42	15.60	13.29	5.20	5.71	7.40
Male (%)	46.70	28.47	50.22	49.76	69.12	40.95
Race/ethnicity (%)						
Non-Hispanic White	75.45	61.74	72.88	79.79	84.94	79.51
Non-Hispanic Black	10.47	14.37	13.32	8.34	6.09	9.54
Hispanic	9.20	14.49	9.48	7.93	6.15	7.37
Non-Hispanic Asian	4.20	8.55	3.10	3.47	2.65	2.97
Other	0.68	0.85	1.23	0.47	0.17	0.61
Married/cohabiting (%)	64.33	59.00	58.61	69.89	72.21	62.46
College degree (%)	30.69	22.22	19.48	40.19	43.98	28.48
Employed (%)	51.16	40.60	38.42	62.09	61.37	53.14
Health behaviors						
Body mass index (%)						
<18.5 (underweight)	1.41	1.84	1.71	1.11	1.16	1.23
18.5-24.99 (healthy)	29.91	31.18	27.31	29.31	33.50	29.48
25-29.99 (overweight)	36.19	33.53	33.96	37.69	42.01	34.92
30+ (obese)	29.44	28.91	34.62	29.33	21.55	30.55
Missing	3.05	4.53	2.40	2.56	1.79	3.82
Any type of leisure time physical activity at least once a week (%)	63.34	49.12	55.84	71.48	76.04	65.53
Vigorous activity	32.09	21.05	23.55	40.79	44.24	31.71
Moderate/light activity	54.34	40.43	48.43	61.38	65.61	57.12
Strengthening activity	21.71	12.61	15.70	27.79	30.59	22.63
Tobacco use (%)						
Current user	18.84	8.89	20.02	18.30	25.15	24.02
Former user	36.14	16.78	43.65	40.44	44.01	36.62
Never user	45.02	74.33	36.34	41.26	30.84	39.35

All group differences are significant at p<0.001.
M, mean; *SE,* standard error of the mean
[a-e]F(4,297)=99.21 for chronological age (Bonferroni-corrected): c=d<b<a; d=e; e<a<b<c.

that possesses given characteristics). On the basis of the class characteristics in the Figure, classes were characterized as follows: Class 1: lowest risk, Class 2: low risk, Class 3: moderate risk, and Class 4: high risk.

Table 4 shows model parameters for the four classes (Class 1: 35% of the sample, Class 2: 21%; Class 3: 37%; and Class 4: 7%) in the probability scale and the ascending order of ED visit risks from Class 1 to Class 4. All pairwise

Table 2. Health status and healthcare use by alcohol nonuse/use pattern.

N (%)	All 15,713 (100)	Lifetime abstainer 3,505 (20.02)	Ex-drinker 3,474 (20.37)	Current infrequent/ light drinker 3,759 (26.18)	Current moderate drinker 2,069 (14.37)	Current heavy drinker 2,906 (19.05)
Health status						
Self-rated health (M,SE)	3.48 (0.01)	3.32[a] (0.02)	3.19[b] (0.03)	3.66[c] (0.02)	3.80[d] (0.03)	3.49[e] (0.03)
No. of diagnosed chronic illnesses (M,SE)	1.65 (0.01)	1.68[a] (0.03)	2.02[b] (0.03)	1.43[c] (0.03)	1.38[d] (0.03)	1.72[e] (0.03)
Hypertension (%)	49.24	52.79	55.62	43.42	43.60	50.95
Heart disease (%)	19.94	20.41	27.06	16.60	16.06	19.32
Stroke (%)	5.07	6.53	7.79	3.02	3.29	4.79
Diabetes (%)	16.60	20.93	23.08	13.06	8.27	16.25
Asthma (%)	11.49	10.16	12.90	10,90	10.20	13.15
COPD/emphysema (%)	6.58	5.13	10.84	4.71	4.53	7.62
Arthritis (%)	39.76	38.60	47.24	35.83	34.79	42.14
Cancer (%)	16.43	13.68	17.85	16.05	17.10	17.81
Functional limitations due to chronic fractures of bone/joint/other injury (%)	6.36	5.60	7.38	5.65	4.87	8.17
Chronic depression/ anxiety/ emotional problems (%)	2.35	2.38	3.21	2.00	1.82	2.28
Chronic pain (%)	58.96	54.70	64.76	56.35	56.87	62.39
Need help with ADL/IADL (%)	6.92	9.94	10.93	3.81	3.17	6.58
Psychological distress (%)						
No symptom	47.82	55.41	43.88	47.47	48.75	43.84
Any symptom	50.45	41.98	54.56	50.97	49.64	54.86
Missing data	1.73	2.61	1.56	1.56	1.62	1.30
Healthcare use in the past 12 months						
Emergency department use (%)	19.04	19.72	24.87	15.41	16.14	19.24
Hospitalization (%)	11.30	12.06	14.83	9.18	8.12	12.04
Saw general doctor (%)	79.04	77.07	80.48	79.38	78.98	79.17
Saw mental health provider (%)	6.50	3.76	8.44	7.31	6.57	6.16

All group differences, except asthma (p=0.007), cancer (p=0.004), and chronic depression/anxiety/emotional problems (p=0.063), are significant at p<0.001.

M, mean; *SE,* standard error of the mean; *COPD,* chronic obstructive pulmonary disease; *ADL,* activities of daily living; *IADL,* instrumental activities of daily living

[a-e]F(4,297)=95.13 for self-rated health (Bonferroni-corrected): b<a<e<c<d. F(4,297)=67.08 for number of diagnosed chronic illnesses (Bonferroni-corrected): c=d<a=e<b.

comparisons between classes were either non-estimable (NE) due to perfect prediction or were significantly different at p<0.001. Class 1 members were almost exclusively infrequent/light/moderate drinkers (i.e., probability >0.99); Class 2 members were almost exclusively lifetime abstainers (i.e., probability >0.99); and Class 3 members were evenly divided between ex-drinkers (probability =0.505) and heavy drinkers (probability =0.495). Class 4 members included all four drinking groups but more heavily ex-drinkers (probabilities =0.333 for ex-drinkers; 0.275 for infrequent/ light/moderate drinkers; 0.212 for lifetime abstainers; and 0.179 for heavy drinkers) and were also almost exclusively those who had repeat ED visits in the past year. As expected, Class 1 had the lowest probability and Class 4 had the highest probability of all chronic illnesses, chronic mental health problems, chronic pain, need for ADL/IADL help.

In sum, Class 3 members were ex-drinkers and heavy drinkers who also had higher probabilities of chronic disease burden than Classes 1 and 2 members. Class 4 members also included higher proportions of ex-drinkers and heavy drinkers than Classes 1 and 2 members. In addition, compared to the other three classes, Class 4 members had the highest probabilities of all chronic physical, functional, and mental health conditions and a history of repeat ED visits.

Table 3. Latent class analysis model fit indices, entropy, LMR-LRT, and average class probabilities for models with 2 through 5 classes.

No. of latent classes	BIC	Entropy	LMR-LRT	Minimum class probability
2	235902.0	1.00	307764.1 (p<0.001)	1.00
3	225724.6	0.995	293451.7 (p<0.001)	0.996
4	219578.7	0.997	274874.9 (p<0.001)	0.996
5	211715.4	0.998	265012.6 (p=0.140)	0.996

BIC, Bayesian information criterion; *LMR,* Lo-Mendell-Rubin; *LRT,* adjusted likelihood ratio test

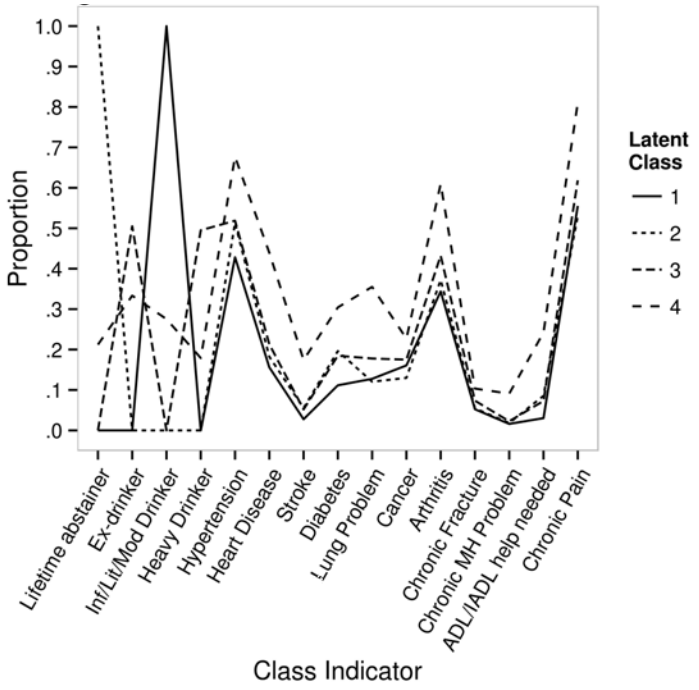

Figure. Indicators across latent classes. The figure presents the proportions of respondents within each class that exhibit each of the characteristics that were used to determine the latent classes (e.g., 100% of Class 1 is comprised of infrequent/light/moderate drinkers, slightly over 40% of Class 1 exhibits hypertension, etc.). *ADL,* activities of daily living; *IADL,* instrumental activities of daily living

Latent Class Membership Characteristics

Table 5 shows that relative to the other three classes, Class 1 members (lowest risk group) were younger and included higher proportions of men, non-Hispanic Whites, married/cohabiting persons, college graduates, employed persons, Northeast residents, those with excellent self-rated health, those doing weekly physical activities, and those with private insurance. Class 1 members also included a higher proportion of overweight people, but a lower proportion of obese people. Relative to the other three classes, Class 2 members (low-risk group) were older and included higher proportions of women, Hispanics, Asians, Southerners, those with no psychological distress symptoms, and those who never used tobacco products. Relative to the other three classes, Class 3 members (moderate risk group) included a highest proportion of Midwesterners. Relative to the other three classes, Class 4 members (high-risk group) included higher proportions of non-Hispanic Blacks (20%), not married/cohabiting persons (49%), obese persons (39%), current smokers (25%), and Medicare- (53%) and Medicaid- (18%) covered persons and lower proportions of college graduates (16%) and those who did any weekly physical activity (47%). Class 4 members were most likely to have visited a general doctor (90%) and to report the ED as their usual healthcare source when sick (3.2%).

DISCUSSION

This study identified four classes of individuals aged 50+ with regard to their ED visit risk levels by examining their alcohol consumption patterns and health status. The findings show that alcohol consumption patterns are a significant indicator for ED visit risk, with infrequent/light/moderate drinkers and lifetime abstainers presenting significantly lower risk probabilities than ex-drinkers and heavy drinkers. As expected, in addition to being infrequent/light/moderate drinkers, Class 1, the lowest-risk group, is also the youngest and the healthiest by all indicators.

In contrast to Class 1, Class 2 members were the oldest of all four classes and had significantly lower socioeconomic status (SES; i.e., more racial/ethnic minorities and fewer college graduates and employed persons). Class 2 was exclusively lifetime abstainers, and despite their older age and low SES had lower rates of chronic health conditions, functional limitations, and mental health problems than Classes 3 and 4. Previous studies show that lifetime abstainers are often genetically predisposed to or have chosen abstention because of their religious beliefs, culture, or family environment and personal values and beliefs about alcohol or other substance use and can thus avoid substance-induced/influenced risky behaviors.[56-58] Other recent studies also show that lifetime abstainers tend to have a more favorable cardiovascular

Table 4. Estimated latent class indicators parameter estimates in probability scale, and contrasts between classes.

Indicators	Class 1 (lowest risk) (0.35; n=5,527)	Class 2 (low risk) (0.21; n=3,242)	Class 3 (moderate risk) (0.37; n=5,802)	Class 4 (high risk) (0.07; n=1,142)
Lifetime abstainer	0.000	>0.99	0.000	0.212
Ex-drinker	0.000	0.000	0.505	0.333
Infrequent/light/moderate drinker	>0.99	0.000	0.000	0.275
Heavy drinker	0.000	0.000	0.495	0.179
Hypertension	0.428	0.513	0.519	0.677
Heart disease	0.156	0.182	0.213	0.440
Stroke	0.028	0.055	0.052	0.174
Diabetes	0.112	0.196	0.185	0.304
Lung problem	0.128	0.120	0.178	0.355
Cancer	0.161	0.130	0.175	0.227
Arthritis	0.344	0.372	0.432	0.610
Chronic fracture	0.052	0.055	0.074	0.103
Chronic depression/anxiety/ other emotional problem	0.016	0.018	0.023	0.091
Chronic pain	0.555	0.531	0.619	0.810
ADL/IADL help needed	0.030	0.085	0.073	0.242
ED visit-none	0.881	0.859	0.847	0
ED visit-once	0.116	0.132	0.151	0.003
ED visit- 2-3 times	0	0	0	0.735
ED visit- 4+ times	0	0	0	0.262

All paired contrasts between classes are significant at p<0.001 or non-estimable due to perfect prediction.
Note: Emergency department (ED) visits were treated as a continuous variable in the latent class analysis model. The ED visit indicator proportions shown above were obtained using participant's most likely class membership for display purposes.
ADL, activities of daily living; *IADL,* instrumental activities of daily living

profile and better overall mental health than ex-drinkers or heavy or binge drinkers.[37,59]

The high probability of ex-drinkers in Classes 3 and 4, the two higher risk groups, with significantly poorer health/mental health than current infrequent/light/moderate drinkers and lifetime abstainers, supports the "sick quitter" assumption and the possibility that ex-drinkers were likely to include former bingers and heavy drinkers. For example, Ng Fat et al.[60] found that worsening health or preexisting poor health and poor psychosocial health were associated with ceasing alcohol consumption at ages 42 and 50. Class 4 members have the highest burden of chronic diseases (especially cardiovascular diseases), chronic pain, and chronic mental health problems. Nevertheless, a substantial proportion of them engage in unhealthy behaviors as shown in their rates of heavy drinking, obesity, smoking, and no physical activity. Although older adults' medical conditions causing chronic pain tend to reduce alcohol consumption over time, some rely on alcohol to manage pain, which leads to more alcohol consumption and/or alcohol-related problems.[61-63]

Unhealthy behaviors among Class 4 members may also stem from their significant SES disadvantages, which may not facilitate adoption of healthy behaviors and effective self-management of chronic medical conditions. Although a majority of Class 4 members appear to have a usual place of healthcare other than the ED, ED visits were likely for health crises resulting from high disease burden and unhealthy behaviors even for those with primary care access.

The findings have the following clinical and research implications. First, primary care physicians and other aging-service providers should provide their patients at high risk for ED visits with more psychoeducation or other such interventions that will encourage reducing problematic alcohol consumption and engaging in other healthy behaviors. Almost all interventions for treatment-seeking older-adult substance abusers demonstrate positive outcomes that are on par with those among younger cohorts.[64] Brief advice or brief interventions at primary-care settings for non-treatment-seeking older-adults with alcohol-related problems have also had positive effects; however, long-term effects of these brief interventions have been mixed.[64] More research on longer-term, age-specific interventions is needed.

Second, all older adults with chronic illnesses are likely

Table 5. Between latent class differences in sociodemographic, health status, health behavior, and healthcare-use characteristics.

N	Class 1 (lowest risk) (0.35; n=5527)	Class 2 (low risk) (0.21; n=3242)	Class 3 (moderate risk) (0.37; n=5802)	Class 4 (high risk) (0.07; n=1142)
Sociodemographics				
Chronological age (M,SE)	61.55 (0.16)[a]	66.30 (0.25)[b]	64.24 (0.18)[c]	64.28 (0.41)[d]
Age group (%)				
50-59 years	48.50	32.70	38.53	41.46
60-69 years	32.21	29.40	32.23	29.27
70-79 years	14.06	22.83	18.85	16.32
80+ years	5.23	15.07	10.39	12.94
Male (%)	56.82	28.78	46.02	41.34
Race/ethnicity (%)				
Non-Hispanic White	81.82	61.92	77.05	61.11
Non-Hispanic Black	7.25	14.14	10.53	19.23
Hispanic	7.36	14.30	8.32	10.40
Non-Hispanic Asian	3.22	8.85	3.16	2.36
Other	0.36	0.80	0.94	0.91
Married/cohabiting (%)	71.40	60.19	61.43	49.42
College degree (%)	42.39	23.10	24.61	15.78
Employed (%)	62.58	41.86	47.03	31.84
Region of residence (%)				
Midwest	22.74	18.01	24.15	24.00
South	33.27	47.34	36.20	39.68
West	22.00	19.55	21.72	19.06
Northeast	21.99	15.10	17.93	17.26
Self-rated health (%)				
Poor	2.19	4.85	4.17	21.02
Excellent	25.45	17.82	17.83	7.42
Psychological distress (%)				
No symptom	48.95	57.42	45.37	26.15
Any symptom	49.45	39.94	53.27	71.98
Missing	1.61	2.64	1.36	1.88
Body mass index (%)				
<18.5	1.05	1.85	1.32	2.81
18.5-24.99	30.59	31.59	28.77	27.25
25-29.99	39.57	33.78	34.97	29.45
30+	26.47	28.03	31.73	38.95
Missing	2.32	4.75	3.22	1.55
Any type of leisure time physical activity at least once a week (%)	73.53	49.84	62.21	46.83
Vigorous activity	42.49	21.83	28.97	16.16
Moderate/light activity	63.30	41.00	53.92	40.92
Strengthening activity	28.95	12.66	19.84	14.53

All group differences are significant at p<0.001.

M, mean; *SE,* standard error of the mean

[a-e]F (3,298)=100.90 for chronological age (Bonferroni-corrected): a<b,c,d; b>c,d; c=d.

Table 5. Continued. Between latent class differences in sociodemographic, health status, health behavior, and healthcare-use characteristics.

N	Class 1 (lowest risk) (0.35; n=5527)	Class 2 (low risk) (0.21; n=3242)	Class 3 (moderate risk) (0.37; n=5802)	Class 4 (high risk) (0.07; n=1142)
Sociodemographics				
Tobacco product use (%)				
Current user	20.57	8.39	21.31	25.15
Former user	41.39	16.55	40.12	39.17
Never user	38.05	75.05	38.57	35.68
Private insurance (%)	69.72	52.39	57.66	42.05
Medicare (%)	32.03	48.22	44.07	52.70
Medicaid (%)	2.97	8.81	6.23	17.97
Saw/talked with a general doctor (%)	78.75	76.00	79.10	89.79
Saw/talked to a mental health provider (%)	6.50	3.35	6.10	18.45
Emergency department was the place most often went when sick (%)	0.34	0.44	0.53	3.21

All group differences are significant at p<0.001.

to benefit from better self-management of chronic illnesses by participating in evidence-based programs such as Stanford's Chronic Disease Self-Management Program, which has been found to reduce ED visits and hospitalizations among participants.[65] Primary care and ED physicians should refer their patients to face-to-face or web-based chronic disease self-management programs.

Third, access to preventive care in primary care settings and mental health services needs to be improved for those at high risk of ED visits. Especially given the high-risk group's low SES, transportation and other barriers to accessing primary care should be examined.

Fourth, given the mixed evidence about brief interventions in EDs, trauma care centers, and in-patient hospital care settings with regard to their effects on treatment and healthcare utilization outcomes, more research is needed to refine treatment practice and enhance treatment outcomes.[66,67]

Finally, in addition to individual-level interventions, efforts to improve preventive healthcare access and healthy behaviors require mezzo- and macro-level interventions such as neighborhood-level public health interventions and higher Medicaid and health insurance reimbursement for preventive services.

LIMITATIONS

Our study has some limitations due to data constraints. First, data on ED visits did not include the circumstances leading to these visits, which would have provided a richer contextual description. Second, since ED discharge diagnosis was also missing, potential interaction effects of alcohol, prescription drugs, and over-the-counter medications and alcohol's effects on falls and other injuries on ED visit risk could not be factored in. Third, the LCA indicators, including past-year ED visits, were self-reported and possibly subject to underreporting due to poor recall or social desirability bias. Fourth, NHIS does not collect data on illicit drug use/misuse. Given the continuing increase in drug-use disorders among ED visitors,[5] future research should include both alcohol and drug use/misuse.

CONCLUSION

Alcohol nonuse/use and quantity of use contribute significantly to varying levels of ED visit risk among individuals aged 50+. In the face of projected increases in ED visits by this age group, the findings underscore the importance of clinical practice that takes into account past and current alcohol use/misuse and provides psychoeducation and other interventions to increase healthy behaviors. In particular, clinicians need to help heavy-drinking older adults reducing unhealthy alcohol consumption and help both heavy drinkers and ex-drinkers improve chronic illnesses self-management. More research on effective treatment practices in primary care and other healthcare settings for older adults with alcohol-related problems is needed. On mezzo- and macro-levels, improving access to preventive care in primary care setting and mental health treatment, especially for older adults with low SES and high chronic disease burden and poor mental health, is a necessity.

