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Western Journal of Emergency Medicine:

Integrating Emergency Care with Population Health

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Contents continued on page iii

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Western Journal *of* Emergency Medicine:

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Table of Contents

continued

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Western Journal *of* Emergency Medicine:
Integrating Emergency Care with Population Health
Indexed in **MEDLINE**

Table of Contents
continued

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Reduction in Radiation Exposure through a Stress Test Algorithm in an Emergency Department Observation Unit

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Introduction: Clinicians are urged to decrease radiation exposure from unnecessary medical procedures. Many emergency department (ED) patients placed in an observation unit (EDOU) do not require chest pain evaluation with a nuclear stress test (NucST). We sought to implement a simple ST algorithm that favors non-nuclear stress test (Non-NucST) options to evaluate the effect of the algorithm on the proportion of patients exposed to radiation by comparing use of NucST versus Non-NucST pre- and post-algorithm.

Methods: An ST algorithm was introduced favoring Non-NucST and limiting NucST to a subset of EDOU patients in October 2008. We analyzed aggregate data before (Jan-Sept 2008, period 1) and after (Jan-Sept 2009 and Jan-Sept 2010, periods 2 and 3 respectively) algorithm introduction. A random sample of 240 EDOU patients from each period was used to compare 30-day major adverse cardiac events (MACE). We calculated confidence intervals for proportions or the difference between two proportions.

Results: A total of 5,047 STs were performed from Jan-Sept 2008-2010. NucST in the EDOU decreased after algorithm introduction from period 1 to 2 (40.7%, 95% CI [38.3-43.1] vs. 22.1%, 95% CI [20.1-24.1]), and remained at 22.1%, 95% CI [20.3-24.0] in period 3. There was no difference in 30-day MACE rates before and after algorithm use (0.1% for period 1 and 3, 0% for period 2).

Conclusion: Use of a simple ST algorithm that favors non-NucST options decreases the proportion of EDOU chest pain patients exposed to radiation exposure from ST almost 50% by limiting NucST to a subset of patients, without a change in 30-day MACE. [West J Emerg Med. 2016;17(2):97–103.]

INTRODUCTION

There has been increased medical and public awareness regarding radiation exposure in medical procedures. The U.S. Food and Drug Administration recently issued an initiative to reduce unnecessary radiation from medical imaging and to encourage physicians to order the appropriate diagnostic test for the appropriate patient and only when medically justified.[1] Guidelines from the American College of Cardiology (ACC) and the American Heart Association (AHA) as well as appropriate-use criteria from the ACC Foundation Quality Strategic Directions Committee Appropriateness Criteria Working Group and the American

Society of Nuclear Cardiology have been published that aim at reducing inappropriate use of single photon emission computed tomography myocardial perfusion imaging (SPECT-MPI) as an initial test in low and intermediate risk patients.[2,3] Unfortunately, despite these recommendations and although there have been methods introduced to decrease radiation doses for nuclear stress tests (NucST), a 2011 member survey of the American Society of Nuclear Cardiology reported that no significant assimilation of these approaches into clinical practice had occurred.[4]

In the U.S., approximately 10 million NucST are ordered per year.[4] The amount of radiation from a NucST using technetium (99Tc) tetrofosmin is 11.4mSv, which is equivalent to about 570 portable single-view or 114 two-view chest radiographs.[5] The cancer risk projection of having this NucST at age 50 years is estimated to result in a lifetime risk of 10 cancers per 10,000 tests and is increased to 25 cancers per 10,000 tests for dual isotope (thallium-201 plus technetium-99m) NucST.[6]

Furthermore, this cancer risk is not static, as in younger patients this projection ratio increases.[6] Given that 10 million tests are performed per year, and given the known cancer risk (10 per 10,000 for 50-year-olds), an algorithm that decreased the number of NucST by even 20% would result in substantially less patients with risk of cancer (potentially estimated 2,000 patients with no increased cancer risk if all were 50 years old).

Stress testing is an important diagnostic tool in evaluating emergency department (ED) patients who present with chest pain (CP). Practice guidelines and algorithms for choosing a stress test based on risk stratification, ability to exercise and clinical features, have been published.[7-10] While there is mention of radiation exposure consideration when choosing one ST option over another, to date there is no study that has estimated the magnitude of decreased radiation exposure after adoption of a ST algorithm that favors non-NucST options. The objective of this study was to introduce a simplified ST algorithm for low-risk CP patients placed in an emergency department observation unit (EDOU) that favors non-NucST options and assess the impact on the proportion of NucST vs Non-NucST performed, then determine if adoption of this algorithm would have an impact on 30-day major adverse cardiac events (MACE). A secondary objective was to evaluate algorithm adherence by emergency physicians.

METHODS

Study Design

This was a retrospective observational study of EDOU patients who underwent stress testing between January 2008 and September 2010 in an urban teaching hospital with >100,000 ED patient visits per year. The EDOU is a 30-bed unit located one floor directly above the ED that is managed and staffed by emergency physicians. This study was approved by the hospital institutional review board.

Study Setting and Population

Our EDOU inclusion criteria for stress testing included adult ED patients with a concern for acute cardiac syndrome (ACS) who were low risk for ACS as defined by the ACC/AHA in 2007 and included patients with an initial normal or non-diagnostic electrocardiogram (ECG) and an initial normal cardiac troponin T level.[11] All patients had a repeat ECG and troponin T performed after four hours in the EDOU. Only patients with a repeat unchanged ECG and negative second troponin T level were candidates for stress testing. Our hospital uses the Roche Diagnostics assay Troponin T, cardiac T (cTnT) measured in our central laboratory with a lower limit of detection of 0.01mcg/L and a 10% coefficient of variation of 0.03-0.06mcg/L. A decision limit for normal of <0.03mcg/L and a positive value as ≥0.10mcg/L is used.

Study Protocol

As part of a process improvement project, physicians from the departments of emergency medicine and cardiology collaborated using evidence-based literature to construct an algorithm in October 2008 that favored Non-NucST over NucST and limited nuclear imaging only to patients with known low ejection fraction (<50%), history of coronary revascularization, pacemaker or AICD, or left bundle branch block (Figure 1). Emergency physician education of the algorithm was implemented in October 2008 and was reinforced intermittently thereafter. Physician (attending and resident) education included introduction and explanation of the algorithm and lectures related to ED CP evaluation, risk stratification and stress testing. The algorithm was also posted in the physician workspaces.