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Correlation of the National Emergency Medicine M4 Clerkship Examination with USMLE Examination Performance

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Introduction: Assessment of medical students' knowledge in clinical settings is complex yet essential to the learning process. Clinical clerkships use various types of written examinations to objectively test medical knowledge within a given discipline. Within emergency medicine (EM), a new national standardized exam was developed to test medical knowledge in this specialty. Evaluation of the psychometric properties of a new examination is an important issue to address during test development and use. Studies have shown that student performance on selected standardized exams will reveal students' strengths and/or weaknesses, so that effective remedial efforts can be implemented. Our study sought to address these issues by examining the association of scores on the new EM national exam with other standardized exam scores.

Methods: From August 2011 to April 2013, average National EM M4 examination scores of fourth-year medical students taken at the end of a required EM clerkship were compiled. We examined the correlation of the National EM M4 examination with the scores of initial attempts of the United States Medical Licensing Exam (USMLE) Step 1 and Step 2 Clinical Knowledge (CK) examinations. Correlation coefficients and 95% confidence intervals of correlation coefficients are reported. We also examined the association between the national EM M4 examination score, final grades for the EM rotation, and USMLE Step 1 and Step 2 CK scores.

Results: 133 students were included in the study and achieved a mean score of 79.5 SD 8.0 on the National EM M4 exam compared to a national mean of 79.7 SD 3.89. The mean USMLE Step 1 score was 226.8 SD 19.3. The mean USMLE Step 2 CK score was 238.5 SD 18.9. National EM M4 examination scores showed moderate correlation with both USMLE Step 1 (mean score=226.8; correlation coefficient=0.50; 95% CI [0.28-0.67]) and USMLE Step 2 CK (mean score=238.5; correlation coefficient=0.47; 95% CI [0.25-0.65]). Students scoring below the median on the national EM M4 exam also scored well below their colleagues on USMLE exams.

Conclusion: The moderate correlation of the national EM M4 examination and USMLE Step 1 and Step 2 CK scores provides support for the utilization of the CDEM National EM M4 examination as an effective means of assessing medical knowledge for fourth-year medical students. Identification of students scoring lower on standardized exams allows for effective remedial efforts to be undertaken throughout the medical education process. [West J Emerg Med. 2015;16(7):1159–1165.]

INTRODUCTION

Assessment of medical students is complex yet essential to ensure that medical school graduates are prepared for residency training and future practice. Assessment is important to provide feedback to the learner in order to guide development and acquisition of milestones necessary for independent practice; to provide information to the educational program regarding effectiveness of the pedagogies; to provide a metric for stratifying the competency of applicants; and to protect the public by ensuring all graduates have attained the requisite level of competency required to progress to the next level of training.[1,2] The Liaison Committee on Medical Education (LCME), the accrediting body for education leading to the MD degree, has established guidelines for the evaluation and assessment of medical students throughout the continuum of undergraduate medical education.[3] These guidelines specify the use of formative and summative assessment methods to examine a variety of measures of knowledge, skills, behaviors, and attitudes (LCME, Functions and Structure of a Medical School).[3] Clerkships typically employ a number of assessment tools including written examinations, oral examinations, direct observation, simulation, observed structured clinical examination (OSCE), oral presentations, and written reports. While the assessment of clinical performance can be influenced by examiner subjectivity, medical knowledge assessments are often more objective in nature and are an important outcome for curricular assessment and licensure.[4]

Despite the increase in the prevalence of required emergency medicine (EM) clerkships within medical schools a National Board of Medical Examiners (NBME) subject exam in EM did not become available until April 2013.[5-7] In a 2007 survey of EM clerkship directors, 59% of respondents reported using an end-of-rotation final examination as a component of determining a final grade for the clerkship.[5] A subcommittee of the Clerkship Directors in Emergency Medicine (CDEM) recently developed a high stakes, end-of-rotation examination that was released on August 1, 2011 to assess fourth-year (M4) medical students.[7] This high-stakes examination was designed to assess the standardized objectives specified in the National EM M4 curriculum developed by CDEM to ensure a more consistent experience for students rotating in EM throughout the country.[8] This national curriculum also led to the development of online self-study modules designed to offer core knowledge on the core topics in EM (http://www.cdemcurriculum.org/). The examination was developed by a national group of EM educators using published NBME item writing guidelines and was made available to EM clerkships at no cost using online testing software.[7,9,10]

Regarding medical knowledge, many core clerkships use the NBME subject (shelf) examinations as a component of the final clerkship grade to increase objectivity. For example, in a recent survey of Clerkship Directors in Internal Medicine 88% of clerkships required the NBME subject exam to be taken during the clerkship and 99% of those clerkships used the examination score in determining the final clerkship grade.[11] The Alliance for Clinical Education recommends that "end of clerkship examinations should be part of the evaluation process for all medical students in core clerkships and should supplement clinical evaluations."[12] A written examination allows efficient assessment of both breadth and depth of medical knowledge without being impacted by the "halo effect" or tendency to overestimate clinical skills of students well known to them. Global rating scales of clinical performance have low inter-rater reliability and tend to reflect the faculty's undifferentiated judgment of the student's overall performance.[13] A national standardized exam not only allows student-to-student comparison, but also assists clerkship directors in assessing curricular goals and determining whether rotation learning objectives were met. Standardized, multiple-choice exams are well designed to test medical knowledge, but do not necessarily address other Accreditation Council for Graduate Medical Education core competencies (e.g., communication skills, professionalism, complex medical decision-making) that are best assessed via more clinically-focused observational methods within a clinical environment.

Studies evaluating the correlation between student performance on NBME subject exams, USMLE exams and clerkship performance have produced variable results. Successful completion of USMLE Steps 1, 2, and 3 designed to assess knowledge, concepts, and skills essential for patient care is required for medical licensure leading to the practice of medicine without supervision.[14] Moderate to large correlations have been demonstrated between performance on NBME subject exams and USMLE Step 1 and Step 2.[15,16] Most studies correlating the relationship between USMLE performance and NBME subject exam performance analyzed the performance for a single clerkship at a single site. Family medicine and obstetrics and gynecology have demonstrated modest correlation of USMLE Step 1 and Step 2 scores with the NBME subject examinations.[17, 18] In addition, Myles demonstrated that students failing Step 1 were more likely to fail the NBME shelf examination for obstetrics and gynecology and those performing in the bottom 25% of the NBME shelf exam were more likely to perform poorly on Step 2.[15] Only one study was identified that studied the relationship between NBME subject examinations across multiple clerkships with USMLE Step 1 and Step 2 scores ,which demonstrated moderate to large positive correlations (0.69 and 0.77).[16] Ultimately, understanding the correlation between performance of students on a variety of measures of clerkship knowledge and skills and performance on the USMLE examination series will allow undergraduate medical educators to identify at-risk students and institute early inventions to ensure successful completion of licensure requirements.

The primary objective of this study was to describe the correlation of the National EM M4 end-of-rotation examination with USMLE Step 1 and Step 2 Clinical Knowledge (CK)

examination scores at a single medical school.

METHODS

After approval of the institutional review board, all students in the required M4 emergency medicine rotation at the Brody School of Medicine at East Carolina University from August 2011 to April 2013 were eligible to be included in the study (a total of 159 students). We compiled the examination scores of the National EM M4 exam for consecutive fourth-year medical students (classes of 2012 and 2013) taken at the end of a required emergency medicine clerkship. Files containing data regarding performance of visiting medical students (n=14) and files from students not providing consent from our own school (n=12) were excluded from the study, leaving 133 students in the study sample. We correlated the National EM M4 exam scores with first attempts of both USMLE Step 1 and Step 2 CK scores and the final clerkship grade. All analyses were completed using JMP Pro 10 Statistical Software (SAS, Inc. Cary, NC). Correlation coefficients and 95% confidence intervals are reported. We also used one way analysis of variance (ANOVA) procedures to examine relationships between final EM exam scores, final EM rotation grades and USMLE Step 1 and 2 CK exam scores.

The CDEM-developed National EM M4 exam was administered at the completion of a four-week required M4 emergency medicine clerkship and accounted for 25% of the final clerkship grade. In addition to the examination, the final clerkship grade was based on end-of-shift clinical evaluations (55%), patient and procedure log (10%), professionalism (5%), and an evidence-based medicine presentation (5%). The designation of Honors criteria was applied to students who scored at least 80% correct on the National EM M4 end-of-rotation exam, demonstrated superior performance on shift evaluations, participated in an EMS experience, submitted an evidence-based medicine paper, and performed procedures beyond the basic requirements. All students completed the EM rotation at Vidant Medical Center, a tertiary care center with the only Level I trauma center for the 29 counties it serves in eastern North Carolina. The emergency department (ED) has greater than 110,000 patient visits annually with students rotating in both the adult and pediatric EDs. M4 students maintain primary patient care responsibility with the assistance of either faculty or teaching resident assigned for direct supervision. Educational objectives defining both medical knowledge and procedural competencies are taught through simulation exercises (three hours weekly), procedural skill labs, CDEM curriculum online reading, and didactic sessions. These objectives, along with simulation cases and required readings, are based on the revised national curriculum recommendations for required M4 clerkships in emergency medicine as delineated by CDEM and published in Academic Emergency Medicine.[8]

Students at the Brody School of Medicine at East Carolina University are required to take the USMLE Step 1 after completion of their basic science courses during the M2 year and before beginning their third-year core clinical clerkships. USMLE Step 1 must be passed in order to complete the M3 year without delay. The USMLE Step 2 may be taken in the summer or fall of the M4 year. Successful completion of both the USMLE Step 2 Clinical Knowledge and Step 2 Clinical Skills is a requirement for graduation.

RESULTS

Among 133 students, the mean USMLE Step 1 score was 226.8 SD 19.3. The mean USMLE Step 2 CK score was 238.5 SD 18.9. The mean score of the National EM M4 exam was 79.5 SD 8.0, compared to a national mean of 79.7 correct SD 3.89.[9] The range of score for these 133 students was from 62 to 94, compared to the range for national administration of the exam of 40 to 98.[9] With 59 students scoring below the median and 74 students scoring at or above, the median score was 80. For the 59 students who scored below the median on the EM national exam, the mean USMLE Step 1 score was 218.8 and the mean USMLE Step 2 CK score was 230.0. For the 74 students who scored at or above the median on the EM national exam, the mean USMLE Step 1 score was 233.4 and the mean USMLE Step 2 CK score was 245.2.

National EM exam scores from these 133 students were correlated with USMLE examination scores using Pearson's coefficient. Emergency medicine examination scores showed moderate correlation with both USMLE Step 1 (mean score= 226.8; correlation coefficient= 0.50; 95% CI [0.28-0.67], Figure 1) and USMLE Step 2 (mean score= 238.5; correlation coefficient= 0.47; 95% CI [0.25-0.65], Figure 2).

Final EM rotation grades were correlated with scores on the end-of-rotation EM examination as well as with

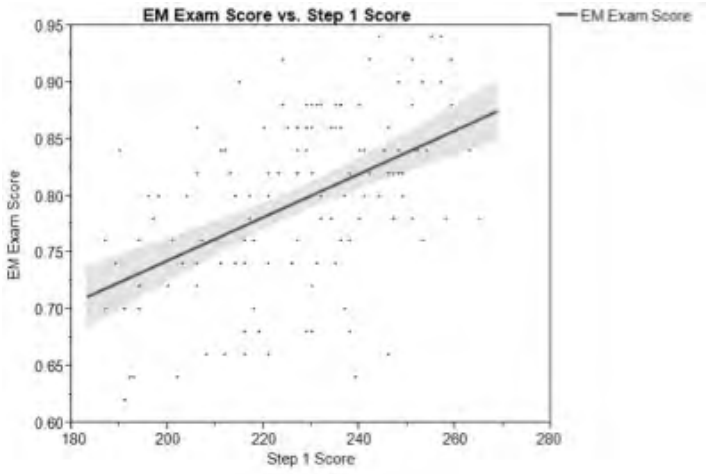

Figure 1. Correlation of National EM M4 Exam and USMLE Step 1 score. The bold line represents correlation and the shaded area represents the 95% confidence interval at each point. Correlation coefficient for the National EM M4 Exam and USMLE Step 1= 0.50. *EM*, emergency medicine; *USMLE*, United States medical licensing exam

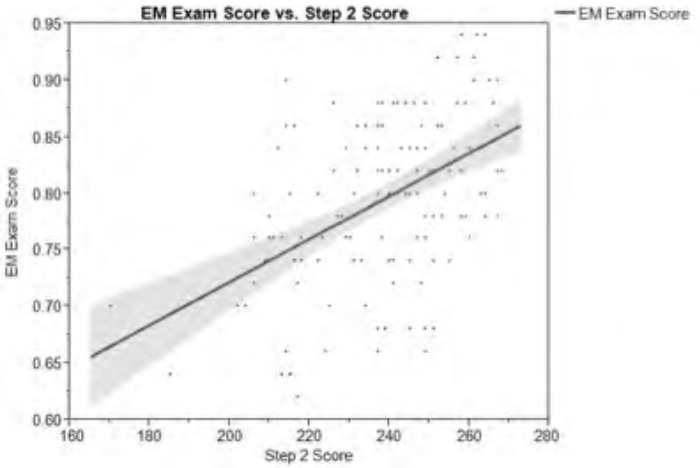

Figure 2. Correlation of National EM M4 Exam and USMLE Step 2 CK score. The bold line represents correlation and the shaded area represents the 95% confidence interval at each point. Correlation coefficient for the National EM M4 Exam and USMLE Step 2=0.47.
EM, emergency medicine; *USMLE*, United States medical licensing exam; *CK,* clinical knowledge

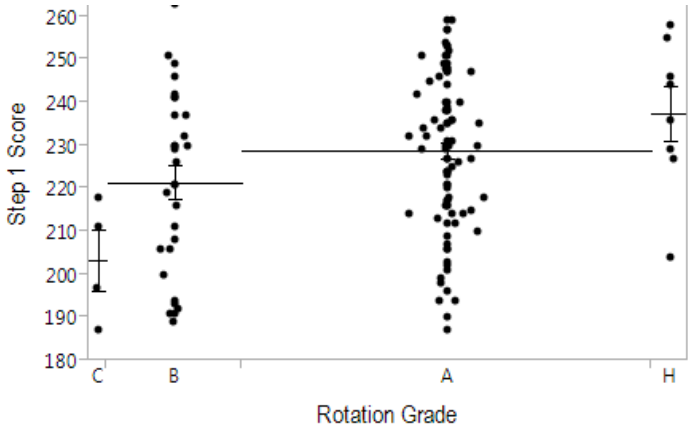

Figure 3. One way analysis of Step 1 Score by rotation grade. Individual data points are represented for each end-of-rotation grade category. Mean scores and standard errors are represented for each group by the horizontal lines.
H, honors

USMLE Step 1 and Step 2 examination scores. The final EM rotation grade was weakly correlated with the EM exam score (correlation coefficient=0.19), the USMLE Step 1 exam score (correlation coefficient=0.08) and USMLE Step 2 CK exam score (correlation coefficient=0.04). None of these correlations were statistically significant.

To better interpret the correlational analyses, we also used one way ANOVA to examine the relationships between final EM rotation grade, National EM M4 examination and USMLE Step 1 (Figure 3) and Step 2 CK scores (Figure 4). For students who achieved a final rotation grade of either A or Honors, the Step 1 scores were significantly higher than students whose final rotation grade was a C. For students who achieved a final rotation grade of A, their scores on USMLE Step 2 were significantly higher than students whose final rotation grade was a C. No other significant differences were found.

DISCUSSION

Our results, the first published data comparing exam performance for this newly-created national examination for emergency medicine with national benchmarks, are encouraging in that medical students who performed well on USMLE Step 1 and Step 2 CK licensure exams during the first three years of the curriculum appeared to also perform well on the National EM M4 clerkship exam. These findings are also consistent with previous studies from other specialties that report correlations between NBME subject examinations and USMLE examinations.[15,16]

Demonstration of the association between performance on earlier and later knowledge examinations is particularly important as the National EM M4 examination is offered free of charge as compared to the NBME Emergency Medicine Advanced Clinical Exam. The NBME released an EM subject exam in April 2013, after the release of the National EM M4 exam in 2011.[19,20] In an era of limited financial resources for medical education, decisions regarding test selection must consider not only the psychometric properties of the examination, but must take into consideration the financial implications for the institution.[21] The psychometric properties of this nationally standardized exam need further study, but our results demonstrate that its ongoing use with M4 medical students completing EM rotations remains a viable option for assessing medical knowledge, particularly for schools who may struggle to find resources to use other similar national exams.

What are the implications of our findings for the educational process itself? Our results showed that students who scored lower on the national EM exam also scored lower on the USMLE licensing series. The use of scores on the USMLE series to predict performance on subsequent examinations is part of a larger conversation concerning predictive validity in general. Medical schools place a great deal of emphasis on the importance of high stakes, multiple-choice examinations. A plethora of studies concerning predictive validity exists, and it seems apparent that students who do well on multiple-choice exams early in medical school tend to be consistent in that performance across a variety of standardized exams.[22,23] The same principle appears to be the case for student performance on USMLE Step exams, particularly Step 1. Our study illustrates the importance of using student scores from the continuum of USMLE Step 1, Step 2 and other local exams in the identification and strategic assistance for students who are "at risk" of poor performance on subsequent subject, in-service, and licensure examinations. We advocate the judicious use of student exam scores in this manner, in order to identify early in medical school those students who may have difficulty with exams given during core clinical clerkships such as our required

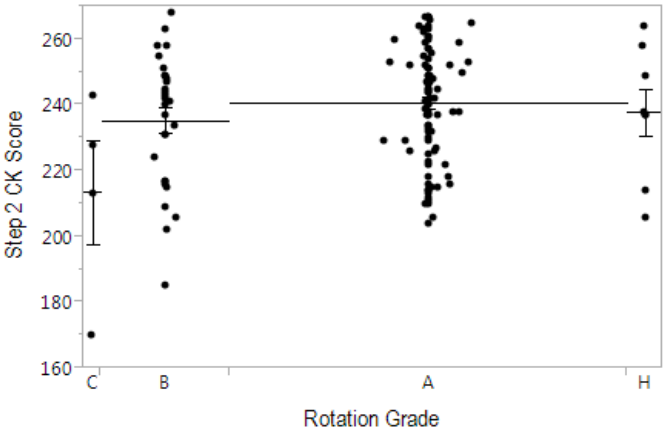

Figure 4. One way analysis of Step 2 CK Score by rotation grade. Individual data points are represented for each end-of-rotation grade category. Mean scores and standard errors are represented for each group by the horizontal lines.
CK, clinical knowledge; *H,* honors

fourth year EM rotation, and even standardized examinations given during residency training. A recent study reported that students performing poorly on one NBME subject exam were significantly more likely to fail USMLE Step 3 (OR 14.23) compared to peers without any subject exams 1SD below the mean.[25] Many clerkship directors do not have knowledge of their students' USMLE scores prior to the students' arrival on a given rotation. While some faculty opposed to sharing those scores feel this information will provide bias against the student's clinical performance evaluation, one must also consider how this information could be used more proactively by clerkship educators to provide enriched learning opportunities for students with a history of performance difficulties on standardized examinations.[25-27] This strategy is particularly relevant for students from under-represented minority groups and/or students who have diagnosed learning difficulties.[28-30] Developing a method for early identification and intervention for "at risk" students (however "at risk" is defined) may lead to improved performance on future licensure exams. This is critically important as many state licensing bodies are imposing limitations on the number of attempts required to pass USMLE or Comprehensive Osteopathic Medical Licensing Examination (COMLEX) examinations. Educational strategies such as administering a rotation pretest of medical knowledge may provide assistance to clerkship directors in identifying these "at risk" students in need of focused tutoring, mentoring, or other specialized assistance. Remedial strategies including mandatory lecture attendance or extended time with a preceptor have been shown to improve student performance on NBME clinical subject examinations.[31,32] The goal of medical education should be to establish learning environments targeted at helping students achieve their maximum potential, including improved performance on medical knowledge exams. By considering the performance differences of students at different levels, EM educators can consider how the continuum of standardized exam results can be used proactively to meet the needs of students facing academic challenges. This latter need is especially critical for medical educators in Emergency Medicine, the majority of whom encounter medical students on clinical rotations during the latter part of the third year or the senior year. The critical need to remediate students prior to graduation may not be identified earlier, thus leaving this task up to EM faculty who teach students that have limited time remaining in their medical school experience.

LIMITATIONS

Our study is limited by its enrollment of students at a single institution and the relatively small number of students included. From 2010-2015, an average of 8.3% of our students matched into EM or combined EM residency programs, consistent with the national average of 8.5% of students matching into EM and suggesting a representative sample of EM-bound versus non-EM bound students.[33] While the majority of students take the USMLE step 1 at a similar period of time, students complete the required M4 EM rotation throughout their M4 year. The majority, but not all, of our students have also taken USMLE Step 2 prior to entering the M4 EM clerkship. This presents students with significant differences in both experience level and motivation. An additional potential source of error is the effect of rotation sequence and clerkship rotations selected during the M4 year. Previous studies have suggested that primary care rotations account for variance in USMLE scores and may represent significant content on USMLE Step 2, which is not emphasized on the National EM M4 exam. This may contribute to the slightly lower correlation between the national EM examination and USMLE Step 2. The correlation with USMLE Step 1 may more accurately reflect students' overall test-taking ability and inherent knowledge (as opposed to specific knowledge obtained on the EM clinical rotation).

Larger studies are necessary to further examine the correlation of the National EM M4 examination with USMLE Step 1 and Step 2 scores, thus increasing our confidence in the construct validity of the National EM M4 exam. And, future research should also focus on gathering information about the clerkship learning activities provided to prepare students for the examination and the remediation strategies utilized for struggling students.

CONCLUSION

Our study provides support for the validity of the CDEM National EM M4 Emergency Medicine examination as a means of assessing medical knowledge for fourth-year medical students on an EM clerkship. Future studies of examination performance should be designed to help identify students who can benefit from remedial efforts, and how

those efforts can best be structured.

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Simulation in Pre-departure Training for Residents Planning Clinical Work in a Low-Income Country

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Introduction: Increasingly, pediatric and emergency medicine (EM) residents are pursuing clinical rotations in low-income countries. Optimal pre-departure preparation for such rotations has not yet been established. High-fidelity simulation represents a potentially effective modality for such preparation. This study was designed to assess whether a pre-departure high-fidelity medical simulation curriculum is effective in helping to prepare residents for clinical rotations in a low-income country.

Methods: 43 pediatric and EM residents planning clinical rotations in Liberia, West Africa, participated in a simulation-based curriculum focused on severe pediatric malaria and malnutrition and were then assessed by survey at three time points: pre-simulation, post-simulation, and after returning from work abroad.

Results: Prior to simulation, 1/43 (2%) participants reported they were comfortable with the diagnosis and management of severe malnutrition; this increased to 30/42 (71%) after simulation and 24/31 (77%) after working abroad. Prior to simulation, 1/43 (2%) of residents reported comfort with the diagnosis and management of severe malaria; this increased to 26/42 (62%) after simulation and 28/31 (90%) after working abroad; 36/42 (86%) of residents agreed that a simulation-based global health curriculum is more useful than a didactic curriculum alone, and 41/42 (98%) felt a simulator-based curriculum should be offered to all residents planning a clinical trip to a low-income country.

Conclusion: High-fidelity simulation is effective in increasing residents' self-rated comfort in management of pediatric malaria and malnutrition and a majority of participating residents feel it should be included as a component of pre-departure training for all residents rotating clinically to low-income countries. [West J Emerg Med. 2015;16(7):1166-1172.]

INTRODUCTION

Pediatric and emergency medicine (EM) residents in the United States are increasingly interested in undertaking clinical rotations in low-income countries.[1,2] In response to this interest, the number of residency programs offering opportunities to work clinically in low-income international sites has grown significantly, resulting in more U.S. residents rotating to these settings than ever before.[3,4] The disease spectrum and available resources residents encounter in these settings are often vastly different from what they are accustomed to at their home training institutions. Thus, without additional training, residents may be ill prepared to function in these new environments. There are significant ethical considerations at stake in ensuring that U.S. residents working in low-income countries are competent in their practice there.[5] Consequently, the need for high-quality, competency-based, pre-departure training to prepare residents for practice in these international settings has been recognized.[6,7]

Despite this, few formal pre-departure curricula presently exist to prepare residents for clinical work in low-income countries.[4] One survey of pediatric residency programs offering global health electives revealed that only 36% of programs offered any type of pre-departure training for

their residents planning clinical work abroad.[8] Among those programs offering pre-departure training, there exists wide variability in the nature, duration and learning modalities employed in such training, and the optimal teaching methods for pre-departure training have not yet been established.[6,9]

At the same time, medical simulation is increasingly being used to help EM and pediatric residents gain knowledge, skills and comfort in situations they may have limited or no prior experience with, while allowing repetitive practice to occur in a safe environment without risk to patients.[10,11]

Simulation has a history of use in preparing learners to effectively manage stressful circumstances in foreign environments they have not previously encountered. It has been used effectively by the American military to prepare combat medics for the new and unfamiliar circumstances they encounter upon deployment abroad.[12] High-fidelity medical simulation is especially useful in pediatric EM given the relative rarity of severe childhood illness in the U.S. and other developed countries, limiting meaningful training opportunities for providers who care for acutely ill children.[13,14] It has been used effectively to train practitioners to handle rare but critical pediatric emergencies.[10,13,14] It follows that medical simulation has the potential to help residents preparing for clinical work in an unfamiliar, foreign country setting, managing pediatric diagnoses they have rarely, if ever, managed before.

To date, no pre-departure curriculum for residents planning clinical work in low-income countries has been published that incorporates the use of high-fidelity medical simulation. We hypothesized that a pre-departure global health curriculum incorporating the use of high-fidelity medical simulation would be effective in helping pediatric and EM residents improve comfort with specific pediatric emergencies commonly encountered during an international clinical elective in a low-income country yet uncommonly encountered within U.S. teaching hospitals.

METHODS

Simulation Curriculum Development

We developed two simulation cases for the pre-departure curriculum: a case requiring residents to diagnose and manage severe pediatric malaria and its sequelae and a case requiring residents to diagnose and manage severe pediatric malnutrition complicated by sepsis and hypoglycemia. These two topics were selected as the focus for the pre-departure simulation curriculum because of the relatively high frequency of emergent presentations of these diagnoses in West Africa, the region for which the pre-departure curriculum was designed, as well as the fact that most U.S.-trained residents were unlikely to have significant prior experience in managing these diagnoses at their home institutions. The simulation cases composing the curriculum and their respective learning objectives are described in Figure 1. We based learning objectives on World Health Organization (WHO) guidelines for acute treatment of severe malaria and severe malnutrition.[15,16]

We pre-programmed each simulation case using Laerdal SimBaby Scenario Editor software (Laerdal Medical Co, Wappingers Falls, New York), such that successful navigation of the case required performance of clinical tasks related to the learning objectives iterated in Figure 1. In addition to programming the cases, we created a content-standardized debriefing presentation on PowerPoint slides highlighting the learning objectives of each case.

Participants

All participants in this curriculum were EM or pediatric residents planning a four- to eight-week clinical elective at the John F. Kennedy Medical Center in Liberia, West Africa, through the Health Education and Relief Through Teaching (HEARTT) non-governmental organization (NGO). HEARTT is an NGO facilitating placement of EM and pediatric residents from a variety of U.S. teaching hospitals into clinical rotations in the emergency department and inpatient wards of the John F. Kennedy Medical Center. HEARTT organizes an annual two-day pre-departure workshop for residents planning to rotate clinically in Liberia. Our simulation curriculum was integrated into this pre-departure workshop for two consecutive years. The institutional review board of Boston Medical Center approved this study.

Procedure

Prior to participating in the simulation curriculum, all participants attended a 30-minute didactic lecture on malaria diagnosis and management and a 30-minute didactic lecture on malnutrition diagnosis and management. The content of these lectures reflected WHO guidelines regarding clinical management of these diagnoses. Participants were then given a five-minute orientation to the patient simulator and to the supplies and medications that would be available to them during the simulations. Next, participants were divided into teams of five to six residents. Each team participated in both of the simulations except where time constraints did not allow for this. When time did not allow all teams to participate in both simulations, as was the case for 23 participants, rather than participate in both simulations, each team would participate in one of the simulations and then watch the other simulation by closed circuit television. Irrespective of whether a team had participated in or watched a given simulation, they participated in the debriefing session following each simulation. Each simulation case ran for 10 minutes, followed by a 15-minute debriefing session.

For this program, the participants were restricted to using only those supplies and medications provided to them in the simulator room. These supplies and medications were selected based on what is actually available at the John F. Kennedy Medical Center in Liberia. The medications and supplies available were those typical of a regional hospital in West Africa.[17]

Figure 1. Clinical cases and learning objectives for simulations teaching residents how to treat malaria and pediatric malnutrition.

Malaria Case: 2y/o brought to Emergency Department in West African Hospital with 2d of fever and now unresponsive with seizures, pallor, scleral icterus and hepatosplenomegaly on exam.
Learning Objectives: 1) Recognize seizure with fever is a common presentation of severe malaria and should be treated with Diazepam PR or IV if status epilepticus. 2) Recognize hypoglycemia is common in severe malaria and should be checked for and corrected with D10W by IV. 3) Know that for patients with severe malaria, treatment with an effective antimalarial agent should be initiated without delay. Either Quinine IV or Artemether IM may be used. 4) Be aware that severe anemia is common in severe malaria and children with Hb <5 and clinical signs of impaired consciousness, heart failure, or shock should be transfused with whole blood. 5) Recognize that severe anemia may cause high-output heart failure characterized by gallop rhythm, enlarged liver and rarely, pulmonary edema. 6) Be aware that for patients presenting with altered mental status from presumed cerebral malaria, other treatable causes of coma should be addressed including hypoglycemia and bacterial meningitis. 7) Recognize that chloramphenicol with ampicillin, or ceftriaxone alone should be given empirically to patients in whom meningitis cannot be excluded. 8)Identify signs and symptoms of severe vs. uncomplicated malaria
Malnutrition Case: 14 month old with history of poor growth presenting with watery diarrhea x 2 weeks now acting lethargic w/ poor feeding and exam significant for severe muscle wasting and extremity edema presents to West African Hospital Emergency Department.
Learning objectives 1) Recognize that 02 supplementation is recommended for patients with severe malnutrition. 2) Recognize that severe malnutrition patients are at high risk for hypoglycemia and the preferred treatment is D10 bolus by nasogastric tube. 3) Be aware that severe malnutrition patients are at high risk for hypothermia and should be kept warm by wrapping in blankets +/- skin-to-skin contact with mother. 4) Recognize that severe malnutrition patients are at high risk for sepsis and that antibiotics, typically ampicillin and gentamicin, should be started early. 5) Be aware that IV fluid boluses should generally be avoided in patients with severe malnutrition as they are at high risk for heart failure. 6) Know that severe malnutrition patients are often dehydrated and the preferred initial treatment is Oral Rehydration Solution by nasogastric tube. 7) Identify signs and symptoms of severe malnutrition (kwashiorkor and marasmus)

Program Evaluation

The primary outcomes evaluated in this study were participant self-rated comfort in the diagnosis and management of severe malnutrition and its complications and self-rated comfort in the diagnosis and management of malaria and its complications. Secondary outcomes included participants' overall satisfaction with the curriculum, as well as learners' opinions regarding usefulness and applicability of the curriculum to real world situations.

We evaluated all of the above outcomes by the administration of written surveys at three specific time points: A pre-simulation survey was administered to participants after they had attended didactic sessions but prior to participating in the simulation cases. Immediately after participating in the simulation curriculum, a second, post-simulation survey was administered containing the same questions as the pre-simulation survey and some additional questions regarding the experience of the simulation. Thereafter, between one and 11 months after completing the simulation curriculum, residents would complete a four- to eight-week clinical rotation in Liberia, West Africa at the John F. Kennedy Medical Center. Upon their return from this rotation, residents were asked to complete a third and final post-trip survey. Participants were randomly assigned a subject number upon enrollment and identified only by this number thereafter in order to maintain survey anonymity. Participants were provided a $10 Starbucks gift card for completing the surveys. Funding for these gift cards was provided from internal divisional funds from the division of pediatric emergency medicine at Boston Medical Center. There was no other funding for this study.

RESULTS

Characteristics of curriculum participants are detailed in Table. Forty-three residents participated in this curriculum. Of these, 43 residents completed the pre-simulation survey, 42 of 43 (98%) completed the post-simulation survey, and 31 out of 43 (72%) completed the online post-trip survey. Residents travelled to Liberia from one month to 11 months after participating in the simulation curriculum with a median length of time elapsed between the simulation curriculum and

Table. Characteristics of curriculum participants.

Characteristic	Number of residents
Pediatric resident	17
Emergency medicine resident	26
Postgraduate year (PGY)	
PGY-1	0
PGY-2	2
PGY-3	37
PGY-4	4
Prior clinical work in a low-income country	
Yes	24
No	19

their trip of five months.

Of those participating, 41/42 (98%) agreed with the statement "The simulations were a positive learning experience;" 36/42 (86%) agreed with the statement "A simulation-based global health curriculum is more useful than a didactic curriculum alone," and 41/42 (98%) agreed with the statement "A simulator-based curriculum should be offered to all residents planning a clinical trip to a developing country." Further, 28/31 (90%) residents agreed: "I was able to directly apply knowledge I learned in the simulator while abroad."

The proportion of residents who agreed with the statement "I am comfortable with the diagnosis and management of severe malnutrition and its complications in children" after the didactic curriculum but prior to the simulation was 1/43(2%). After the simulation, 30/42 (71%) of participants agreed with this statement. After returning from clinical work in Liberia, 24/31(77%) agreed with this statement (Figure 2).

The proportion of residents who agreed with the statement "I am comfortable with the diagnosis and management of malaria and its complications in children" after the didactic curriculum but prior to the simulation was 1/43(2%). After the simulation 26/42 (62%) of participants agreed with this statement. After returning from clinical work in Liberia, 28/31(90%) agreed with this statement (Figure 2).

DISCUSSION

Our study demonstrates that high-fidelity medical simulation improves pediatric and EM residents' comfort in the diagnosis and management of pediatric malaria and severe malnutrition when incorporated into a pre-departure global health training. Malaria and malnutrition are both diagnoses U.S. residents are unlikely to have significant prior exposure to during their training, and yet the ability to manage these diseases competently while practicing in a setting such as West Africa or other malaria endemic area with high pediatric malnutrition rates is critical. The AAP Committee on Global Child Health has highlighted requisite preclinical training and adequate pre-trip preparation as critical components of a global health curriculum.[18] A survey of faculty directors of pediatric residency program global health tracks found that pre-trip preparation represents one of the most important strategies to alleviate the burden rotating residents place on global health partner institutions abroad.[9] Our study suggests that high-fidelity simulation should be a key part of high-quality pre-departure global health training with 98% of participants in our curriculum endorsing the statement that a simulator-based curriculum should be offered to all residents planning a clinical trip to a developing country.

While medical simulation has been used previously to successfully train clinicians in the management of malaria, such training was not targeted at improving comfort for practice in a low-income country setting.[19] To our knowledge, our curriculum is the first time simulation has been used to help residents prepare to treat this diagnosis as well as pediatric malnutrition and its sequelae in the low-income country hospital setting.

Our study limited groups of participants to teams of a maximum of six residents, which is, in general, the largest-sized team generally participating in other simulation studies.[13] A disadvantage to medical simulation is that there is a limit to the number of learners who can be in the simulator suite at any one time. In our study, due to time constraints, in some cases, not every resident was able to directly participate in both the malaria and the malnutrition simulation and some only had the opportunity to participate directly in one of the simulations while watching the other simulation by closed circuit television, an arrangement that has been used in other simulation studies.[20] Of note, when this subgroup was analyzed, the same benefit was observed in participants who watched a given simulation via closed circuit TV as for those who participated directly in the simulation, though the numbers were small and the study was not designed or powered to specifically address this question. Prior studies do corroborate this, however, and suggest that the learning benefit of simulation is not limited to those directly in the simulator room.[19] As residents' time is often quite limited and there is much to cover during pre-departure training, the notion that watching a simulation can have similar benefit to direct participation may represent a means to engage a greater number of learners in simulation learning without requiring additional curriculum time.

Over half of the participants in our simulation curriculum reported prior clinical experience in a low-income country setting. Thus, many of the participants in our study may have already been familiar with the types of diagnoses this curriculum focused on, though we did not query the specific country in which they had worked and thus they may not have had direct prior experience with pediatric malnutrition and malaria.

The high-proportion of residents with prior experience in low-income country settings participating in our curriculum is unsurprising, as prior work has established that a major predictor of interest in clinical work in low-income countries

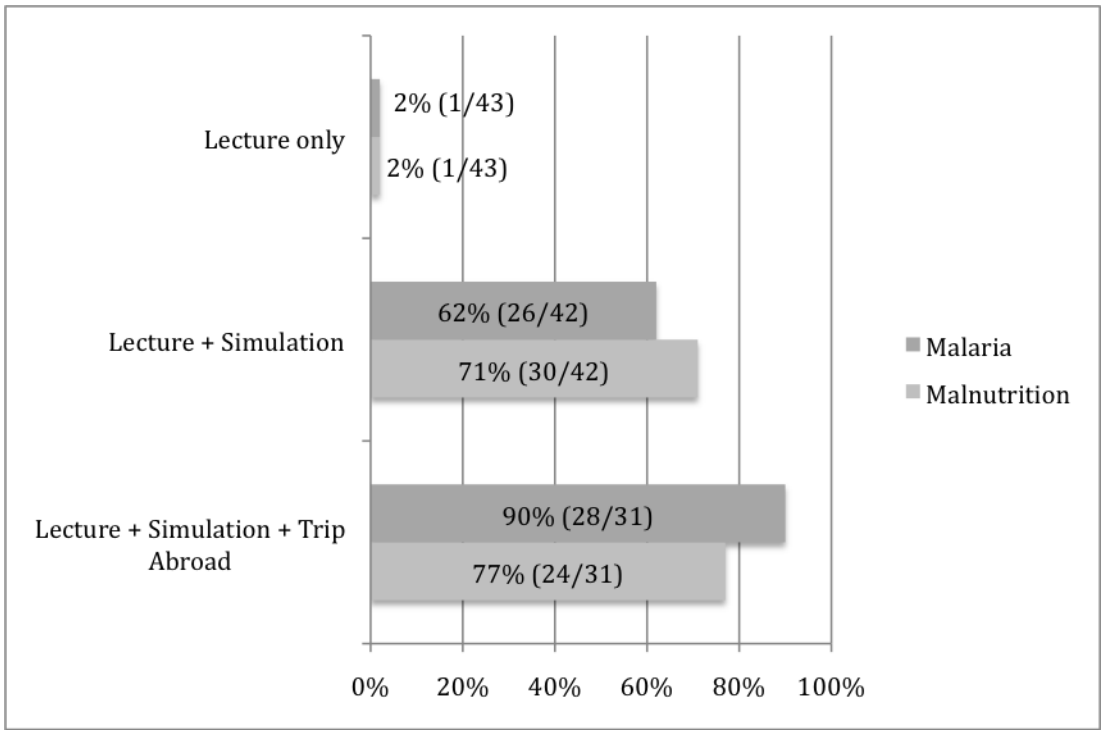

Figure 2. Proportion of residents agreeing with the statement "I am comfortable in the diagnosis and management of malaria (dark grey) or malnutrition (light grey) and their complications, surveyed at different time points.

in the presence of prior experience in such settings.[21] Therefore, it is likely that for any pre-departure curriculum, a sizable portion of participants will come to the curriculum with some degree of prior clinical experience in low-income country settings. Yet, even among participants with prior experience in low-income countries, the nature and location of such experience is highly variable and prior experience in a low-income country which is, for example, malaria endemic, compared to experience in a non-endemic country likely impacts comfort with this diagnosis. Furthermore, clinical experience in an observational capacity versus that in the capacity of a direct clinical care provider likely portends different levels of subsequent comfort with disease management. Even with prior direct experience with the diagnoses of malaria and malnutrition, residents who are training in the U.S. are infrequently encountering tropical medicine diagnoses in their everyday practice and comfort may decline over time. For such learners, a "refresher" experience in the simulator lab may be of very great value.

This project focused on acute presentations of disease in children. EM residents, in general, have less experience with treating children than pediatric residents. Pediatric residents, in general have less experience in treating medical emergencies as compared to EM residents. In subgroup analysis for our curriculum, there was no significant difference in the relative increase in self-rated comfort for pediatric as compared to EM residents, suggesting that both groups can benefit from increased practice in managing high acuity pediatric cases.