Stress Testing

Non-NucST included the graded exercise stress test (GXT), stress echocardiography (SE) and dobutamine echocardiography (DE). GXTs were performed according to AHA/ACC guidelines using a Bruce protocol, with increased treadmill speed and velocity every three minutes, continuous symptom and ECG monitoring, and termination according to ACC/AHA guidelines.[7] The patient recovered from exercise by walking slowly on the treadmill until heart rate was less than 100bpm or by resting in a supine or seated position if unable to walk in recovery. For SE, the patient transferred as quickly as possible from the treadmill after peak exercise to the left decubitus position for imaging. The heart rate recovery, or heart rate one minute post exercise, was recorded. Ischemia was noted if at least 1mm flat or down-sloping ST depression was present on ECG, a new or worsened segmental wall motion abnormality was detected on echocardiography, or if a new or worsened perfusion defect was present on nuclear imaging. When the endocardium was not adequately visualized during echocardiography, intravenous contrast (Optison [GE Healthcare, Milwaukee WI] or Definity [Lantheus, N. Billerica, MA]) was infused.

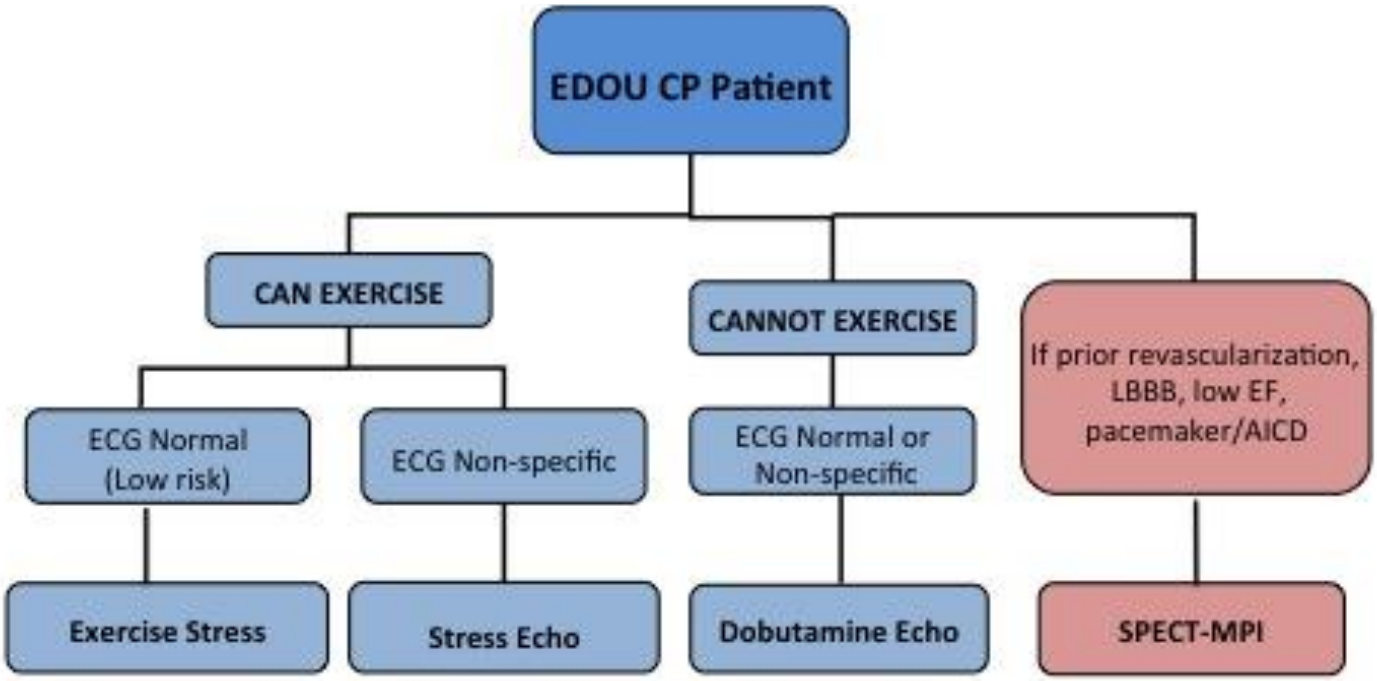

Figure 1. A simple stress test algorithm for patients in the emergency department observation unit (EDOU).
CP, chest pain; *ECG*, electrocardiogram; *LBBB*, left bundle branch block; *EF*, ejection fraction; *AICD*, automatic implantable cardioverter-defibrillator; *SPECT-MPI*, single photon emission computed tomography myocardial perfusion imaging

Pharmacologic stress testing was performed using intravenous dobutamine primarily combined with echocardiography, or adenosine or regadenoson combined with nuclear imaging. Graded dobutamine infusion was performed by increasing infusion dosage every three minutes by 10ug/kg/min increments, to a maximum of 50ug/kg/min, with a targeted heart rate of 85% of the age-predicted maximum. The infusion was supplemented by intravenous atropine if heart rate response to dobutamine was inadequate. Four standard images were obtained at rest, 10 ug/kg/minute infusion, peak infusion, and recovery (when heart rate had dropped to less than 100bpm). Intravenous metoprolol (or diltiazem if metoprolol was contraindicated) was administered in most patients to terminate the effects of dobutamine during recovery. NucST was performed with single photon emission computed tomography myocardial perfusion imaging (SPECT-MPI) after tetrofosmin injection and at two to four hours of rest after the first injection.

Measurements

We compared aggregate data of stress test utilization from patients presenting to the EDOU during three similar time periods: period 1 (baseline phase: January–September 2008), period 2 (intervention phase: January–September 2009), and period 3 (maintenance phase: January–September 2010). The algorithm was introduced in October 2008 after period 1 and before period 2.

To assess for adherence to the algorithm, the department of cardiology kept a log of all ST that required re-ordering due to incorrect test selection after introduction of the algorithm (periods 2 and 3). These data were used to obtain the percent of correct ST ordered (i.e. the ST ordered by the ED physician did not need to be changed to another type) and were used as a surrogate for algorithm adherence. We compared Period 2 to Period 3 to assess retention.

We used a random sample of 240 patients from each period to assess for 30-day MACE before and after algorithm implementation. Data were collected using the hospital electronic medical record and the National Death Index. Data collection included demographics (age, gender, race); presence of cardiac risk factors defined as hypertension, diabetes, hyperlipidemia, family history, and tobacco use; and history of cardiac co-morbidities defined as coronary artery disease, myocardial infarction, percutaneous intervention or coronary bypass artery grafting. We defined MACE as acute coronary syndrome (ACS), catheterization with lesions >50% requiring percutaneous coronary intervention (PCI), coronary artery bypass grafting (CABG), and death.

Data Analysis

Descriptive statistics were generated to characterize the study population. Data are presented as means or proportions with 95% confidence intervals. We calculated confidence intervals for proportions or the difference between two proportions without the continuity correction using the method of Wilson.[12] Data was analyzed with SPSS v. 22.0.

RESULTS

A total of 5,047 EDOU patients underwent ST during

the three time periods: 1,584 in Period 1, 1,645 in Period 2, and 1,867 in Period 3. Of the 720 patients randomly selected during the first three time periods, six pwere excluded due to missing or incomplete data.

NucST in the EDOU decreased from Period 1 to 2 (40.7%, 95% CI [38.3%-43.1%] vs. 22.1%, 95% CI [20.1%-24.1%]), and remained at 22.1%, 95% CI [20.3%-24.0%] in Period 3. See Table 1. The mean proportion of correct stress tests ordered by emergency physicians/residents was similar between Period 2 (91.3%, 95% CI [83.8-95.2]) and Period 3 (89.6%, 95% CI [81.4-93.8]).

In the random sample of 714 patients during Periods 1, 2 and 3, there were no significant differences in mean age, distribution by race, or history of cardiac co-morbidities. See Table 2. There was a difference between periods by gender, with 32.23% male in Period 1 (95% CI [26.6-38.4]), 30.2% in Period 2 (95% CI [24.7-36.4]) and 41% in Period 3 (95% CI [35.0-47.3]). There was no difference in MACE within 30 days of index EDOU visit between periods. Two patients in Period 1 (0.1%) returned within 30 days of their index visit and underwent PCI, and two patients in Period 3 (0.1%) returned and were found to have ACS and subsequently required PCI during that hospital visit. No patients in Period 2 returned to the hospital with MACE. Figure 2 has the details of the four patients with a 30-day MACE.

DISCUSSION

It is important to find ways to decrease radiation exposure to our patients. In this study, introduction of a simple ST algorithm that promotes Non-NucST options and limits NucST in EDOU CP patients decreased NucST utilization by almost 50%. This decrease in utilization of NucST was sustained over two years. One factor that may have contributed to this is that the algorithm is specific in limiting NucST only to the subset of patients with certain cardiac co-morbidities where nuclear testing is optimal. All other patients regardless of cardiac risk factors or other cardiac co-morbidities, such as history of coronary artery disease without revascularization or diastolic heart failure with preserved ejection fraction, are eligible for Non-NucST options. The algorithm included ST options that were consistent with current guidelines (ACC/AHA) and previously published algorithms.[7-10] However, it was important for our process improvement goal of decreasing radiation exposure to our EDOU CP patients that the algorithm be both specific in limiting NucST only to a subset of patients with certain cardiac co-morbidities where nuclear testing is optimal and be easy to use by our attending and resident staff. Although it is intuitive that radiation exposure will be less if non-NucST is used and preferred over NucST, this is the first study to attempt to quantify the decrease in radiation exposure after the algorithm initiation.

Although NucST does have higher sensitivity than Non-NucST (85% vs. 79%)[13] and has the advantage of being able to identify distinct lesion sites,[14] for most low-risk CP patients requiring stress testing in an EDOU setting, this higher sensitivity is not needed. Because the negative predictive values for ACSs and death are similar Non-NucST and NucST (96.6%-98.8% vs. 97.4%-98.4%), either could be used to safely discharge a patient if negative.[15] The findings of our study support this premise; in our subset analysis of the 714 randomly selected patients, there was no difference in 30-day rates of MACE before or after use of the ST algorithm. In the study by Buchsbaum et al of low cardiac risk patients who presented to the ED with CP, of the 138 who had normal stress echocardiograms, all were cardiac event free at three-month follow up and only one had a cardiac event at six months.[16] This is similar to what we found in our study.

Emergency physicians correctly ordered the appropriate stress test approximately 90% of the time suggesting the algorithm is easy to use and assimilate into practice. Therefore, this simple ST algorithm seems to be practical for clinical use in assigning which ST to choose for patients who are placed in an EDOU setting for evaluation of CP.

The AHA and the ACC guidelines for appropriate use of NucST imaging in the evaluation of CP suggest that NucST imaging in CP evaluation should be reserved for a distinct set of high-risk patients.[2,3] The importance of appropriate ST selection is re-emphasized, as patients with a longer life expectancy will also be at increased risk of cancer directly related to nuclear imaging.[6] Recently, Eisenberg et al. stated that patients exposed to low-dose ionizing radiation from cardiac imaging are unequivocally at an increased risk of cancer,[17] lending support in favor of Non-NucST when possible. Furthermore, use of Non-NucST options for evaluation of CP specifically in women (the majority in our study) is also supported by the AHA.[18] The necessity and utility of implementing such algorithms and guidelines is therefore clearly indicated and can be argued that it is also of some urgency. The U.S. radiation burden from nuclear cardiology increased from 1% of all radiation exposure to patients in 1982 to 10.5% of total radiation exposure in Americans in 2006. Clearly the increase in use of NucSt is substantial and the effects of such radiation to the population are unequivocally not without harm.[6,19]

In the U.S., approximately 10 million NucST are ordered per year.[4] The amount of radiation from a NucST using technetium (99Tc) tetrofosmin is 11.4mSv, which is equivalent to about 570 portable single view or 114 two-view chest radiographs.[5] The cancer risk projection of having this NucST at age 50 is estimated to result in a lifetime risk of 10 cancers per 10,000 tests.[6]

Given the 18.6% absolute risk reduction (40.7% reduced to 22.1%) of NucST after the new algorithm, the five-year estimated lifetime risk of cancer changed (assuming all were age 50) from 4.3 patients to 2.3 patients at this institution alone. To understand the potential national effect, extrapolating to the 10 million NucST/year (assuming the pre-

Table 1. Emergency department observation unit utilization patterns of nuclear versus non-nuclear stress tests.