LIMITATIONS

This study had several limitations. As the primary metric for assessment was learner self-rated comfort and knowledge as assessed by survey, it is not clear from our study that the increase in learners' comfort regarding malaria and malnutrition management actually translates to changes in behavior. The question as to whether participation in this curriculum actually resulted in improved care and better outcomes for pediatric patients with malnutrition and malaria in Liberia was not directly addressed by this study. The surveys used to assess participants self-rated comfort and rating of the curriculum's overall utility were not pre-validated which could have provided greater credulity to our survey's findings.

Furthermore, our study did not include a control group that did not receive any high-fidelity simulator training for comparison. All residents participating in our pilot did receive a 30-minute didactic session on diagnosis and management of malaria and another 30-minute didactic on diagnosis and management of malnutrition. It was only after receiving these lectures that residents completed the first pre-simulation questionnaire. At that point, only 2% reported they were comfortable in the diagnosis and management of malnutrition and the diagnosis and management of malaria, respectively. Therefore, it seems that simulation is able to add considerably to a didactic curriculum. However, a control group who did not receive any simulator training at all was not employed in the study.

The simulation cases used in this study were created *de novo* by the authors using WHO guidelines for reference.

Pre-existing, peer-reviewed simulation cases addressing the topics covered in this study were not publicly available. Such previously vetted simulation cases could potentially provide greater validity to the appropriateness and accuracy of the curriculum in mitigating the bias that exists in having the study authors also serve as the curriculum developers.

Future studies should examine the effect of simulation-based curricula on residents' actual behaviors in their practice in international settings, as well as examine whether these behaviors indeed result in better outcomes for patients.

CONCLUSION

The development of highly effective pre-departure clinical training for U.S. residents planning rotations in developing countries is critical. Our study found that residents planning clinical rotations in Liberia, West Africa, felt more comfortable in the management of pediatric malaria and malnutrition after a curriculum addressing these diagnoses that incorporated high-fidelity simulation. Participating residents felt strongly that simulation should be a part of pre-departure training offered to all residents. It is critical that we continue to study what type of pre-departure training best prepares residents for work abroad as we owe it to our global health partner sites to send residents who are well prepared to work in their setting, under proper supervision, and we are obliged to make sure our residents who are going to such settings feel as comfortable and safe as possible in their clinical practice there. Crucial to developing such curricula is knowledge of the available resources, common disease entities, setting-specific guidelines and standards of practice in the destination country. Low-income countries can vary greatly in the disease spectrum and available resources they have and selection of a pre-departure curriculum should take these differences into account.

Our study of a simulation-based pediatric malaria and malnutrition curriculum for residents planning clinical work in West Africa suggests that simulation has significant potential as an important component of pre-departure training for residents planning clinical work abroad.

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Posterior Reversible Encephalopathy Syndrome (PRES) After Acute Pancreatitis

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Posterior reversible encephalopathy syndrome (PRES) is an unusual condition typified by acute visual impairment caused by sudden, marked parieto-occipital vasogenic edema. Thought to be inflammatory in origin, it has been described in patients undergoing chemotherapy, with autoimmune disease, and in some infections. We report a case of PRES that occurred one week after an episode of acute pancreatitis in an otherwise healthy 40-year-old female. There was progressive visual impairment over a 24-hour period with almost complete visual loss, with characteristic findings on magnetic resonance imaging. After treatment with steroids, the visual loss recovered. Clinicians should retain an index of suspicion of this rare condition in patients with visual impairment after acute pancreatitis. [West J Emerg Med. 2015;16(7):1173-1174.]

INTRODUCTION

A 40-year-old female presented to our emergency department with sudden visual loss over a 24-hour period. She was otherwise healthy, but had been admitted two weeks previously with an episode of acute pancreatitis secondary to alcohol intake from which she had recovered uneventfully, and without any obvious sequelae. An urgent magnetic resonance imaging (MRI) scan was performed. This revealed symmetrical areas of hypoattenuation in both posterior parieto-occipital and cerebellar regions (Figures 1, 2). She was seen by a neurologist and diagnosed with posterior reversible encephalopathy syndrome (PRES). After a two-month course of steroids she had almost complete resolution of her vision and the radiological changes had improved.

DISCUSSION

PRES is extremely rare, and usually diagnosed by a history of sudden visual impairment in the presence of specific radiological changes on MRI. Bilateral symmetrical hypodensitities in the parieto-occipital areas and cerebellar hemispheres on imaging are characteristic. The condition has been associated with chemotherapy,

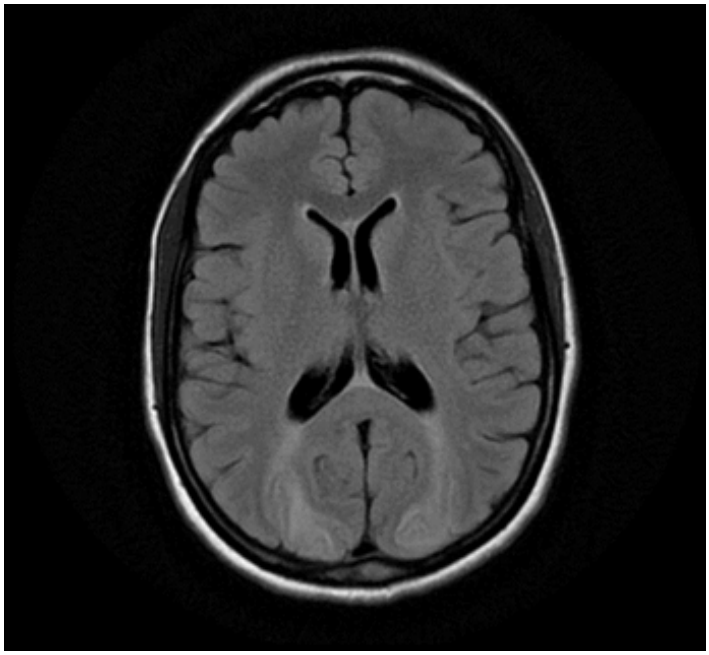

Figure 1. Magnetic resonance imaging scan showing symmetrical areas of increased signal in the occipital lobes (T2 and FLAIR sequences).
FLAIR, fluid-attenuated inversion recovery

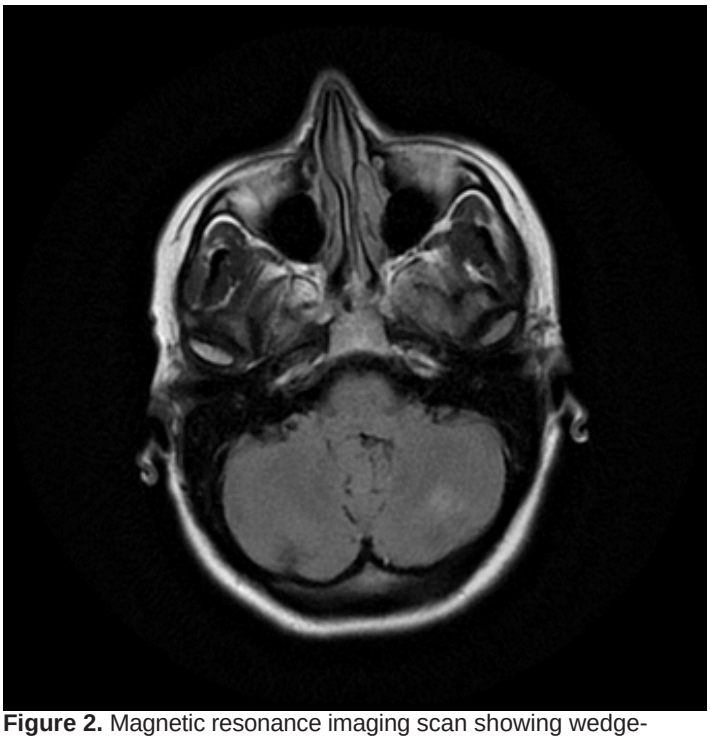

Figure 2. Magnetic resonance imaging scan showing wedge-shaped area of increased signal in the left cerebellar hemisphere (T2 and FLAIR sequences).
FLAIR, fluid-attenuated inversion recovery

hypertension, infection and autoimmune disease.[1]

It is thought to occur from temporary impairment of the blood brain barrier causing vasogenic edema with symptoms of reduced consciousness, seizures, headaches, and typically visual problems.[2] Around 26-67% of patients with PRES present with visual symptoms of blurred vision, visual neglect, homonymous hemianopsia, hallucinations or cortical blindness.

Our case is unusual, as PRES caused by pancreatitis has only been reported in very sick patients with other comorbidities. It probably occurred in this case as a result of the systemic inflammatory response.[3,4,5,6]

Whilst pancreatitis itself can be life threatening, this case reminds clinicians of unusual complications that can occur after discharge of patients who seem to have recovered from the disease.

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Posterior Scleritis with Inflammatory Retinal Detachment

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A 14-year-old African American male presented to the emergency department with worsening left eye redness, swelling, and vision loss over the preceding three days. History was notable for similar eye redness and swelling without vision loss four months earlier, which improved following a brief course of prednisone. He endorsed mild eye irritation and tearing with bright lights. There was no history of fever, respiratory symptoms or trauma. Mother was medicating patient with leftover antibiotic eye drops x3 days without improvement. Physical examination on presentation notable for proptosis of left eye, lid, and periorbital swelling, mild scleral injection, and central vision loss in affected eye (20/200 OS, 20/25 OD). Extraocular movements and pupillary exam were normal. No corneal fluorescein uptake, abnormal cell, flare, or siedel sign were seen during slit lamp exam. Eye pressures were 24 mmHg in both eyes. Bedside ultrasonography was performed (Figure 1 showing retinal detachment, Ultrasound Video 2 showing detachment in orbital scan). [West J Emerg Med. 2015;16(7):1175-1176.]

DIAGNOSIS

Posterior Scleritis with Inflammatory Retinal Detachment

Scleritis is a potentially sight-threatening underdiagnosed inflammatory disease affecting the sclera of the eye.[1] Of the five categories of scleritis described by the Watson System (diffuse anterior, nodular anterior, necrotizing anterior without inflammation, necrotizing anterior with inflammation, and posterior scleritis), posterior scleritis is the most rare, accounting for only 2% to 12% of all cases. Because the average age of patients with posterior scleritis is 45 to 49 years, posterior scleritis in children is even rarer.[2-4] The ophthalmic literature consists of predominantly single case reports. Scleritis can be the first symptom of an onset of connective tissue systemic diseases, but in children often no systemic association is found.[1]

Decreased vision can be a presenting sign, although normal vision can still be present. Other symptoms include, but are not limited to, periocular pain, headache, and pain with extraocular movement.[3] Signs of physical examination may include concurrent ciliary or conjunctival injection, anterior uveitis, disc swelling, serous thickening, detachment of the retina, retinal striae, proptosis, and limitation of extraocular motility.[1]

Diagnosis is typically arrived at using a combination

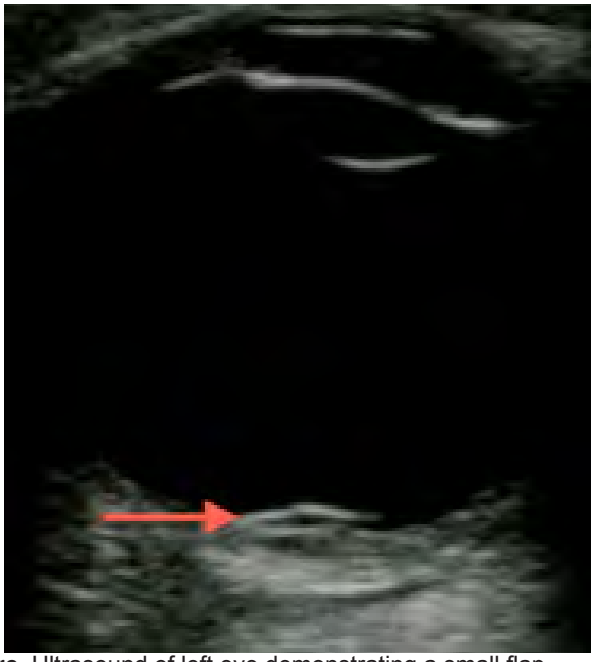

Figure. Ultrasound of left eye demonstrating a small flap irregularity on posterior retina near optic nerve indicating the retinal detachment (red arrow).

of clinical features and demonstration of scleral thickening (T-sign) on B-scan ultrasonography (tool used by ophthalmologists). Our patient underwent an optical coherence tomography scan confirming serous detachment over the macula.

First-line treatment includes topical steroid and oral nonsteroidal anti-inflammatory drugs. Systemic corticosteroids are added if first-line therapy is ineffective, and are adjusted to clinical response. Secondary immunosuppressive agents are sometimes used if symptoms are not adequately controlled. Long-term suppression is often required to prevent recurrence, and visual outcome is favorable.[1]

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Video. Video of retinal detachment. Scan of left eye showing the retinal detachment, with audio commentary.

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A Massive Overdose of Dalfampridine

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Multiple sclerosis (MS) is an immune mediated inflammatory disease that attacks myelinated axons in the central nervous system. Dalfampridine (4-aminopyridine) was approved by the Food and Drug Administration in January 2010 for treatment of MS. Our patient was a 34-year-old male with a history of MS, who was brought to the emergency department after being found unresponsive. His current medications were valacyclovir, temazepam, dalfampridine (4-AP) and a tysabri intravenous (IV) infusion. Fifteen minutes after arrival the patient seized. The seizures were refractory to benzodiazepines, barbiturates and phenytoin. The 4-AP level was 530ng/mL (25ng/mL and 49ng/mL). The patient stopped seizing on hospital day 3 and was discharged 14 days later with normal mental status and neurologic exam. 4-AP is a potassium channel blocker that blocks the potassium ion current of repolarization following an action potential. The blockade of the potassium channel at the level of the membrane widens the action potential and enhances the release of acetylcholine, thus increasing post-synaptic action potentials. The treatment of patients with 4-AP overdose is supportive. Animal data suggest that patients with toxic levels of 4-AP may respond to phenytoin. Our case illustrates the highest recorded level of 4-AP in an overdose. Our patient appeared to be refractory to a combination of high doses of anticonvulsants and only improved with time. [West J Emerg Med. 2015;16(7):1177-1179.]

INTRODUCTION

Multiple sclerosis (MS) is an immune-mediated inflammatory disease that attacks myelinated axons in the central nervous system. It is characterized by short-term episodes of neurologic deficits that usually resolve completely or almost completely. Patients with MS may suffer from pain due to spasticity, fatigue and progressive disability.[1] There is currently no cure for the disease, but a plethora of treatments are available and are continuously being developed.

One of the more novel medications on the market is dalfampridine, or 4-aminopyridine (4-AP). 4-AP was originally developed to be used as an avicide. The chemical was studied in mammals and was shown to cause hyperexcitability, hypersalivation, tremors, muscle incoordination, convulsions, cardiac or respiratory distress.[2]

4-AP acts as a voltage-gated potassium channel blocker that blocks the potassium ion current of repolarization in an axon following an action potential. Potassium efflux out of the axon is the ionic mechanism that results in repolarization of the axon. Repolarization must occur before the axon can generate another action potential. In MS, the myelin sheath is thinned and this results in either a weakened signal when the action potential reaches its destination or a complete block. This leads to weakness and fatigability of strength.[3] The blockade of the potassium channel widens the action potential, and thus 4-AP increases the conduction of action potentials and this leads to increased strength.[2] Due to the ability of 4-AP to reverse synaptic blockade it has been used as a treatment in many different neuromuscular disorders such as Alzheimer's disease, botulism, Eaton Lambert syndrome and multiple sclerosis.[4] In January 2010, 4-AP was approved by the FDA in the United States under the name dalfampridine to help patients with MS improve their gait and strength when walking.[5]

There are always new medications being developed for the treatment of MS, a disease with many potential comorbidities; among them, depression is the most notable.

This occurs in part because MS is a chronic disease and also there are theories that it occurs because of frontal or subcortical white matter disease.[6] Here we present a case of a 4-AP overdose with the highest reported level in the literature.

CASE REPORT

A 34-year-old male with a past medical history of MS was brought into the emergency department by Emergency Medical Services after being found unresponsive by his mother with three pill bottles at his side. The bottles were an empty bottle of valacyclovir, an empty bottle of temazepam and a bottle of dalfampridine still containing some pills. His mother gave the history that the patient was under multiple social stressors of late. Other than MS, the patient was diagnosed with insomnia and had no other pertinent past medical history. His current medications were valacyclovir, temazepam, dalfampridine (4-AP) and a tysabri IV infusion (all part of his MS treatment regimen).

The initial vital signs were as follows: Blood pressure: 155/82mmHg; Heart rate: 106/min; Respiratory rate: 24/min; Temperature: 97.4°F; O_2 sat: 97% 2L NC. The bedside glucose was 144mg/dl. The patient appeared extremely tremulous, was awake, but not responding to questioning nor following simple commands. He responded to tactile stimulation by localizing to the pain. He did not appear to have any focal deficits. His pupils were 4 mm, equal and reactive and his mucous membranes were moist. His heart sounds were tachycardic, with no murmurs. The patient had clear breath sounds bilaterally and no retractions. The abdomen had normoactive bowel sounds. The skin was diaphoretic with piloerection.

Intravenous access was established, labs were drawn and the patient was given two liters of normal saline. Soon after arrival, the patient lost consciousness, his oxygen saturation decreased to below 90% and he began to have a tonic-clonic seizure. The patient was administered boluses of lorazepam, to a total of 8 mg, without effect in seizure resolution. He was intubated and subsequently placed on a lorazepam and propofol infusion for sedation. He was loaded with one gram of phenytoin and 300mg phenobarbital and then placed on a phenobarbital infusion. Clinically the patient continued to have frequent, recurrent seizures.

The patients lab values on arrival were significant for a white blood cell count of 31.1×10^3/mcL, a sodium of 143mEq/L, potassium 3.1mEq/L, chloride 107mEq/L , bicarbonate of 24mEq/L, a blood urea nitrogen of 15mg/dL and a creatinine of 1.2mg/dL. The anion gap was 12. The lactic acid was 3.4mg/dl. Total creatinine kinase was 99 units/L. Liver function tests and coagulation studies were all within normal limits. Ethanol, acetaminophen and salicylate levels were all negative. A urine toxicology screen was positive for benzodiazepines. An arterial blood gas showed pH 7.22, pCO_2 65, pO_2 127 and HCO_3 26.6 (performed immediately after intubation). Computerized tomography of the brain and chest x-ray were both normal. The electrocardiogram showed a sinus rhythm at 88 beats per minute with normal QRS and QT intervals. Drug levels were sent for 4-AP and valacyclovir. The 4-AP level resulted at 530ng/mL (therapeutic: 25 to 49ng/mL). The valacyclovir level was 7.5mcg/mL (therapeutic 2.0-4.0mcg/mL).

The patient was admitted to the intensive care unit (ICU) and while he was there he continued to have seizures. While in the ICU the patient had two electroencephalographs (EEGs) performed. The EEG on hospital day 2 showed epileptiform activity and the other EEG was performed on hospital day 7 and was indicative of epileptiform encephalopathy.

The patient stopped seizing on hospital day 3. The patient was extubated on hospital day 12. He was discharged, with normal mental status and neurologic exam to an inpatient psychiatric facility.

DISCUSSION

Due to the fact that 4-AP is not a commonly used medication, not much is known about how it acts at toxic levels in humans. Van Diemen et al. looked at the dosage and serum level related to efficacy and safety. During this study a maximum daily dose of 0.5mg/kg body weight was not surpassed in any patient. Patients in this study experienced dizziness, paresthesias and restlessness at levels approaching 0.5mg/kg. No patient in the study had a seizure, as the level at which seizures usually occur is 0.8mg/kg body weight.[7]

4-AP acts as a potassium channel blocker that prolongs the action potential, thus increasing neuromuscular activity. It is theorized that the increase in neuromuscular activity is therapeutic at appropriate levels, but that the same mechanism causes adverse reactions at elevated levels.[8] The adverse reactions are not only of the central nervous system, but also include injury to the cardiac and skeletal muscle. One study showed that 4-AP toxicity could result in permanent damage to the hippocampus and Papez circuit affecting memory and learning.[9]

The 4-AP level of our patient resulted at 530ng/mL. Until now, the highest documented 4-AP level published was 233.6ng/mL.[10] In that case, the patient was treated with lorazepam boluses and the seizures subsided, as opposed to our patient who was refractory to treatment with multiple anti-convulsant medications. The valacyclovir level was also elevated and valacyclovir itself can be associated with neuropsychiatric symptoms. Seizures associated with valacyclovir are not well reported in the literature, and the few case reports on valacyclovir associated seizures are in patients with renal failure, which our patient did not have.[11,12]

The current treatment of 4-AP overdose is supportive. Animal data suggests that patients with 4-AP toxicity will respond to phenytoin. It is hypothesized that because phenytoin acts as a sodium channel blocker it will inhibit action potentials from continuing.[9] A study by Yamaguchi et al.[13] showed that treatment of mice with elevated levels of 4-AP with gamma butyric acid (GABA) was comparable to other phenytoin-like therapies. Our patient did not respond to

treatment with phenytoin. This raises the question of whether or not a second phenytoin load should be used, or additional anti-convulsants that have a similar mechanism of action to phenytoin should be added.

Using phenytoin to treat seizures secondary to 4-AP is an important concept because phenytoin is not usually part of the algorithm for the treatment of toxin-induced seizures. The recommendation for treating an undifferentiated toxin-induced seizure is to use a benzodiazepine or barbiturate, then pyridoxine and finally propofol.[14] Toxin-induced seizures differ from seizures from other causes because they usually occur due to a global lowering of the seizure threshold in previously normal neurons, whereas seizures due to epilepsy occur in a focal lesion of abnormal neurons. Phenytoin is effective for patients with idiopathic seizure disorders or with defined structural or electrical foci of seizure activity, as phenytoin prevents the propagation of seizures (include reference). There are many reports of phenytoin used in toxin-induced seizures causing clinical detriment to the patient.[14]

This case illustrates the highest recorded level of 4-AP in an overdose. Optimal therapy for this overdose is unknown. Our patient appeared to be refractory to a combination of high dose intravenous benzodiazepines, phenytoin, propofol and phenobarbital and only improved with time.

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More Than Just an Abscess: Ultrasound-Assisted Diagnosis of Ventriculoperitoneal Shunt Infection

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A 60-year-old female with a history of ventriculoperitoneal shunt (VPS) placement three years prior presented with a painful abdominal wall mass. The patient denied fevers, nausea, vomiting, headaches, or dizziness. Physical exam revealed an afebrile, well-appearing female with a raised, erythematous, fluctuant mass on the right lower abdominal wall. She had no abdominal tenderness otherwise. Labs were unremarkable. A bedside ultrasound revealed a complex fluid collection over the area of fluctuance that tracked along the course of the VPS tubing into the abdomen. Plan for incision and drainage was deferred. Neurosurgery was consulted. The neurosurgeon attempted to tap the shunt but encountered very high resistance. The patient was admitted for intravenous antibiotics for VPS infection and malfunction.

VPSs are neurosurgically implanted devices used to treat hydrocephalus by shunting cerebral spinal fluid from the lateral ventricles of the brain into the peritoneum. Shunt infections, including meningitis, ventriculitis, and peritonitis, occur in 2-17% of VPS cases.[1-3] Clinicians should maintain a high index of suspicion for VP shunt complications in patients who present with typical symptoms suggestive of increased intracranial pressure. In this case, a less obvious complication such as an abscess in an atypical location lowered the practitioner's threshold for bedside imaging and further investigation.

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Video. Circumferential fluid collection surrounding ventriculoperitoneal shunt (white arrow).

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Computed Tomography Following Body Stuffing Heroin

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CASE

A 37-year-old male presented to the emergency department (ED) in police custody for "medical clearance" before being taken to jail. The patient was approached by police officers for suspicion of selling illicit drugs. When approached by police he ran away and was witnessed to swallow several small plastic baggies suspected to contain heroin. He was apprehended and brought to the ED. On arrival, he was asymptomatic with a blood pressure 144/83mmHg, heart rate 67bpm, respiratory rate of 19bpm, oxygen saturation of 99% on room air and afebrile. A Glasgow coma score was 15 and he was alert and oriented to person, place and time. Patient had a negative review of systems. On physical examination pupils were 4mm and reactive to light, lungs clear to auscultation and had normal respiratory rate with normal cardiovascular exam. Abdomen was soft, non-tender and non-distended with present bowel sounds. The patient admitted to ingesting approximately 20 packets of heroin to avoid being charged with possession. The patient declined activated charcoal and whole bowel irrigation (WBI) with polyethylene glycol-electrolyte solution (PEG-ELS). The patient declined a urine toxicology immunoassay screen. A computed tomography (CT) of his abdomen with contrast was obtained and read as normal except for a cluster of foreign bodies within the distal stomach likely contained within a plastic bag (Figures 1 and 2).

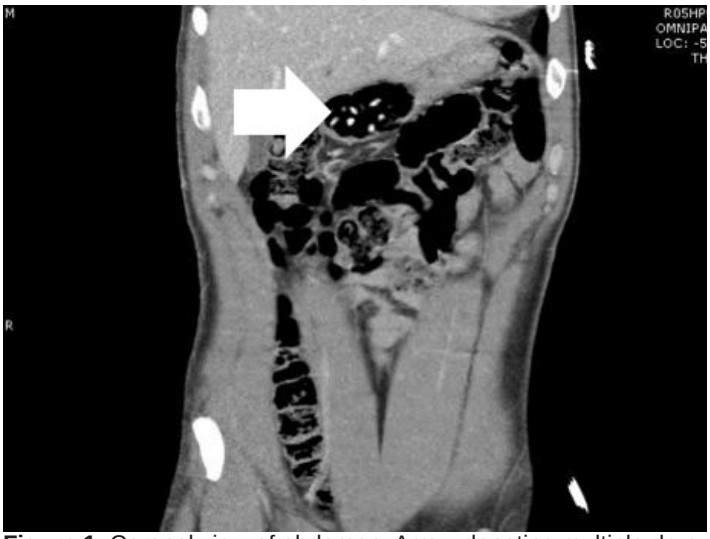

Figure 1. Coronal view of abdomen. Arrow denoting multiple drug packets in distal stomach.

DISCUSSION

Ingesting illicit substances generally falls into two broad categories: "body packing" where illicit substances are deliberately ingested as a means for transporting illicit drugs, and "body stuffing."[1,2] Body stuffing as in case presented is hastily ingesting drugs as means of evading possession charges from law enforcement. The major differences between body packing and body stuffing are the amount ingested, which is usually a large amount with body packing and also the wrapping of the illicit substance itself. With body packing the illicit drug is usually well wrapped often with double layers of condoms or balloons to prevent inadvertent rupture of the packets.[1,2] As body stuffing is not usually pre-planned, the packets are often poorly wrapped and contained in the plastic baggies measured out in the amount by which they are generally sold. As such, body stuffers can be at increased risk for acute poisonings compared to body packers. Body packers may present with bowel obstruction.[1] However, due to the large amount of drug contained in body packers, if they do rupture it can be fatal, particularly with cocaine or methamphetamine.[1] The patient presented ingested heroin by history. Heroin is somewhat easier to manage; if the patient had developed respiratory depression the opioid-specific reversal agent naloxone would have been administered, including continuous naloxone infusion.[1] Plain abdominal radiographs are often negative following body stuffing and even packing, and as such a negative radiograph

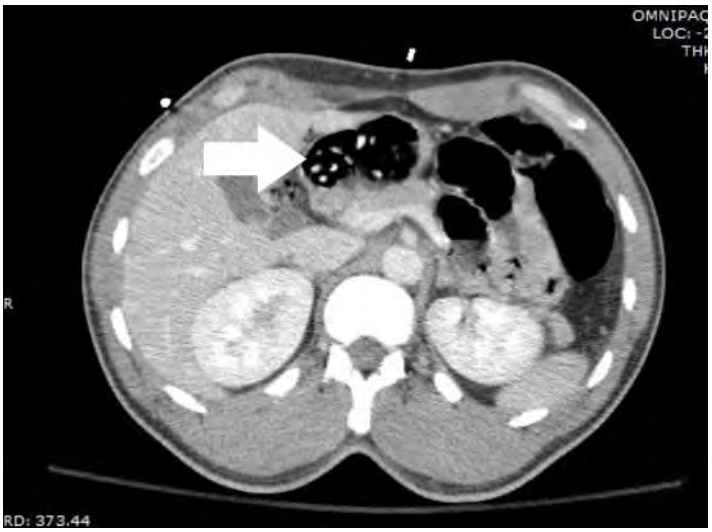

Figure 2. Axial view identifying multiple drug packets (arrow).

cannot exclude ingestion particularly with smaller number of packets ingested.[1,2] Multi-detector CTs are much better at detecting drug packets than conventional radiology with a reported sensitivity and specificity of 95 to 100% but may not detect all packets.[2,3] Consideration of CT abdominal imaging can be considered following plain abdominal radiographs, particularly if negative and high clinical suspicion. Anticipation of clinical signs of toxicity should be monitored for, as there may be a delay in the onset of toxicity from late opening of ingested packets. The role of WBI with PEG-ELS is better described with body packers than body stuffers but was considered in this case based on the large amount of packets ingested.[1,3] Activated charcoal also may have a role with the goal of binding up leaking contents of packets before they reach systemic circulation.[1] In patients who remain asymptomatic the general recommendation is to allow spontaneous passage.[1] He was admitted to a monitored setting and observed until the packets were passed in the stool. The patient remained asymptomatic throughout his hospital course and was discharged to jail.

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Primary Epiploic Appendagitis

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A previously healthy 27-year-old man presented to the emergency department with a three-day history of left lower quadrant pain. He denied fever, nausea, vomiting, or diarrhea. Vital signs were unremarkable, and physical examination revealed tenderness in the left iliac fossa without peritoneal signs. His leukocyte count and C-reactive protein were slightly elevated. On abdominal computed tomography (CT) (Figure), a fatty ovoid mass abutting sigmoid colon demonstrated the infarcted or inflamed appendix epiploica. A surrounding hyperdense rim (hyperattenuating ring sign) represented the inflamed visceral peritoneal covering, and the central linear hyperdensity corresponded to the thrombosed central vessel.[1] The patient was treated with pain control and intravenous hydration, and was discharged uneventfully five days later.

Epiploic appendages are fat-filled, serosa-covered, pedunculated structures located on the antimesenteric border of the colon. These structures are between 1–2cm thick, 0.5–5cm long, and the size and number increase in the lower abdominal quadrants (57% in the rectosigmoid junction and 26% in the ileocecal region).[1,2] Primary epiploic appendagitis is an acute ischemic inflammation, resulting from torsion of an appendage or spontaneous thrombosis of a central draining vein.[1,2] Patients may experience an abrupt onset of non-migratory, localized pain in the lateral lower quadrants, that worsens with cough and abdominal stretching. Depending on the location of the inflammation, the symptoms may mimic those of acute appendicitis or diverticulitis.[1] Careful clinical examination and appropriate use of noninvasive imaging studies, including CT or ultrasound, helps in the correct diagnosis preoperatively. Epiploic appendagitis is usually a self-limited illness that can be managed conservatively with pain control.[1,2] Prompt and accurate diagnosis can avoid

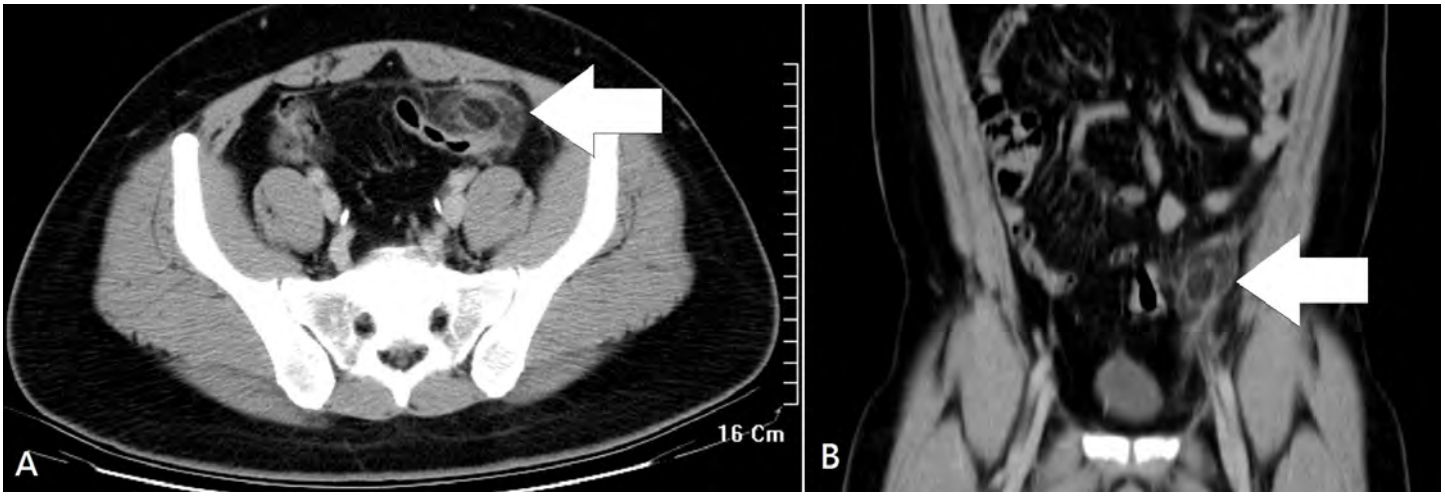

Figure. A) Axial and B) coronal abdominal computed tomography showed a pericolonic oval mass (arrow) with a hyperattenuating rim and surrounding fat stranding. A central hyperdense linear lesion corresponded to the thrombosed draining vein.

unnecessary surgical intervention.

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An Unusual Case of Angiotensin-Converting-Enzyme Inhibitor-Related Penile Angioedema with Evolution to the Oropharynx

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A 52-year-old African American male with a long history of poorly controlled hypertension presented to the emergency department (ED) with two days of genital edema and pain. During ED work-up, the patient developed sudden onset of non-pitting, non-pruritic, and non-urticarial upper lip edema. Review of his antihypertensive medication list revealed that he normally took benazepril, highly suggestive of a diagnosis of angiotensin-converting-enzyme inhibitor-related angioedema (ACEI-RA). We present the first reported case of penile ACEI-RA that progressed to involve the oropharynx. The ED management of the condition and some of the newer treatment options available for ACEI-RA is also briefly discussed. [West J Emerg Med. 2015;16(7):1185-1187.]

INTRODUCTION

Angioedema, one of the true airway emergencies, is a non-pitting, often asymmetric swelling of subcutaneous or submucosal tissues. Typically isolated to an oropharyngeal distribution, it can also affect the gastrointestinal tract, extremities, and genitalia.[1] Angiotensin-converting-enzyme inhibitor-related angioedema (ACEI-RA) is the most common type of angioedema and can occur in both long- and short-term use of angiotensin-converting-enzyme inhibitor (ACEI) medications.[1] Though ACEI-RA is well-described in the literature and not a rare disorder, angioedema of the penis has only been reported in three previous publications (four total cases overall).[2-4] In each case, the symptoms were isolated to the genitalia without additional sites of involvement. Here we present the first known case of a patient with delayed-onset ACEI-RA that was initially isolated to the genitalia with evolvement to the oropharynx, and discuss possible etiologies and treatment options for emergency department (ED) management.

CASE REPORT

A 52-year-old African-American male with a past medical history of poorly controlled hypertension (due to intermittent medication compliance), alcohol abuse, and alcohol withdrawal was referred to the ED for two days of penile and scrotal edema and pain. The patient stated that he noted the non-pruritic, non-erythematous diffuse genital swelling two days prior, but had delayed seeking treatment as he assumed it would self-resolve. Due to increasing pain, he visited his primary care practitioner (PCP), who then immediately referred him to the ED for further evaluation. On interview, he denied recent sexual intercourse, allergies to latex/condoms, penile rings, painful erections, lotions or creams applied to the genital area, traumatic sexual injuries, penile discharge, or history of sexually transmitted infections. Additionally, the patient also denied any other new exposures, known allergies, history of similar symptoms that would suggest angioedema to the face, extremities, or genitals, or a family history of recurrent angioedema. The patient stated that he only knew the name of two of his five prescribed antihypertensive agents, hydrochlorothiazide and benazepril, both of which he had taken for at least 10 years. His benazepril dose had recently been increased from 20mg to 40mg, but he admitted to not taking any of his anti-hypertensive medications on the day of his ED visit. He also disclosed a daily average alcohol intake of "one gallon of vodka per day" and had consumed one pint that morning. A review of systems was negative for any other complaints, including fevers, chills, dysuria, hematuria, urinary retention, abdominal or back pain, respiratory symptoms, any sensation of facial, oral, or pharyngeal swelling, change in voice, or difficulty swallowing.

On physical examination, blood pressure was significantly elevated at 198/112mmHg, pulse was 87 beats per min, respiratory rate was 20 breaths per min, oral temperature was recorded at 98.4°F, and room air pulse oximetry saturation

of 97%. His skin exam revealed no rashes, urticaria, or discolorations. The facial, oropharyngeal, cardiopulmonary, and abdominal examinations were within normal limits. Examination of the genitalia revealed edema isolated to the scrotum and uncircumcised penis. The edema was soft and non-pitting with no excessive warmth, erythema, induration, or other signs of local infection. The foreskin was partially retractable with no evidence of paraphimosis or balanoposthitis. The bladder was non-distended, there were no hernias, and scrotal contents were of normal size and consistency with no epididymal tenderness. There was no penile discharge or inguinal lymphadenopathy. The extremities did not exhibit any edema, erythema, or skin changes.

ED work-up revealed a normal urinalysis with no hematuria, proteinuria, or evidence of infection. The patient's complete blood count, comprehensive metabolic panel, and prothrombin time were within normal limits and did not exhibit evidence of hypoalbuminemia, increased creatinine, or impaired hepatic function. The patient also did not exhibit any symptoms or physical exam findings suggestive of congestive heart failure, although an incidental right middle lobe pulmonary nodule was noted on the patient's chest radiograph. The preliminary read of the testicular ultrasound described a small hydrocele, but no evidence of torsion, abscess, tumor, or varicocele. The patient's blood pressure improved to 170/98 with subsequent stay in the ED and upon restarting his home dose of hydrochlorothiazide.

While awaiting the formal read of his scrotal ultrasound, the patient developed anterior oropharyngeal edema isolated to his upper lip. On examination, there appeared to be no airway involvement and the patient denied change in voice, difficulty swallowing, or shortness of breath. Given the acute onset of oropharyngeal edema, the patient was given diphenhydramine 50mg IV, famotidine 40mg IV, and methylprednisolone 125mg IV for possible allergic reaction versus acute onset of angioedema. He was observed in the ED for six hours, without progression or significant improvement in symptoms, and discharged home with explicit instructions to discontinue his benazepril and to avoid all ACEIs and angiotensin receptor blockers (ARBs). It was recommended that the patient follow up with his PCP as soon as possible for medication reconciliation to optimize his blood pressure control and to return to the ED for any of the following symptoms: increased oropharyngeal swelling, respiratory difficulty, difficulty urinating, worsening penile pain, or paraphimosis. Four days later, he followed up with his PCP and his symptoms had completely resolved.

DISCUSSION

ACEI-RA was first reported in 1984[5] and is now the leading cause of drug-induced angioedema, accounting for up to 30% of angioedema cases presenting to the ED.[6] The incidence of angioedema in patients taking ACEI has been estimated at 0.68%,[7] most commonly affecting the face, lips, tongue, and upper airway. Infrequently, it involves the gastrointestinal tract, extremities, and very rarely, the genitalia.[1] While the majority of cases of ACEI-RA present within the first week of exposure, many patients will experience symptoms after years of ACEI therapy.[8, 9] The most important risk factor for ACEI-RA is African descent, followed by previous angioedema episode, age >65 years, nonsteroidal anti-inflammatory drug (NSAID) use, female sex, history of drug-related rash, and seasonal allergies.[1] Angioedema is divided into mast-cell mediated and bradykinin-associated angioedema (ACEI-RA), with a lack of pruritus or urticaria as the hallmark of bradykinin-associated angioedema.