Variable %(n) (95%CI)	Period 1 (before algorithm)	Period 2 (after algorithm)	Period 3 (after algorithm)
Nuclear stress tests	40.7% (n=644) (38.3%, 43.1%)	22.1% (n=363) (20.1%, 24.1%)	22.1% (n=412) (20.3%, 24.0%)
Non-nuclear stress tests	59.3% (n=940) (56.9%, 61.7%)	77.9% (n=1282) (75.9%, 79.9%)	77.9% (n=1455) (76.0%, 79.8%)

Table 2. Patient demographics, cardiac co-morbidities and major adverse cardiac events by period.

Variable mean (95% CI) or % (n) (95% CI)	Period 1 (before algorithm)	Period 2 (after algorithm)	Period 3 (after algorithm)
Age	55.3 (53.6-56.7)	55.0 (53.3-56.9)	55.2 (53.6-56.9)
% Male	32.2% (77/239) (26.6%-38.4%)	30.2% (71/235) (24.7%-36.4%)	41.0% (98/239) (35.0%-47.3%)
% Black	72% (162/225) (65.8%-77.5%)	81.4% (184/226) (75.8%-86.0%)	72.3% (167/231) (66.2%-77.7%)
H/o CAD	20.9% (50/239) (16.2%-26.5%)	14.0% (33/236) (10.1%-19.0%)	16.7% (40/239) (12.5%-22.0%)
H/o MI	10% (24/239) (6.8%-14.5%)	11.9% (28/236) (8.3%-16.6%)	12.2% (29/238) (8.6%-17.0%)
H/o PCI	11.3% (27/239) (7.9%-15.9%)	10.6% (25/236) (7.3%-15.2%)	15.5 (37/239) (11.4%-10.6%)
H/o CABG	5.4% (13/239) (3.2%-9.1%)	6.8% (16/236) (4.2%-10.7%)	4.6% (11/239) (2.6%-8.1%)
ACS within 30 days of index visit (%)	0.0% (0/239) (0.0%-1.6%)	0.0% (0/236) (0.0%-1.6%)	0.8% (2/239) (0.2%-3.0%)
PCI within 30 days of index visit (%)	0.8% (2/239) (0.2%-3.0%)	0.0% (0/236) (0.0%-1.6%)	0.8% (2/239) (0.0%-1.6%)
CABG within 30 days of index visit (%)	0% (0/239) (0.0%-1.6%)	0% (0/236) (0.0%-1.6%)	0% (0/239) (0.0%-1.6%)
Death within 30 days of index	0% (0/239) (0.0%-1.6%)	0% (0/236) (0.0%-1.6%)	0% (0/239) (0.0%-1.6%)

H/o, history of; *CAD*, coronary artery disease; *MI*, myocardial infarction; *PCI*, percutaneous coronary intervention; *CABG*, coronary artery bypass grafting; *ACS*, acute coronary syndrome

algorithm rate of NucST was similar and assuming all were 50 years old), the 18.6% reduction equates to an estimated reduction in lifetime risk of cancer for 1,860 patients/year after institution of the algorithm. While extrapolation nationally may not be accurate, it helps to understand the impact an 18.6% absolute risk reduction in NucST may have.

LIMITATIONS

The limitations of this study include the retrospective nature of the data collection and outcome analysis as well as it being a single-center study. A prospective multicenter study would be important to evaluate if use of this algorithm could be applied in other EDOU. In addition, the electronic medical record abstractors were not blinded to the study hypothesis. However, the recorded data were specific (which test was done and the results positive or negative, etc.) and were not readily open to interpretation that could contribute to bias. We did not control for the experiences of the emergency physicians. However, as the changes were sustained, it is likely not relevant to the outcomes whether or not the emergency physicians had more or less experience with the algorithm. The 30-day MACE follow-up data was limited in that only the hospital electronic medical record data were used; therefore, no individual follow up was performed (ex. phone calls) and patients presenting to other hospitals with adverse events within 30 days was not captured.

It has been argued that the low rates of 30-day MACE seen in low-risk ED CP patients may not warrant ST in this population[20,21] or that use of only serial contemporary biomarkers could be used to discharge patients from the ED without further index testing.[22,23] Current ACC/AHA guidelines for evaluation of low-risk CP patients recommend stress testing as part of the workup prior to ED or OU discharge or as an outpatient within 72 hours.[11] In our population of low-risk ED CP patients placed in our EDOU, most reside in a highly litigious county. Therefore, our emergency physicians are much less confident with the option of discharge from the ED. Furthermore, the significant proportion of uninsured patients and/or those without an established primary care physician coupled with

2008
84-year-old female; history of CAD, HTN, DM; non-diagnostic SPECT-MPI (adenosine ST showing "mild reversible defect of the anterior wall, probably attenuation artifact, possibility of mild ischemia cannot be ruled out."); 24 days later had an elective coronary catheterization and PCI with stenting.

76-year-old male; history of HTN and CAD with PCI; negative dobutamine echo ("non-ischemic ECG and echo response at the target heart rate achieved, adequate images"); 17 days later had an elective coronary catheterization and PCI with stenting.

2010
41-year-old male; history of HTN, tobacco use; negative SPECT-MPI (regodenoson ST with impression "no reversible ischemia"); four days later returned with unstable angina and had PCI with stenting.

65-year-old female; history of CAD, HTN, dyslipidemia; non-diagnostic dobutamine echo ("target heart rate and adequate double product not achieved") and a negative SPECT-MPI (regodenoson ST with impression "no reversible ischemia") during the same EDOU visit; nine days later returned with a STEMI and had PCI with stent, then PCI again two weeks later with stenting.

Figure 2. Patients with a major adverse cardiac event within 30 days of emergency department observation unit (EDOU) visit. *CAD*, coronary artery disease; *HTN*, hypertension; *DM*, diabetes mellitus; *SPECT-MPI*, single photon emission computed tomography myocardial perfusion imaging; *PCI*, percutaneous coronary intervention; *ECG,* electrocardiogram; *STEMI*, ST elevation myocardial infarction; *ST*, stress test

the challenge of available transportation and lack of assured availability of outpatient ST within 72 hours also makes this option less attractive.

CONCLUSION

For EDOU patients requiring CP evaluation with a ST, a simple algorithm favoring Non-NucST options and limiting NucST to a specific subset of patients reduced radiation exposure by almost 50% without a change in 30-day MACE. Emergency physician adherence to the algorithm was excellent.

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Acute Stroke: 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 a patient with a suspected stroke 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 a patient with a suspected stroke and augmented this review with guidelines from various national and international societies to create our evidence-based recommendations. We then compared the stroke protocols of each of the 33 EMS agencies for consistency with these recommendations. The specific protocol components that we analyzed were the use of a stroke scale, blood glucose evaluation, use of supplemental oxygen, patient positioning, 12-lead electrocardiogram (ECG) and cardiac monitoring, fluid assessment and intravenous access, and stroke regionalization.