A clinical diagnosis of ACEI-RA should be considered in a patient with angioedema to a characteristic anatomic site, without pruritus or urticaria, and a history of ACEI exposure. In all patients who present to the ED with swelling to an affected area, it is paramount to differentiate angioedema from other causes of soft-tissue swelling (i.e. cellulitis, contact dermatitis, low oncotic states, etc.). ACEI-RA should be distinguished from mast-cell associated angioedema as ACEI-RA is minimally responsive to antihistamines, glucocorticoids, epinephrine, and lacks allergic symptoms.[10]

The mainstay of treatment for ACEI-RA, no matter the affected location, is the prompt discontinuation and future avoidance of all ACEIs, assessment of the airway, and supportive care. In those with suspected oropharyngeal involvement, the airway should be evaluated emergently, as up to 10% of patients will require intubation.[11] In patients with progressive symptoms or those who will require advanced airway management imminently, medical management should be attempted. Icatibant, a synthetic bradykinin B2 receptor antagonist, has been shown to be effective for severe ACEI-RA if given within the first 10 hours of symptom onset.[12] Medications approved for hereditary angioedema should also be considered in severe cases of ACEI-RA in which intubation is imminent. These include fresh frozen plasma, purified C1 inhibitor concentrate, and ecallantide.[1] Patients with ACEI-RA should be given strict precautions to avoid all ACEIs in the future, as continued use is associated with increased recurrence and severity.[13] The use of ARBs is controversial, as patients with ACEI-RA have a 1.5-10% risk of recurrent angioedema when switched to ARBs.[14, 15] Those with penile angioedema should be instructed to avoid retraction of the foreskin to reduce the risk of paraphimosis.[3]

Importantly, as seen in our case, penile angioedema can be associated with oropharynx involvement, and ED physicians should perform a thorough examination of the upper airway and educate their patients on the possibility of this potentially life-threatening complication. Patients in whom there is no disease progression, no involvement of the larynx, tongue, or elevation of the floor of the mouth can be discharged safely if they express understanding of the possible complications of ACEI-RA, have the ability to return promptly if necessary, and have follow up with a primary provider.

This case report, as well as the three previous publications describing genital angioedema as a presentation of ACEI-RA, demonstrates the importance of including angioedema in the differential for new onset penile or scrotal swelling. This case is the first to show that isolated genital angioedema can progress to involve the oropharynx, further underscoring the importance of airway evaluation in all patients in whom ACEI-RA is suspected and observation to ensure there are no additional complications. Following diagnosis, physicians can reassure patients that they are experiencing a drug reaction that is likely to resolve quickly without long-term complications, reducing significant anxiety and distress associated with acute swelling of the genitalia.

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Single Fascia Iliaca Compartment Block is Safe and Effective for Emergency Pain Relief in Hip-fracture Patients

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Introduction: Currently, it is common practice in the emergency department (ED) for pain relief in hip-fracture patients to administer pain medication, commonly systemic opioids. However, with these pain medications come a high risk of side effects, especially in elderly patients. This study investigated the safety profile and success rate of fascia iliaca compartment block (FICB) in a busy ED. This ED was staffed with emergency physicians (EPs) and residents of varying levels of experience. This study followed patients' pain levels at various hourly intervals up to eight hours post procedure.

Methods: Between September 2012 and July 2013, we performed a prospective pilot study on hip-fracture patients who were admitted to the ED of a teaching hospital in the Netherlands. These patients were followed and evaluated post FICB for pain relief. Secondary outcome was the use of opioids as rescue medication.

Results: Of the 43 patients in this study, patients overall experienced less pain after the FICB (p=0.04). This reduction in pain was studied in conjunction with the use and non-use of opioids. A clinically meaningful decrease in pain was achieved after 30 minutes in 62% of patients (54% with the use of opioids, 8% without opioids); after 240 minutes in 82% of patients (18% with opioids, 64% without opioids); after 480 minutes in 88% of patients (16% with opioids, 72% without opioids). No adverse events were reported.

Conclusion: In a busy Dutch ED with rotating residents of varying levels of experience, FICB seems to be an efficient, safe and practical method for pain reduction in patients with a hip fracture. Even without the use of opioids, pain reduction was achieved in 64% of patients after four hours and in 72% of patients after eight hours. [West J Emerg Med. 2015;16(7):1188–1193.]

INTRODUCTION

In current emergency department (ED) practice, pain management in hip-fracture patients is hampered by a high risk of side effects. These side effects are particularly noticeable in elderly patients. Twenty-four hours after a hip fracture, 50% of patients aged 50 and up reported "severe to very severe" pain.[1] To control this pain, nonsteroidal anti-inflammatory drugs (NSAIDs), with or without acetaminophen, were usually not effective. NSAIDs can have a negative impact on renal function, on the mucosa of the gastrointestinal tract and on platelet aggregation. For these and other reasons, pain management in the ED of the Onze Lieve Vrouwe Gasthuis (OLVG), a Dutch teaching hospital in Amsterdam, is based on systemic opioids such as fentanyl and morphine. However,

opioids also have a large potential for side effects. Intravascular administration of opioids can lead to nausea and vomiting. Other common side effects of opioids include sedation, respiratory depression and possible delirium. Moreover, many patients will receive suboptimal pain management, which is another risk factor for delirium.[2,3]

One of the goals of the ED in the OLVG is safe, rapid and effective pain management to insure avoidable complications. To achieve this, fascia iliaca compartment block (FICB) can be a good option. FICB using the "two pop technique" is found to be safe and relatively easy to perform.[4-12] Anesthesiologists have performed this block for perioperative pain relief with good results in a controlled environment.[5-7,10,12,13] FICBs are given by emergency physicians (EP) and residents without complications.[8,9,11,14]

Prior studies have shown good results from FICB in hip-fracture patients. These studies, however, all have small numbers, use different cut offs in evaluating pain, and pain scores are usually documented for short periods. Our objective was to investigate the success rate of administration of FICB in a busy Dutch ED with a standardized cut off for pain and a follow up of eight hours. The additional component in this busy ED is the always-rotating interns and residents. In the Netherlands, there have been no studies performed which investigated FICB in hip-fracture patients. Our study was initially designed in anticipation of a randomized double blind placebo-controlled trial (RCT).

METHODS

Study Design

This prospective pilot study was carried out on hip-fracture patients, presenting to the ED of the OLVG, between September 2012 and July 2013. The institutional review board approved the study.

Study Setting and Population

Eligible patients were over the age of eighteen with clinical or radiological signs of a hip fracture. They presented with an intact cognitive status on admission and were able to give informed consent. We eliminated patients from the study if they displayed any cognitive impairment such as dementia or delirium or when surgery was planned within one hour. Patients were also excluded if they had any known allergy to local anesthetics, if an infection at the injection site was present, or if there was a history of femoral bypass surgery or an elevated International Normalized Ratio (above 4.5), or if they were admitted by the orthopedic department instead of general surgery. In the Netherlands, hip-fracture patients are treated by orthopedic and surgical teams. In the ED, patients are assigned to a specialty team based on day of the week rather than fracture type. During this study, for practical purposes, we only paired up with the surgical team. We included patients in the study when they met all inclusion criteria.

Study Protocol

The study investigators (LG, MZ, JR) trained EPs and residents with different levels of experience in how to perform the FICB. The form of teaching was through lectures and assisting physicians in performing the procedure until competency was demonstrated. EPs and residents were supervised three times in the performance of FICB until the study investigators felt they were competent to perform it independently. The lecture was comprised of background information, anatomy, technique, drug interactions and study protocol. The study investigator gave multiple demonstrations in the ED. EPs and residents were encouraged to ask any questions. All physicians were provided with a pocket card containing information about FICB, such as procedure protocol and details of the medications to be administered.

A standardized FICB technique was used on all eligible patients. The patient was placed in a supine position, the inguinal ligament was identified and the femoral artery was palpated. After the skin was cleaned with chlorhexidine, FICB was given with a SonoPlex Stim cannula 22G×50mm needle without the use of a nerve stimulator. The needle was inserted perpendicular to the skin at a point 1cm below the juncture of the lateral and medial two-thirds of a line that joins the pubic tubercle to the anterior superior iliac spine. The needle was inserted until a loss of resistance was felt as the fascia lata was passed, and further advanced until a second loss of resistance occurred when the fascia iliaca was pierced (often described as "two pops"). This technique was first described by Dalens et al.[6] We ruled out intravascular injection by aspiration. The dosage was 2mg levobupivacaine per kg, with a maximum of 175mg. When patients were under 75kg, we diluted the levobupivacaine 0.5% with saline solution to achieve an injection volume of at least 30 ml. We chose levobupivacaine as the local anesthetic due to its proven safety, widespread availability, and long-lasting effects.[15] The FICB was never re-administered: it was a single shot.

All of the patients had a peripheral intravascular access and were supplied with oxygen as needed. Electrocardiogram, non-invasive blood pressure and oxygen saturation were monitored and documented. Any change in cognitive functioning after the administration of the FICB was recorded in each patient's chart. EPs and residents were interviewed by the investigator after finishing two or more FICBs to ascertain whether they felt they had mastered the technique. Nurses were interviewed and asked to give feedback on whether the FICB was successful in patients' pain management. Other collected data included patient demographics and type of fracture.

Data Analysis

Nurses performed pain assessment during the first hour in the ED and until eight hours on the surgical ward. We used a 10-point numeric rating scale (NRS). This assessment was done before any medication was given, during FICB, and after the

FICB was performed at 30, 60, 120, 240 and 480 minutes. The need for and use of supplemental analgesia was documented. Patients received a short-acting opioid in the ambulance or in the ED if pain was rated NRS≥7. In our analysis, we rated these patients "positive" for one hour because these short-acting opioids are usually active for more or less one hour. If patients received a long-acting opioid, for example morphine, we rated them "positive" for opioids for the duration of four hours. All patients received one gram of acetaminophen and 50 mg of diclofenac (Voltaren, an NSAID), when there were no contra indications for the use of these medicines.

For the analysis, we put patients in two groups: group one were patients who achieved a clinical reduction in pain without additional opioids. Group two were patients who achieved a clinically relevant reduction in pain with the supplemental use of opioids. A clinically relevant reduction of pain was reached when patient's level of pain was lowered by ≥35% when the initial pain score was ≥6 (moderate pain) on the NRS. For patients with severe pain (NRS≥8) a decrease of ≥45% was regarded as clinically meaningful according to Soledad Cepeda and colleagues.[16]

We used a one-way repeated measures analysis of variance to assess the change in NRS in time. A $p<0.05$ was considered statistically significant. Statistical analyses were performed using SPSS 18.0 software package for Windows (SPSS Inc, Chicago).

RESULTS

Figure 1 shows the study flowchart. In total, 149 hip-fracture patients were screened for inclusion in the study. Forty-three patients were included in the study, while 84 patients met predetermined exclusion criteria. Twenty-two patients dropped out due to unrelated study failure.

Forty-three patients were included in this study: 22 women, 21 men, with a mean age of 76 years. Nineteen patients had a femoral neck fracture and the other 24 patients had a pertrochanteric or subtrochanteric fracture. There were no patients with an ASA-score of 4 or 5. Thirty-three percent of patients showed an ASA-score of 3; 49% of patients showed an ASA score of 2. Only 12% of patients had a history of diabetes.

Figure 2 shows the reduction in pain during admission. Overall, it is clear that patients experienced less pain after the FICB ($p=0.04$). This reduction in pain was studied in conjunction with the use and non-use of opioids.

Differences in pain were registered from 30 minutes to 480 minutes after the FICB, which are represented in Figure 3. Analyzing all patients 120 minutes after the FICB, there was a clinically relevant reduction in pain in 76% of patients. At this moment, 12% showed this reduction with the use of opioids. However, 65% achieved this reduction without additional opioids. After 240 minutes, this clinically meaningful reduction was achieved in 82% (in total) where 64% did not receive any opioids (these patients ended up in group one). After 480 minutes, this goal was reached in 88% where 72% of patients achieved this reduction without additional opioids (again, this is called group one). In 16%, this reduction was achieved with additional opioids, such as morphine (group two).

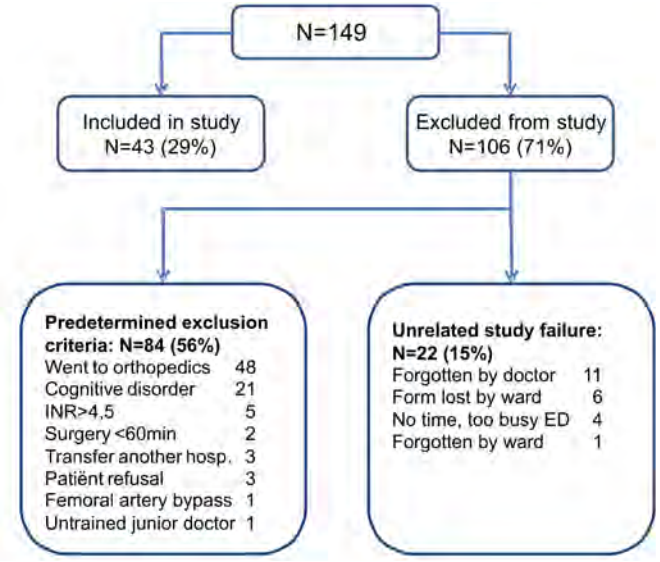

Figure 1. Flowchart showing hip-fracture patients included and excluded from study-analysis.
INR, international normalized ratio; *ED*, emergency department

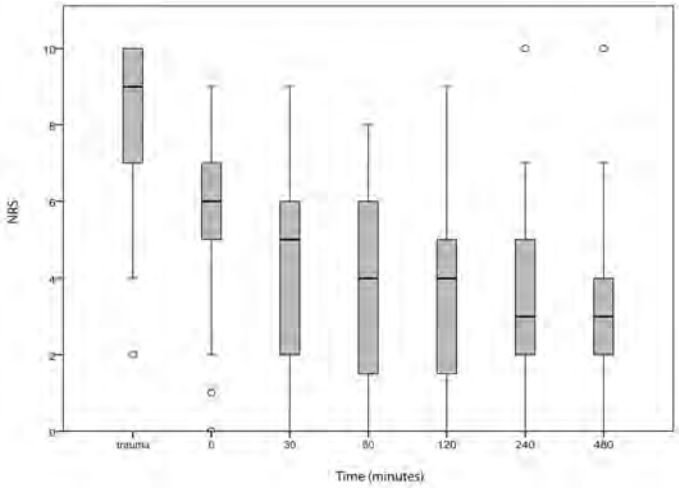

Figure 2. Boxplots showing overall reduction in pain (NRS) during admission (in time).
NRS, numeric rating scale

The FICB technique was performed with minimal risk to patients. The levobupivacaine was given at a safe distance from the neurovascular bundle. During this study 17 different residents were responsible for 34 FICBs, while EPs were responsible for the remaining nine. Close observations of the patients' vital signs and cognitive function increased the safety profile of the procedure by allowing early detection of systemic toxicity. No adverse events were reported. FICB was easy to perform and required minimal training. They found it easy to master the technique. EPs and residents performed the procedure successfully within less than five minutes of instruction.

Nurses from the department of general surgery were

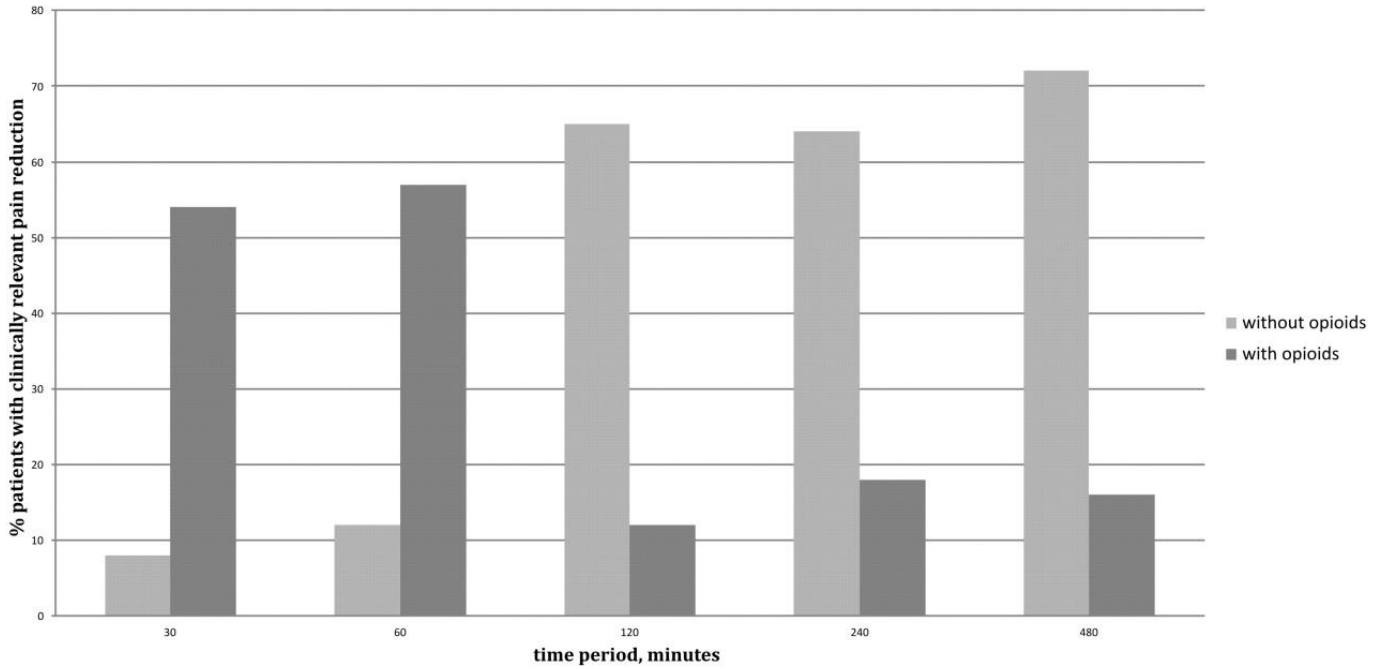

Figure 3. Percentage of patients with a clinically relevant reduction in pain. All values are reported in number (%). Time period is minutes after block placement. Missing values were respectively: 6, 8, 9, 15, 18, which means: numbers of documented pain scores at time 30 minutes were for 37 patients; after 60 minutes for 35 patients; after 120 minutes for 34 patients, after 240 minutes for 28 patients and 480 minutes after block placement pain scores are documented for 25 patients. Clinically relevant reduction in pain was reached when patient's level of pain was lowered by ≥35% when the initial NRS was between 6-8 (moderate pain). For patients with severe pain (NRS≥8) a decrease of ≥45% was regarded as clinically meaningful.
NRS, numeric rating scale

enthusiastic because they believed they could take better care of patients after FICB placement. After this positive feedback we interviewed four nurses randomly. They were all very satisfied after block placement since they found an improvement in care when the patient received a FICB. Although we did not measure pain levels during movements such as transfers, most patients indicated experiencing no pain during transfers.

DISCUSSION

FICB seems to be a safe and practical method for reducing pain in patients with a hip fracture. FICB has been reported to provide effective pain relief in hip-fracture patients when performed by anesthesiologists, without the use of a nerve-stimulator or ultrasound, and without causing major side-effects.[7,12,13]

The aim of this study was to investigate the safety profile and success rate in a busy ED in the Netherlands with rotating physicians and time pressures, as an alternative or additive to conventional analgesia for hip-fracture patients. In this study, we achieved clinically relevant differences in pain in 76% of 34 documented patients at 120 minutes and in 88% of 25 documented patients at eight hours. Our results are comparable to those published in earlier studies, in which the block was performed by non-anesthesiologists with a success rate of 70-80%.[9,14] Elkodair considered a difference of three points or more from the patient's baseline to be clinically meaningful while we used 35% or even 45%, regarding to Soledad Cepeda and colleagues. According to Soledad Cepeda it is a variable that depends of the baseline NRS[16] instead of a fixed number.

Anesthesiologists routinely place nerve blocks for pain control in the pre- and post-operative period, but have traditionally used nerve stimulators to guide their placement. Most EPs do not routinely use nerve stimulators but are increasingly trained in ultrasonography. There is good evidence to show that peripheral nerve blocks performed with ultrasound guidance can be placed with great success. However, with a success rate of 76-88% we achieved very good results and ensured that our EPs and residents performed the loss of resistance technique correctly. This increases practicality in our busy ED as it avoids the need for ultrasound scanners. Most Dutch EPs have no access to an ultrasound machine in their EDs and it takes less time to perform a FICB without ultrasound.

This study shows a clinically relevant reduction in NRS in 62% of patients after 30 minutes (Figure 3), which is due to the effect of the FICB or to short-acting opioids. Because these opioids wear off after one hour, we could at least tell something about FICB's effect after two hours, when it is certain there is no effect from short-acting opioids. Two hours after FICB placement, there was a clinically meaningful decrease in pain in 65% of patients, which is very likely due to the FICB effect since these patients didn't use any opioids in the given timeframe. In this teaching hospital in the Netherlands, hip-fracture patients stay for one to two hours

in the ED, after which they are brought to the department of general surgery, the orthopedic ward or to the operating room. So for two-thirds of the remaining patients, FICB seems to be a useful intervention. Moreover, after eight hours this effect is even more pronounced because after this period, almost three-quarters of patients showed a clinically relevant reduction in pain without the use of opioids. Satisfaction scores among them will be higher since they will need less or even no opioids at all, which are known to make patients feel nauseous or cause them to vomit.