Results: Protocols across EMS agencies in California varied widely. Most used some sort of stroke scale with the majority using the Cincinnati Prehospital Stroke Scale (CPSS). All recommended the evaluation of blood glucose with the level for action ranging from 60 to 80mg/dL. Cardiac monitoring was recommended in 58% and 33% recommended an ECG. More than half required the direct transport to a primary stroke center and 88% recommended hospital notification.

Conclusion: Protocols for a patient with a suspected stroke 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. [West J Emerg Med. 2016;17(2):104–128.]

INTRODUCTION

Each year, 795,000 people experience a new or recurrent stroke causing significant mortality and neurologic disability.[1] On average, every 40 seconds, someone in the United States has a stroke, accounting for one of every 18 deaths in the U.S.[1] Emergency medical services (EMS) plays a pivotal role in recognizing acute strokes and providing timely transport to hospitals

with specific stroke treatment capabilities. The optimal prehospital management and stroke system organization continue to evolve. EMS care varies widely across the U.S. The Institute of Medicine report, "Emergency Medical Services at the Crossroads," notes that EMS needs more uniform high-quality care and specific standards for evaluating that care.[2] One such standard is the prehospital protocol that EMS personnel follow while taking care of patients. Protocols vary widely between jurisdictions. We provide a summary of the evidence for the prehospital treatment of patients with suspected acute stroke and evaluate the consistency of California protocols.

METHODS

The state of California divides EMS care into 33 local EMS agencies (LEMSAs). One set of governmental medical control policies regulates first responders and ambulance transporters in each county-wide or region-wide system. Medical directors of those agencies, along with other interested EMS medical directors, make up the EMS Medical Directors Association of California (EMDAC). EMDAC supports and guides the various agencies and makes 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. Those recommendations and previous reviews are intended to assist medical directors of the various LEMSAs to develop high quality, evidence-based protocols.

A subcommittee of EMDAC developed this manuscript and chose by consensus the elements that should be included in any protocol for a patient with a suspected acute stroke. The subcommittee then created a narrative review of the existing evidence for prehospital treatment of a patient with a suspected acute stroke. Clinical questions regarding those interventions were developed in the population, intervention, control and outcome (PICO) format. Our population included those patients in the prehospital setting with a suspected acute stroke. The intervention varied by clinical question. The control consisted of patients who were not receiving the specific intervention, and outcomes were defined by accuracy of diagnosis and neurologic or imaging outcome after intervention.

We relied heavily on recommendations made by various organizations that have performed systematic reviews and meta-analyses regarding treatment interventions including the American Heart Association (AHA) and the International Liaison Committee on Resuscitation (ILCOR). We supplemented the recommendations from those organizations with additional literature searches through PubMed from 1966 to 2015 for each question. The primary literature review of PubMed searched for the term "Prehospital and Stroke." That yielded 476 articles, 86 of which were published in English, not review articles, and pertinent to the topics identified by the EMDAC subcommittee. That search was supplemented with additional PubMed searches for specific topics.

We assigned levels of evidence (LOE) and graded our recommendations based on the American College of Emergency Physicians (ACEP) process of creating their clinical policies with slight modification to better fit our objectives.[3] This 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. 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, we translated those to clinical grades of 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 based on only poor quality or minimal LOE III studies or based on consensus.

No Recommendation

No recommendation was given in those cases where only preliminary data or no published evidence exists and we had no expert consensus. We also withheld recommendation when studies, no matter their LOE, showed conflicting data.

After answering the clinical question and providing recommendations for diagnostic and treatment interventions, we reviewed each current acute stroke protocol for the 33 agencies for consistency with the recommendations. The clinical protocols were reviewed during the month of June 2015. We deemed institutional review board approval not necessary for this review of publicly available research and clinical protocols.

Use of a Stroke Scale

Clinical Question

Does the use of a prehospital stroke scale help identify

strokes in patients found with acute neurological deficits, and which stroke scale is most effective?

Summary of Current Evidence

Timely recognition is the most critical step in the prehospital care of a patient with an acute stroke. Sepsis, hypo- or hyperglycemia, seizure, tumor, intracranial hemorrhage, migraine, and syncope can all cause acute neurological deficits. If a stroke is correctly identified, the patient can be appropriately transported to a designated stroke center that can provide timely care, including tissue plasminogen activator (tPA) or endovascular therapy when appropriate. The misdiagnosis of stroke may lead to delayed care or inappropriate treatment. When not recognized in the field, the initial triage process frequently misses the stroke.[4] When EMS providers do not document a stroke scale, they are more likely to miss the diagnosis.[5,6]

There are many scoring systems to screen for an acute ischemic stroke in the field. EMS groups most commonly use Face Arm Speech Test (FAST), Cincinnati Prehospital Stroke Scale (CPSS) (most commonly used in California), or Los Angeles Prehospital Stroke Screen (LAPSS). Many of the more commonly used stroke scales are not designed to identify posterior circulation strokes.

FAST includes facial droop, arm weakness, speech difficulties, and time to seek medical help. FAST is simple to use and has shown reproducibility between physicians and paramedics.[7] It had a sensitivity of 79-85% and specificity of 68%.[8,9] However, FAST did not detect 38% of posterior cerebral circulation strokes.[7]

The CPSS includes three components – pronator drift, speech difficulties, and facial droop. Many studies have shown the reproducibility and validity of this scale between physicians and prehospital providers.[10] Sensitivity ranged from 44-95% and specificity was 23-96%.[5,6,8,10-16] With a score of two, it predicted patients receiving thrombolytic therapy with a 96% sensitivity and 65% specificity, although that has been studied less.[17] The CPSS, like the FAST, is limited in that it was designed to identify middle cerebral artery strokes.

Recently, the Cincinnati Prehospital Stroke Severity Scale (CPSSS) was developed to predict severe anterior ischemic strokes and large vessel occlusions (LVO).[18] Unlike the CPSS, the CPSSS grades the severity of the stroke. The scale gives two points for conjugate gaze deviation and one point for incorrectly answering at least one of two level of consciousness questions (age or current month).[18] The scale further gives one point for not following at least one of two commands (close eyes, open and close hand) and one point for not holding an arm up for 10 seconds.[18] CPSSS greater than or equal to two was 89% sensitive and 73% specific for National Institute of Health Stroke Scale (NIHSS) greater than or equal to 15, which predicts LVO.[18] The recognition of LVOs may become more important as stroke systems develop and as advanced therapies show more efficacy.