Our recommendation is to give hip-fracture patients a FICB in the ED, but because levobupivacaine is a long-acting anesthetic, we have to bear in mind that additional short-acting opioids are possibly needed in the ED. Levobupivacaine seems to be more helpful in patients who have to wait four to eight hours for surgery. For ED patients, the use of lidocaine could be more helpful since onset of effect is usually within half an hour. Further research is needed and one of our recommendations is to investigate the use of lidocaine in FICB because this is a short-acting anesthetic and its effect will be more pronounced in the ED.

This pilot study ended after nine months because of reasons indicated below. Furthermore, willingness from personnel to start with the intended randomized placebo controlled double-blind study was low, due to very promising results. FICB was implemented in the protocol of our department.

LIMITATIONS

The dropout rate was significant and mainly due to pre-defined exclusion criteria. During one shift, there was no EP available who could perform this technique. In the beginning of the study, doctors forgot to include patients in the study protocol. Unfortunately study forms were lost in six cases, probably during the transfer to another ward. For example, when patients went to the cardiology ward for cardiac problems and were thereafter brought to the department of general surgery, the forms weren't traceable. In four cases it was too busy in the ED, so patients went upstairs before they were included in the study. And in one case, nurses from the department of general surgery forgot to fill in the form.

Unfortunately not all measurements of pain scores were performed. A possible explanation could be that nurses of the department of general surgery forgot to fill in the pain scores because patients didn't complain about pain after administration of the FICB, or because the nurses may have been too busy to fill in the forms. The use of an independent research nurse would be a good option to minimize patient drop out.

We did control the amount of conventional pain treatment used before and after the FICB, but incidentally the patient was given morphine instead of fentanyl, which may have influenced the level of pain. To compensate this problem we measured pain at different time intervals, even after eight hours after block placement. The decrease in pain at four (and eight) hours after the FICB was likely due to the analgesia provided by the FICB, as this was beyond the scope of the effect of morphine.

CONCLUSION

In a busy ED with rotating residents of varying levels of experience, fascia iliaca compartment block seems to be an efficient, safe and practical method for reducing pain in patients with a hip fracture. In two hours there was a clinically meaningful decrease in NRS in 76% where 65% of patients achieved this reduction without the use of opioids. Even after eight hours this reduction was achieved in 88% of patients from whom 72% didn't needed opioids. No adverse events were reported. Because of small numbers and the lack of a control group, the investigator aims to collect more data to answer questions on safety and efficiency.

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Iliac Pseudoaneurysm from Endoleak

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A 65-year-old male presented to the emergency department complaining of two hours of severe lower abdominal pain radiating into his left testicle. The patient described a vascular procedure in the past but did not recall the details. An emergent bedside ultrasound was performed to evaluate the abdominal aorta. During the exam an echogenic object consistent with a prior endovascular stent was discovered in the distal aorta prompting further ultrasound evaluation of the iliac artery (Figure). A true lumen (thin black arrow) was visualized with evidence of leak (white arrows) during color Doppler evaluation. The patient was taken emergently to computed tomography and the diagnosis of an iliac artery pseudoaneurysm from an endoleak was confirmed.

A pseudoaneurysm is formed after a disruption causes a saccular expansion at the site of injury that is contained by adventitia or perivascular soft tissue. Rupture is common in patients with iliac artery pseudoaneurysm, with associated mortality rates of approximately 50%.[1] An endoleak is a potential complication of endovascular stenting that involves blood leaking around or through the graft site.[2]

Presenting symptoms of a pseudoaneurysm are variable, based on the location, and are often caused by pressure on adjacent organs. Symptoms that have been described include abdominal pain, urinary symptoms, renal failure, lumbosacral pain, groin pain, rectal bleeding, or constipation.[1]

Our patient had prior endovascular stenting of an iliac artery aneurysm that extended into the distal aorta. He had developed a pseudoaneurysm (thick black arrow) arising from the medial aspect of the left iliac artery at the juncture of two metallic stents with active extravasation suggestive of an endoleak (white arrows). The patient underwent endovascular repair with endograft placement to repair the leak and

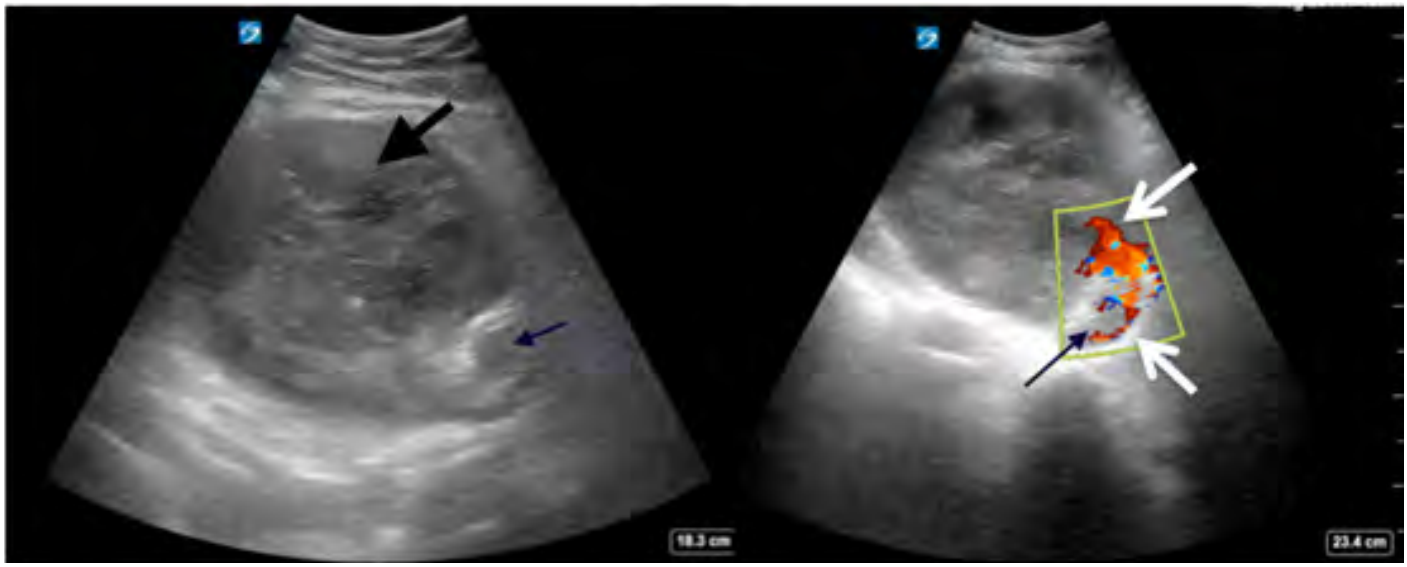

Figure. Ultrasound of the left iliac (left) with color Doppler flow (right) showing the true lumen (thin black arrow) and evidence of the leak (white arrows) creating a pseudoaneurysm (thick black arrow).

subsequent coil embolization of the pseudoaneurysm cavity.

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Oral Ulcerations

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A 35-year-old male presented with lower gum pain associated with fever, chills, and sore throat. His medical history included intravenous drug use, human immunodeficiency virus infection, and hepatitis C. Physical exam revealed tachycardia, a temperature of 38.9°C, anterior cervical lymphadenopathy, halitosis, an edematous lower lip, and purulent ulcers anterior and posterior to lower central incisors with marked tenderness and erythema (Figure). His laboratory work was notable for a low white blood cell count (2.6 thousand/μl), neutropenia (0.11 thousand/μl), a low absolute CD4 lymphocyte count (0.5 thousand/μl), and elevated C-reactive protein (129mg/L) and sedimentation rate (23mm/hr). A computed tomography study showed a 0.5×1.3×0.3cm abscess anterior to the mandibular symphysis.

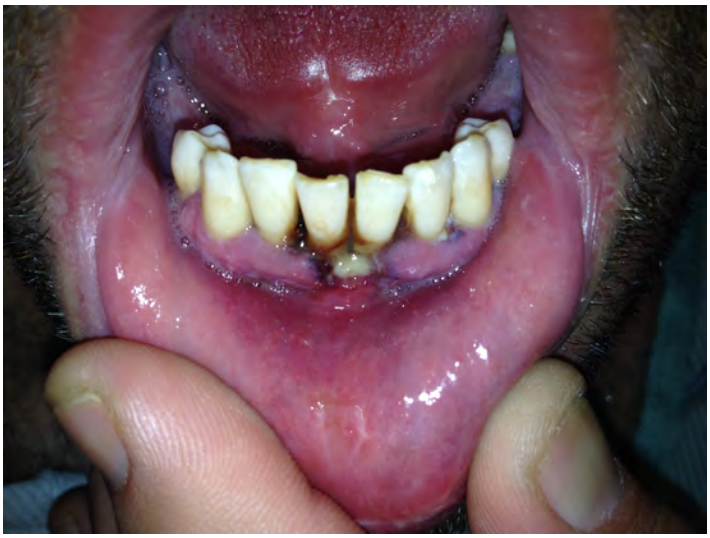

Figure. Lower lip and gums with inflammation and ulceration.

DIAGNOSIS

Acute Necrotizing Ulcerative Gingivitis

Intravenous vancomycin, piperacillin/tazobactam, and fluconazole were initiated. Oral-maxillofacial surgery was consulted and performed debridement. Continued intravenous antibiotics and chlorhexidine rinses were recommended.

The patient was admitted to the medicine service for three days. Herpes simplex and syphilis studies, sent to rule out other causes of the patient's ulcers, were negative. His oral infection improved and his absolute neutrophil count, ultimately thought to be low due to acute infection, normalized. He was discharged with outpatient oral antimicrobial therapy and was ultimately lost to follow up.

Necrotizing periodontal disease presents as interdental necrosis with "punched out" ulcerative papilla, gingival bleeding, and pain. It usually affects young adults, commonly military and college students.[1,2] Secondary features of disease include foul-smelling breath, yellowish-white or grayish "pseudomembrane," lymphadenopathy, and fever.[1] Risk factors include immunosuppression, psychological stress, smoking, poor oral hygiene, and poor nutrition.[1] Common organisms include Bacteriodes, Prevotella, Fusebacterium, and Selenomonas but fungal infections also occur.[2] Treatment usually involves debridement, oral antimicrobial rinses, and antibiotics for any signs of systemic involvement.[1]

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Adult Female with Abdominal Pain

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CLINICAL SCENARIO

A 42-year-old female presented to the emergency department with diffuse abdominal pain, vaginal discharge, and a fever of 102°F. She described multiple recent male sexual partners, with inconsistent condom use. Her vital signs were unremarkable. Her physical exam was notable for moderate right lower quadrant tenderness to palpation. There was no cervical motion tenderness. The emergency physician performed a bedside abdominal ultrasound (Video), and subsequently ordered a computed tomography (Figure), which confirmed the diagnosis.

DIAGNOSIS

Tubo-Ovarian Abscess (TOA). The patient was admitted to the gynecology service and provided with intravenous antibiotics. Approximately 70cc of purulent material was drained from the abscess. Of note, chlamydia and gonorrhea cultures were both negative. She was discharged from the hospital with a two-week course of oral antibiotics. A TOA is the most severe manifestation of pelvic inflammatory disease (PID), which is traditionally defined as an infection of the upper genital tract. TOAs are most commonly caused by *Chlamydia trachomatis* and *Neisseria gonorrhoeae*.[1] Although PID is a clinical diagnosis, abdominal imaging can identify potentially life-threatening complications, such as pyosalpinx or TOA. Classic ultrasound findings of TOA include a complex, mixed solid and cystic mass in the pelvis, which is often preceded by a dilated, fluid-filled, tubular structure in the adnexae characteristic of hydro/pyosalpinx.[2] These findings were quickly recognized on bedside ultrasound, facilitating the prompt diagnosis of TOA by an emergency physician.

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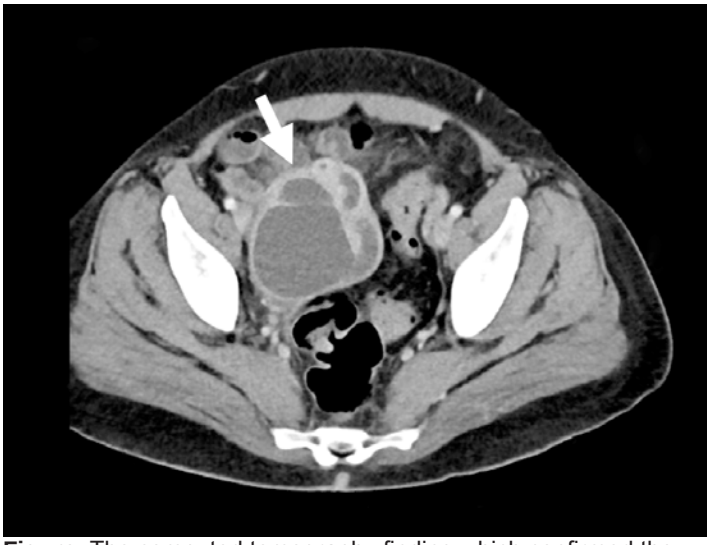

Figure. The computed tomography finding which confirmed the diagnosis.

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Video. A trans-abdominal video sweeping across the pelvis.

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Mal-positioned Gastrojejunostomy Tube

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CASE REPORT

A 41-year-old female presented to the emergency department with nausea, vomiting and foreign body sensation in her throat. The patient had multiple co-morbidities including hypertension, diabetes, cervical cancer and gastroparesis with gastrojejunostomy (GJ) tube. The patient had stable vitals, was in no respiratory distress, and her only complaint was mild throat pain and abdominal pain at the GJ tube insertion site. Physical exam revealed a foreign object in the oropharynx (Figure 1). Abdominal exam showed a soft, non-distended, non-tender abdomen with GJ-tube and colostomy in place. Abdominal series and upright chest radiograph were obtained (Figure 2).

DIAGNOSIS

Mal-positioned GJ tube. Oral exam showed the distal end of the GJ tube protruding into the oropharynx (Figure 1). Upright chest radiograph showed the GJ tube extending superiorly up the esophagus into the oropharynx (Figure 2).

A GJ tube is a percutaneous device that provides access to both the stomach and jejunum[1,2]. This tube is positioned at the same location as a gastric feeding tube but is longer in order to reach the jejunum. Its purpose is to provide decompression of the stomach and enteric feeding to patients with poor caloric intake.[3] The rate of complications of GJ tubes vary between 1-13%.[4,5] Many of these complications are considered minor with <1% causing mortality.[6-9] In patients with vomiting there is a chance that the GJ tube is displaced from the jejunum and

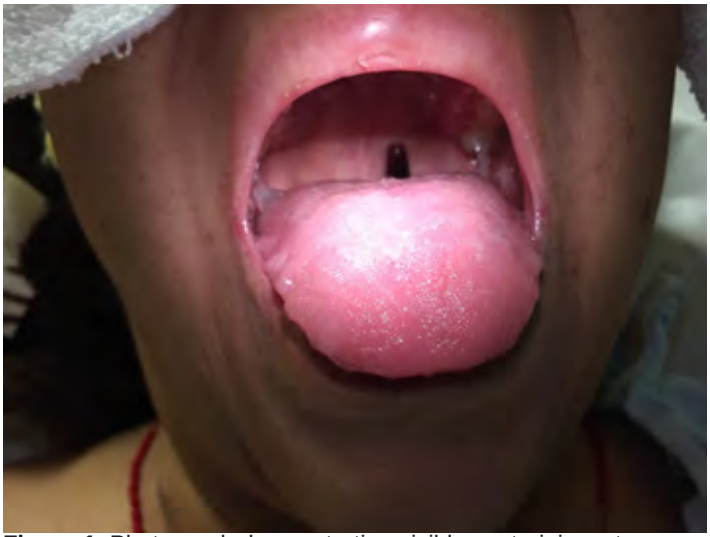

Figure 1. Photograph demonstrating visible gastrojejunostomy tube in patient's oropharynx.

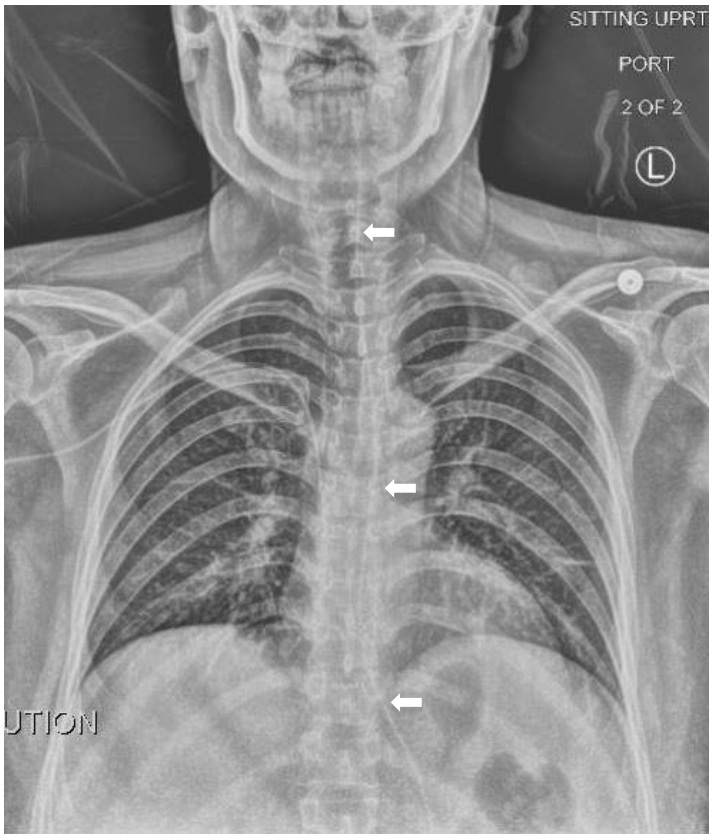

Figure 2. Upright chest radiograph with visible gastrojejunostomy tube superiorly displaced up the esophagus.

can enter into the esophagus. This can be confirmed with chest radiograph or CT chest.[10,11]

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Vallecular Varix: A Perplexing Cause of Oral Cavity Bleeding

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Often discovered only after an extensive work up for hemoptysis and hematemesis, vallecular varices are a rare cause of oral bleeding that increase patient morbidity due to delay of diagnosis.
We describe an 89-year-old male who presented with a week of intermittent oral blood production. A vallecular varix was identified on fiberoptic laryngoscopy after studies for hematemesis and hemoptysis had been performed, including negative esophagogastroduodenoscopy and bronchoscopy.
Awareness of this pathology and key points in the patient history can direct the clinician toward the correct diagnosis, expediting treatment and limiting invasive diagnostic procedures for pulmonary or gastric etiologies of bleeding. [West J Emerg Med. 2015;16(7):1201-1202.]

INTRODUCTION

Blood discovered in the mouth most often originates from the upper airway, lungs, esophagus, or stomach. Due to difficulty of visual inspection, bleeding from the vallecula may be confused with hemoptysis or hematemesis. This case report details a vallecular varix, which can cause significant patient distress and morbidity as well as increased healthcare cost burden due to delay in diagnosis.

CASE REPORT

The patient was an 89 year-old man who presented to the emergency department (ED) with one week of hemoptysis. He described that twice per day he would "feel warm liquid in my mouth, gag, and spit up clots of blood." He denied a history of coughing, vomiting, or postnasal drip. His medical history was significant for coronary artery disease, hypertension, and chronic kidney disease. He was not taking anticoagulants. He had never smoked or consumed excess alcohol. His vitals on arrival included a temperature of 36.7 degrees Celsius, pulse of 82 beats per second, blood pressure at 135/64mmHg, respiratory rate 18 breaths per minute, and an oxygen saturation of 97% of room air. Laboratory data included hemoglobin 12.5gm/dL, platelets 131K/mm^3, INR 1.0, PT 14.5 seconds. After obtaining a chest plain film with normal findings, a head, neck, and chest computed tomography was performed in the ED, which showed no evidence of masses, vascular malformations, or pulmonary embolism. Esophagogastroduodenoscopy showed mild duodenitis but no gastric ulcers or esophageal varices. After bronchoscopy failed to identify a source of bleeding, the patient was discharged as his symptoms seemed to have resolved during his hospitalization.