The LAPSS is only used for patients over 45 years of age with an absence of history of seizure disorder, symptom duration less than 24 hours, and a blood glucose range of 60-400mg/dL.[19] It detects unilateral weakness in facial grimace, handgrip and arm strength.[19] With those criteria, LAPSS was designed to decrease the false positive rate of CPSS. Paramedics using LAPSS demonstrated a sensitivity of 74-98%, with a specificity of 44-97%, PPV 86%, and NPV 98%.[8,11,12,19,20]

Los Angeles Motor Scale (LAMS) assigns values to the points on the LAPSS to assess severity, giving a score of zero through 10 with bilateral weakness or zero through five with unilateral weakness.[8,21,22] LAMS quickly and effectively assesses for LVO. LAMS demonstrated a sensitivity of 81%, specificity of 89%, and accuracy of 85% for LVO if the LAMS score was four or higher.[21] LAMS correlated closely with NIHSS and predicted three-month outcome.[22]

The Melbourne Ambulance Stroke Screen (MASS) includes speech difficulties plus the components of the LAPSS. In contrast with LAPSS, blood glucose range begins at 50mg/dL.[8,11,14] Age must be greater than 45 years, and there must be no history of seizure or epilepsy. Patient must be ambulatory at baseline. Sensitivity was found to be as high as 83-98% with a specificity of 44-86% and 100% sensitivity for ischemic strokes eligible for thrombolytic therapy.[8,11,14]

If the patient does not have a history of seizures, symptom duration greater than 25 hours, or blood glucose outside 60-400mg/dL, the Medic Prehospital Assessment for Code Stroke (Med PACS) can rule in a stroke. Under those circumstances, it evaluates facial droop, gaze, arm and leg weakness and speech.[8] Sensitivity ranged from 44-74% with specificity 32-98%.[8,16]

The Recognition of Stroke in the Emergency Room (ROSIER) score assesses facial, arm, or leg weakness, speech, and visual field deficits. Blood glucose must be >62mg/dL. Scores range from -2 to 5, with a score less than or equal to zero indicating a low likelihood of stroke. Seizure or syncope are scored as -1.[8,13,23] It demonstrated a sensitivity of 80-89% and a specificity of 79-83%.[8,13] Physicians confirmed 64% of strokes and 78% of non-strokes identified by ambulance clinicians with ROSIER.[23]

The most common scale used in the hospital setting is the NIHSS. For prehospital assessment, the shortened version was developed, including assessment of gaze, visual field, motor function of the right and left leg, language, level of consciousness, facial paresis, and dysarthria.[8,24] It attempts to predict stroke severity but is more complicated than some of the other stroke scales. With its complexity, it can evaluate strokes outside of the middle cerebral artery distribution.

The Kurashiki Prehospital Stroke Scale (KPSS) is applied after a stroke is recognized by another stroke

scale, such as the CPSS. It awards 13 points assessing consciousness, motor weakness, and speech.[8,25-29] When used for recognition, sensitivity ranged from 83-86% and specificity ranged from 60-69% for detecting stroke.[8] A KPSS score of 3-9 predicts candidates for tPA with a sensitivity of 84% and specificity of 93%.[26] It is a simpler scale than the full NIHSS but showed good correlation with the NIHSS when used by emergency medical technicians and can predict long-term outcome.[25,28,29]

The Maria Prehospital Stroke Scale Score (MPSS) can be used both to identify strokes and to determine stroke severity. It grades facial droop, arm drift and speech disturbances, and the score predicts tPA use.[30] The Rapid Arterial Occlusion Evaluation (RACE) scale is also based on the NIHSS to evaluate LVO via assessment of facial palsy, arm motor function, leg motor function, gaze, and aphasia or agnosia.[31] The scale showed strong correlation with the NIHSS, sensitivity of 85%, and specificity of 68%.[31]

With the development of endovascular capable centers, the recognition of LVO may become more important, and the use of scales such as CPSSS, NIHSS, and KPSS may be useful in grading stroke severity and making destination decisions.

Current Prehospital Treatment Recommendation

Level A Recommendation

- A stroke scale should be used in the prehospital setting for any patient with an acute neurological deficit to rapidly assess and triage patients with possible stroke.
- There is currently no practical prehospital scale that accurately detects strokes outside of the middle cerebral artery distribution.
- CPSS and LAPSS are the most validated and most frequently used scales.

Level B Recommendation

- None given.

Level C Recommendation

- In the future, scales such as CPSSS, NIHSS and KPSS may be added to gauge stroke severity and direct transport to a higher level of care, e.g. comprehensive rather than basic stroke receiving center.

Blood Glucose Evaluation

Clinical Question

Should paramedics measure glucose and administer dextrose in hypoglycemic patients in cases of suspected stroke?

Summary of Current Evidence

Hypo- and hyperglycemia both mimic stroke.[32] It is critical to measure glucose levels when there is concern for a possible stroke. This will differentiate between stroke and hypoglycemia. Symptoms such as hemiparesis, hemiplegia, speech or visual disturbances, confusion, and poor coordination can all present in patients with hypoglycemia and can be corrected with administration of dextrose.[33-35] While symptoms such as tremulousness and altered behavior may occur with milder degrees of hypoglycemia, focal stroke-like neurological symptoms, such as hemiplegia, typically do not manifest until glucose levels are less than 45mg/dL.[36-38] There is a clear benefit to giving dextrose to those patients with glucose below 45mg/dL. That treatment will differentiate between those having stroke-like symptoms from hypoglycemia and those truly having a stroke.

However, it is less clear if dextrose should be routinely given to patients with mild coincidental hypoglycemia. A bolus administration of dextrose typically results in an acute, transient (less than one hour) elevation in serum glucose into a hyperglycemic range.[39-41] The utility and safety of dextrose administration in patients with large focal neurological deficits but mild, possibly non-contributory hypoglycemia may need to be evaluated in the future. Hyperglycemia can also present as a stroke mimic, and elevated blood glucose on admission correlates with worse outcomes after stroke, specifically infarct expansion,[42-48] and with intracranial hemorrhage after tPA.[49,50]

Current Prehospital Treatment Recommendation

Level A Recommendation

- Blood glucose should be checked in every patient with suspected stroke.
- Patients with hypoglycemia (glucose below 45mg/dL) should be treated with dextrose.