Two days later the patient presented to the ED again with bleeding from the mouth. Otolaryngology was consulted and fiberoptic nasopharyngoscopy was performed, revealing normal nasal mucosa and no bleeding from the pharynx. However, upon asking the patient to protrude his tongue, a 0.5cm, non-bleeding, pedunculated varix was observed in the left vallecula. At this point the patient's hemoglobin had decreased to 10.7gm/dL. The patient underwent direct laryngoscopy with microscope and yttrium aluminum garnet laser cauterization, followed by cold steel resection (Figure 1 and 2). The pathology report was varix with acute thrombus.The patient was discharged the next day after overnight observation for bleeding.

The patient's post-operative course was complicated by a need to return to the operating room on post-operative day 10 due to bleeding from the surgical site. There was no evidence of recurrence of his varix and the bleeding was managed with suction cautery. Again, the patient was monitored overnight, demonstrated no further bleeding, and was discharged. The patient has remained well since.

DISCUSSION

A patient presenting with blood in the mouth with no obvious source is a diagnostic puzzle as the etiology could be upper airway, pulmonary, or gastroesophageal. A detailed history is crucial in distinguishing which is the most

likely anatomic location. Hemoptysis tends to present with cough, a history of lung disease, and frothy sputum, while hematemesis is frequently associated with nausea, a history of gastroesophageal disease, and frank or coffee-ground emesis.[1] Bleeding from a nasal or anterior oral source is typically apparent on physical exam.

Bleeding from the vallecula, however, presents a particular diagnostic challenge, as it is neither common nor readily identified. Laryngoscopy is necessary, which may not be readily available in the ED setting and may require consultation. Moreover, it can present with hematemesis, hemoptysis, melena, or a combination of the three.[2-4] This patient presented solely with gagging and sporadic pooling of blood in the back of his throat. Had the history guided intervention resulting in laryngoscopy first, the patient would have been spared tests that required radiation exposure and general anesthesia, in addition to repeated ED visits.

Unlike vallecular varices, lingual varices are more common in elderly populations, as well as those with a history of smoking and cardiovascular disease.[5] It has been postulated that, like esophageal varices, portal hypertension is the underlying cause of varices at the base of the tongue.[6] Although the patient in this case was advanced in age with a history of cardiovascular disease, he had no history of portal hypertension. Further studies are necessary to determine which patients are at greatest risk for this rare source of bleeding.

Vallecular varices are a rare, potentially life-threatening source of bleeding and should be considered in patients presenting with blood in the oral cavity without a history suggestive of pulmonary or gastroesophageal sources. Fiberoptic laryngoscopy is a fast, easily performed procedure that should be used early in order to prevent unnecessary testing and decrease healthcare costs associated with a delay in diagnosis.

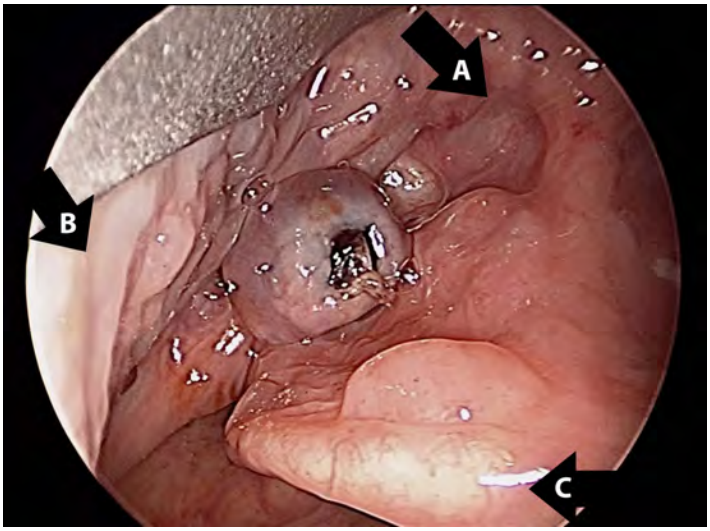

Figure 1. Vallecular varix. Pedunculated varix in the left vallecula with clot in center. A) Tongue base. B) Lateral pharyngeal wall. C) Epiglottis.

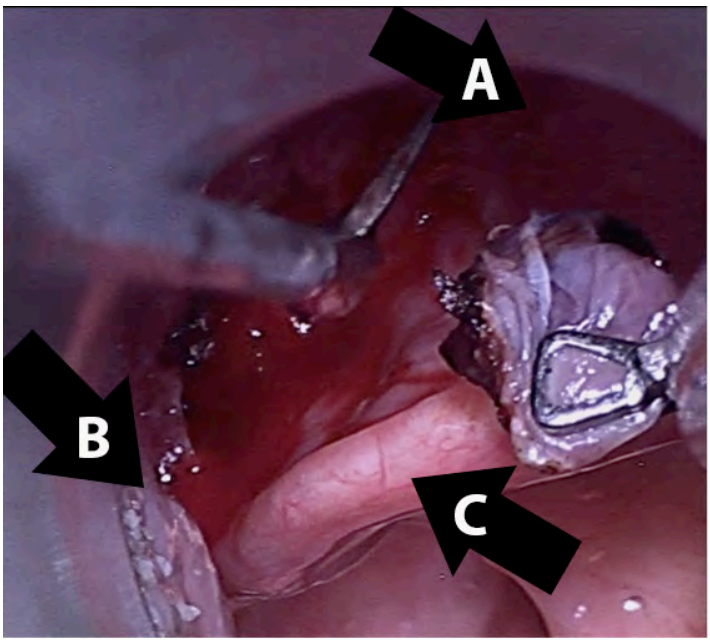

Figure 2. Extrication of varix. Extrication of varix at the base with Jako scissors after yttrium aluminum garnet laser cauterization. A) Tongue base. B) Lateral pharyngeal wall. C) Epiglottis.

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Mistaken ST-Elevation Myocardial Infarction

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A 66-year-old female was transferred from an outside hospital for possible ST segment elevation myocardial infarction (STEMI). The patient reported feeling poorly for the last day, with epigastric pain, nausea, and multiple episodes of vomiting. Patient's medical history was significant for diabetes mellitus, hypertension, atrial fibrillation, and multiple sclerosis. Electrocardiogram (EKG) was as noted (Figure). Initial troponin was 0.14 (<0.03ng/mL). The patient was taken emergently to the cardiac cath lab for possible posterior STEMI. Angiogram demonstrated no significant evidence of coronary artery disease, with an EF of 75%.

Digoxin concentration subsequently returned at 8.8ng/mL (reference range 0.5-1ng/mL). The ST segment changes gradually improved as the digoxin concentration declined. An echocardiogram demonstrated moderate concentric left-ventricular hypertrophy with estimated ejection fraction of 80%, rheumatic heart disease, and possible hypertrophic obstructive cardiomyopathy physiology. Troponin peaked at 0.29ng/mL and then returned to baseline. Creatine kinase remained within normal limits.

DISCUSSION

Digoxin may cause a multitude of EKG changes including ST depression and numerous cardiac dysrhythmias.[1,2] Differentiation of ST depression in patients with ischemic heart disease and digoxin presence may be feasible in patients undergoing stress testing using heart rate analysis,[2] but the critical nature of a potential acute myocardial infarction patient likely prohibits this in-depth analysis. ST depression may appear indistinguishable from ischemic changes, and the history of digoxin use or digoxin concentration testing should be considered in a patient with nausea and vomiting and signs or symptoms of acute coronary syndrome with marked ST depression.

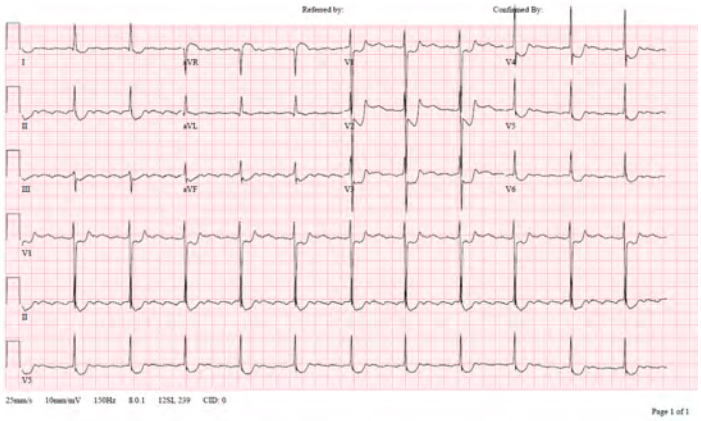

Figure. Initial electrocardiogram of patient with elevated digoxin concentration

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When the Secondary Survey is Primary: Knife Blade in the Spine

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A 42-year-old male was assisted from a car in front of our inner city stand-alone emergency department (ED) with a stab wound to the right chest. He was confused and bleeding; his past medical history was unknown. The patient was diaphoretic, pale and confused with a large vertical stab wound over his right chest with no other obvious injuries. On initial exam in the outlying ED, his back was obscured by blood. He was transferred to the trauma center where during a full secondary survey a 2cm wound was located over the patient's lumbar spine. The patient was stabilized and taken for imaging. No focused assessment with sonography for trauma (FAST) was done at either site; however, the FAST exam, which emphasizes the search for extraluminal blood, would not have been expected to find a foreign body. Computed tomography (Figure) showed a retained 10cm blade extending through the left L1-L2 interlaminar space, spinal canal and disc space with associated injuries to the IVC and renal vein, duodenum and medial left hepatic lobe. On day one he had two damage control laparotomies. The blade could not be removed due to patient instability and inability to turn him prone. On day two, he returned to the operating room and the blade was removed by resecting the spinous process and lamina of L1 with joint efforts by the vascular, neurosurgery and trauma surgeons. He required five additional surgeries to

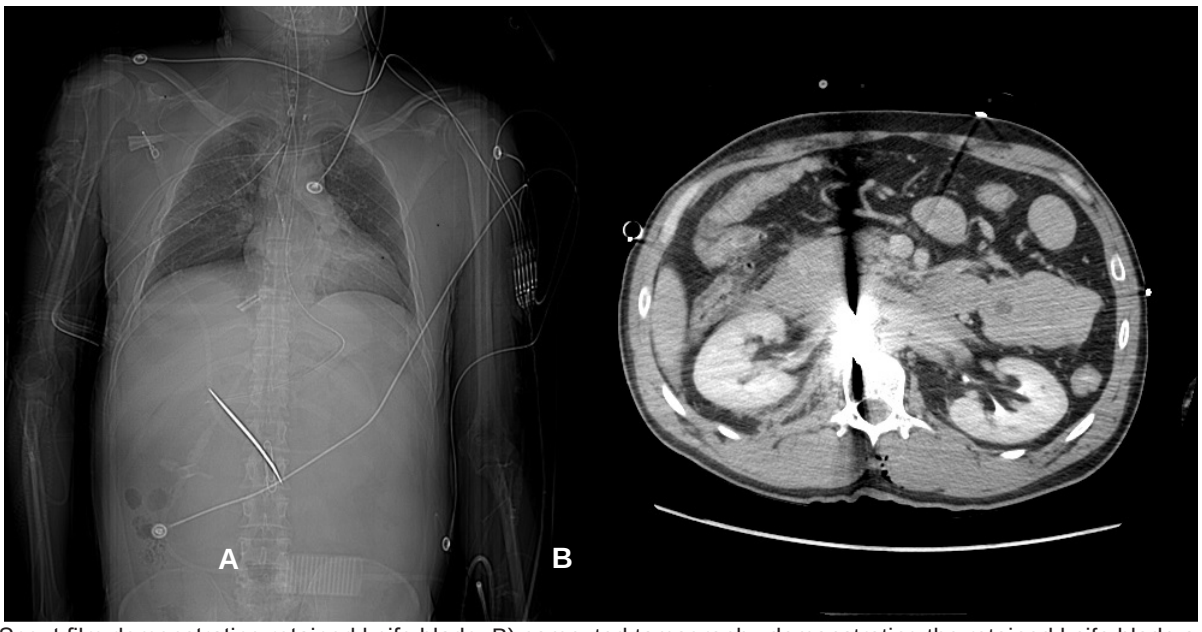

Figure. A) Scout film demonstrating retained knife blade. B) computed tomography demonstrating the retained knife blade and resulting artifact.

wash out and finally close his abdomen and was discharged to home after 39 days. He was neurologically intact.

Spinal stab wounds with retained knife blades are uncommon in the U.S. A literature search revealed few case reports.[1-3] Enicker et. al present a 12-year case series from South Africa where a majority had neurologic deficits consistent with Brown-Sequard syndrome.[4] A U.S. case report presented a patient who presented four weeks after an initial stab wound to the spine with worsening neurologic deficits necessitating knife fragment removal.[5] The importance of a complete secondary survey in the evaluation of assault victims in order to detect spinal injuries and possibly prevent neurologic sequelae is demonstrated in this case.

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Chilaiditi Sign: Rare Incidental Finding on Chest Radiograph

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A 68-year-old male with a history of prostate cancer presented with a two-day history of fever and left flank pain. Vital signs included a temperature of 39.4 degrees Celsius with 93% oxygen saturation and heart rate of 112 beats per minute. An upright chest radiograph showed concern for free intraperitoneal air (Figure) with a white blood cell count of 17.3. A computed tomography of the abdomen and pelvis revealed a Chilaiditi sign with pyelonephritis, which was confirmed on urinalysis. He was admitted for intravenous antibiotics.

DISCUSSION

Chilaiditi sign, also called pseudopneumoperitoneum, is named after the Greek radiologist, Dmitri Chilaiditi, who first described it in 1910.[1] It is an interposition of bowels between the liver and right diaphragm and appears as free air on chest radiograph.[2,3] This sign is found in <0.3% of the population with highest incidence in elderly males.[2] To diagnosis Chilaiditi sign, the following criteria must be met: (1) right hemidiaphragm must be elevated above liver by intestine, (2) bowel must be distended by air, (3) and the superior margin of the liver must be depressed below the level of the left hemidiaphragm.

If symptomatic, this is referred to as Chilaiditi syndrome, which can manifest as abdominal or cardiac symptoms with self-resolution or chronicity.[1,2] Usually only conservative treatment is required for patients with Chilaiditi syndrome, but surgery may be needed for severe cases.[1] The emergency physician should be aware of this condition as a potential mimicker of intraperitoneal free air on chest radiograph.

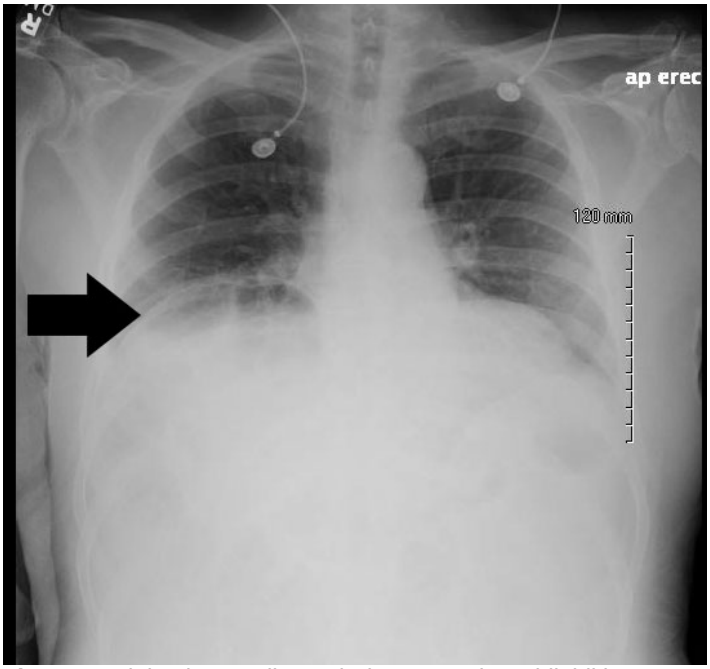

Figure. Upright chest radiograph demonstrating Chilaiditi sign (pseudopneumoperitoneum) mimicking apparent free intraperitoneal air under the right hemidiaphragm.

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Undifferentiated Thyroid Carcinoma Caused Sudden Airway Obstruction

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Case report

An 81-year-old woman was admitted to our emergency department (ED) with neck swelling (Figure 1A) and advancing dyspnea. Stridor was noted on auscultation of her neck, and her breathing was labored. We immediately diagnosed airway obstruction, and emergency intubation was performed using a video laryngoscope (AWS-S100L®, Pentax Corporation, Tokyo, Japan). The epiglottis was found to have shifted to the left on chest video images and chest radiograph (Figure 1B). After intubation, computed tomography and cervical ultrasonography were performed, and we noted swelling of the thyroid, which was superior to the right lobe, and tumor invasion into the trachea without lung metastases (Figure 1C). After admission, fine needle aspiration was performed, and she was diagnosed with undifferentiated carcinoma. We could not perform tracheostomy or place an intratracheal stent because of continuous intratracheal bleeding and disseminated intravascular coagulation. The patient died 28 days after admission.

Discussion

Airway obstruction caused by thyroid carcinoma is rare.[1,2] Lung metastases often are associated with respiratory symptoms and are the most fatal complication.[3]

When patients present to the ED with airway obstruction, physicians should consider acute epiglottitis, peritonsillar or retropharyngeal abscess, and foreign body aspiration as possible causes. Although invasion of thyroid carcinoma

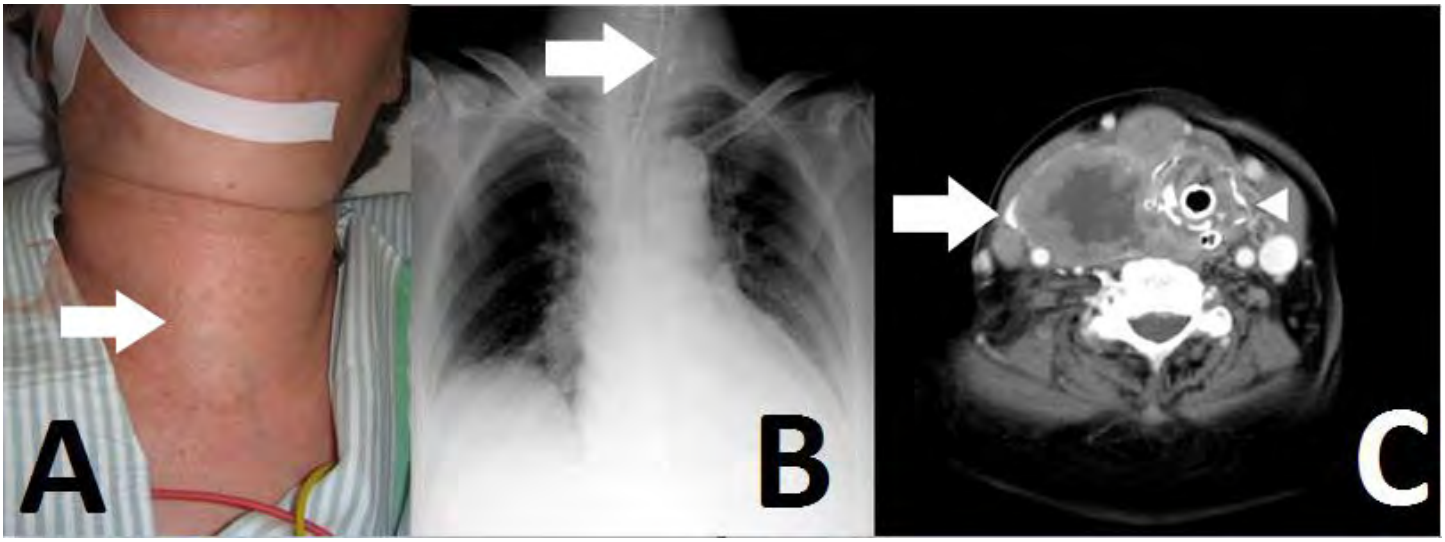

Figure 1. (A) Image showing swelling of the neck in our patient (arrow). (B) Chest radiograph after intubation showing a shift of the trachea to the left (arrow). (C) Contrast computed tomography image showing the thyroid tumor superior to the right lobe (arrow) and tumor invasion into the trachea at the height of the cricoid cartilage (arrow head).

resulting in airway obstruction is rare, physicians should consider it an oncologic emergency. Visual examination, palpation, and auscultation of the neck can help in the differential diagnosis of airway obstruction.

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This article corrects: "Hydrocele of the Canal of Nuck"

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In the Original Research article entitled "Hydrocele of the Canal of Nuck," published in the October 2015 issue of the *Western Journal of Emergency Medicine* (2015;16(5):786-787. DOI: 10.5811/westjem.2015.6.27582), there were the following errors in the published article:

1. On page 786, the following authors should have been included: Phillip Aguiniga, Jason Blake. They are research assistants at the Department of Emergency Medicine, Kern Medical Center, Bakersfield, California.

We apologize for this error.

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