Level B Recommendation

- Stroke mimics are unlikely to be found in those hypoglycemic patients with a glucose of greater than 45mg/dL.

Level C Recommendation

- None given

Supplemental Oxygen

Clinical Question

Does the prehospital administration of oxygen to patients with normal oxygen saturations improve outcomes in cases of suspected acute ischemic stroke?

Summary of Current Evidence

Every stroke patient should be assessed initially for airway compromise and treated accordingly. Airway compromise occurs more frequently in older patients, those with a severe stroke, or those with symptoms of dysphagia. Approximately 63% of patients with a hemiparetic stroke develop hypoxia.[51]

The evidence for oxygen use is less clear for normoxic

patients. One randomized study compared the effect of 3L/min oxygen treatment for 24 hours versus no supplemental oxygen treatment on acute stroke patients and demonstrated no difference in survival and disability scores in those receiving oxygen.[52] One a priori subgroup analysis of those with a more severe stroke demonstrated a statistically significant worsening of survival with supplemental oxygen. Several factors limited the conclusions of that study: a portion of the treated patients did not receive oxygen, patients had late time to therapy, and the study included hemorrhagic stroke patients. A more recent randomized trial with relatively few patients demonstrated short-term improvements but no long-term clinical differences between those given supplemental oxygen and those given no treatment.[53] The research on this subject is limited.

Current practice for acute stroke patients includes the use of supplementary oxygen to maintain oxygen saturation above 94%.[32,54] Beyond 94%, oxyhemoglobin is saturated and no further physiologic benefit is derived.

Current Prehospital Treatment Recommendation

Level A Recommendation

- None given

Level B Recommendation

- Oxygen should be delivered to a titrated dose of 94% oxygen saturation

Level C Recommendation

- None given

Patient Positioning

Clinical Question

In what position should patients with possible strokes be transported?

Summary of Current Evidence

No clinical outcome studies exist to define the optimal position for transporting a patient with an acute stroke. A small number of studies evaluate blood flow and other secondary measures that might be useful in answering that question.

For patients with head injuries, setting the head of bed at 30 degrees alleviates elevated intracranial pressure.[55,56] However, patients with strokes typically do not have elevated intracranial pressure. Cerebral blood flow and cerebral perfusion pressure both improved when the patient was put into the supine position.[57,58] Mean flow velocity increased in patients with persistent occlusions when they were laid flat.[59,60] The sitting position in patients who had suffered strokes caused reduced blood flow distal to the occlusion.[61] When measured with tissue oxygenation index, cerebral oxygenation dropped in the upright patient and rose in the supine patient.[62] Factors such as secretions, congestive heart failure, or respiratory distress frequently confound the acute stroke patient and preclude laying the patient flat because of effects on oxygen saturation and secretions. Oxygen saturation improved in stroke patients sitting upright, but that improvement was minimal.[63,64] Positioning patients on their sides minimally affected oxygen saturation.[63,65] Additionally, stroke patients frequently have sensory deficits in the laryngopharynx that can lead to aspiration.[66] The evidence supports laying the head of the bed flat as tolerated in patients with suspected stroke.

Current Prehospital Treatment Recommendation

Level A Recommendation

- None given

Level B Recommendation

- None given

Level C Recommendation

- Patients should be laid flat as tolerated, unless precluded by clinical issues such as compromised respiratory status, secretions, or aspiration risk.

12-Lead ECG and Cardiac Monitoring

Clinical Question

Should a 12-lead ECG or cardiac monitoring routinely be performed in the prehospital setting for patients with suspected stroke?

Summary of Current Evidence

Cardiac monitoring detects significant cardiac pathology that can cause stroke or occur concurrent with stroke. Monitoring leads to earlier intervention. It is recommended in the prehospital setting and throughout the first 24 hours of care.[32]

Stroke patients frequently have cardiac arrhythmias or ECG abnormalities including ST segment depression, prolonged QTc interval, atrial fibrillation, T-wave inversion, conduction defects, premature ventricular beats, and left ventricular hypertrophy.[67,73] One study showed ECG abnormalities in 60% of patients with cerebral infarction and 44% of patients with transient ischemic attack (TIA).[67] In some of those events, such as atrial fibrillation, the cardiac event may have led to the stroke. In others, such as ST segment depressions, it is poorly understood why stroke patients develop ST segment depressions after their cerebral event. Atrial fibrillation, atrio-ventricular block, ST elevation, ST depression, and inverted T waves predicted mortality in patients with ischemic stroke.[67,72] Care in units with cardiac monitoring led to improved outcomes at discharge, likely because of earlier intervention.[69] The non-specific ECG changes do not change management in the prehospital setting, but significant arrhythmias may change management.

Current Prehospital Treatment Recommendation

Level A Recommendation

- None given

Level B Recommendation

- In patients with suspected stroke, a 12-lead ECG should be acquired and interpreted by prehospital or other emergency providers in a timely manner as long as it does not delay transport to a facility with tPA capabilities.

Level C Recommendation

- In a patient presenting with signs or symptoms of stroke and ST segment elevation myocardial infarction (STEMI), EMS should consider bypassing the nearest tPA capable facility for a facility with a catheterization lab.

Fluid Assessment and Vascular Access

Clinical Question

Should normal saline be routinely given to patients with suspected stroke, and what type of vascular access should be attempted?

Summary of Current Evidence

No strong evidence supports or refutes routinely giving fluid boluses to stroke patients. Patients who have suffered a stroke are typically either euvolemic or hypovolemic.[32] Hypotension occurs infrequently after stroke but leads to poor outcomes.[74] A variety of hydration regimens on normotensive stroke patients resulted in no conclusive standard fluid regimen.[75-82] A bolus of intravenous (IV) fluid acutely improved cerebral perfusion in focal ischemia from subarachnoid hemorrhage-induced vasospasm, a clinical scenario similar to ischemic stroke.[83,84]

It is useful to start a large bore IV access in any patient with a suspected stroke who may be receiving tPA and who could have subsequent hemorrhage. However, transport should not be delayed for this. Because of bleeding risk, multiple attempts at starting IV access should be limited. No studies negate or support the use of intraosseous access in stroke patients, but it is more invasive and carries theoretical greater risk of bleeding.

Current Prehospital Treatment Recommendation

Level A Recommendation

- None given

Level B Recommendation

- None given

Level C Recommendation

- Patients with low systolic blood pressure and no contraindications should be given a bolus of IV fluids.
- An IV should be placed as long as it does not delay transport and more than two attempts are not required.
- An IV should not be placed in the external jugular vein.

Stroke Regionalization

Clinical Question

What parameters should be outlined in the stroke protocol to direct expeditious and appropriate transport? Should there be dispatch at high priority, documentation of time patient was "last seen normal," limiting time on scene, hospital notification, transport to primary or comprehensive stroke center (CSC), and retriage from primary to CSCs?

Summary of Current Evidence

Early use of IV tPA is more effective at one hour than at three hours.[85] It should not be used outside of the four and a half hour window. Recent AHA recommendations endorse the use of endovascular therapy after tPA for persistent LVOs.[86] The efficacy of that therapy is also time sensitive. Thus, EMS protocols must guide timely evaluation and transport to appropriate facilities for those definitive interventions.

EMS should dispatch responders to suspected stroke patients with a high priority and attempt to shorten the time between the receipt of the call and the delivery of the patient to the emergency department. On initial history, responders must document "last seen normal time."[32] Use of specific language, rather than using the standard EMS run times, facilitates clear communication. Furthermore, paramedics can facilitate tPA delivery and definitive care by obtaining a medication list and pre-thrombolysis check list as well as the physician orders for life sustaining treatment (POLST). AHA recommends call to dispatch time of less than 90 seconds, EMS response time less than eight minutes, and an on-scene time less than 15 minutes.[32] Higher priority of dispatch and hospital notification of a stroke both led to shorter times from ambulance call to arrival,[87] assessment by a doctor,[4] door to needle time,[57,87-91] and door to imaging time.[22,88,92-95] Patients received tPA more frequently at hospitals notified prior to patient arrival.[10,90,94-96] Another study showed that one way to decrease on scene time was to explicitly direct an on-scene time of 15 minutes or less. That led to reductions in on-scene time over those with no instructions and those with general instructions to limit on scene time.[97]

A study published in 2010 concluded that 22% of people living in the continental U.S. have access to a primary stroke center (PSC) within 30 minutes, 43% have access within 45 minutes, and 55% have access within 60 minutes.[98] Fewer patients have timely access to a CSC. Patients admitted to designated stroke centers versus community hospitals had increased tPA delivery rates.[99] Additionally, admitting patients to designated stroke centers versus community hospitals was associated with increased tPA rates and decreased 30-day mortality.[100] In a centralized model, where

patients were transported to a stroke center preferentially over a community hospital, EMS transports occurred more frequently, they were given higher priority, more false positives were identified, more patients received tPA, and door-to-needle times were shorter.[101,102]

Throughout the U.S., more communities are shifting to a two-tiered system that includes PSCs and CSCs. Both assess for strokes and deliver tPA, but the CSCs also offer endovascular recanalization to patients with persistent LVOs. In light of the new AHA recommendations, that intervention is an evolving standard of care. The existence of both presents a transport dilemma to EMS. Should a patient with a suspected stroke be sent immediately to a CSC or initially to a PSC? If transport time to the CSC is longer, would it benefit the patient to go initially to the PSC to get tPA? As discussed above, some stroke scales can help to identify severity of stroke. In the future, these may direct transport decisions. The limited sensitivity and specificity of existing stroke scales may cause increased transport time in patients with a false positive on the stroke scale and delay in tPA administration for acute stroke patients with a false negative.

In California, hospitals sought PSC certification more frequently after counties developed protocols directing transport of patients with strokes to PSCs.[103] EMS protocols indicating patients should go to PSCs may be beneficial for the patients and may also drive changes in hospital certification. A number of novel interventions such as Stroke Emergency Mobile Units or the incorporation of telemedicine may influence organization of stroke systems in the future.[104-128]

Current Prehospital Treatment Recommendation

Level A Recommendation

- Time "last seen normal" should be documented.
- Suspected stroke patients should have a high-priority dispatch.
- Hospitals should be notified of a suspected stroke patient prior to arrival.

Level B Recommendation

- Scene times should be minimized and be 15 minutes or less if practical.
- Patients with a possible stroke should be transported to the nearest facility with tPA capabilities, preferably a PSC or CSC.

Level C Recommendation

- The integration of CSCs into EMS systems is rapidly evolving. Stroke systems should include formalized, rapid processes for higher level of care transports of patients with persistent LVOs to CSCs.

Interfacility tPA

Clinical Question

Should tPA be delivered to patients by paramedics with confirmed strokes being transferred to CSCs for a higher level of care?

Summary of Current Evidence

The majority of acute stroke patients will be assessed and imaged at a PSC or community hospital. A subset of those patients will not respond to tPA and will require timely endovascular therapy at a CSC. The tPA infusion will need to be continued during transport. Recent studies indicate that this combination of tPA followed by endovascular intervention for persistent LVOs is rapidly becoming the standard of care.[86]

The use of prehospital tPA presents several logistical challenges. One study showed poor compliance with monitoring of blood pressure, delivery of antihypertensives and discontinuation of tPA with worsening neurological status. Despite these differences, there were similar neurological outcomes and intracranial hemorrhage rates between patients in whom guidelines were followed rigorously and those in whom they were not.[129] Their mean transport time from PSC to CSC was 38 minutes +/- 20 minutes.[129] There are also logistical issues such as the implementation of infusion pumps in the field and the fact that tPA is not in the current scope of practice of paramedics in California.

Some areas are successfully sending nurses from the initial hospital with the patient and the tPA running in a hospital pump. That model avoids the complications of training paramedics in delivery of tPA and the use of new pumps. The practice is still evolving and requires further study.

Current Prehospital Treatment Recommendation

Level A Recommendation

- None given

Level B Recommendation

- None given

Level C Recommendation

- tPA should be initiated promptly on patients with confirmed strokes and no contraindications and, for persistent LVO, they should be transported as quickly as possible to a CSC for possible endovascular therapy.
- It is the responsibility of the sending physician to select appropriate means of transport and the appropriate level of the transporting staff.

RESULTS

We reviewed protocols from all 33 LEMSAs within the state of California. Some LEMSAs had individualized stroke protocols, while others had stroke protocols embedded within those for altered mental status.

Use of a Stroke Scale

Most (85%) LEMSAs directed the use of a stroke scale (See Table 1). The majority used CPSS. Of the 15% that did not specifically use a stroke scale, 9% recommended specific neurological exams that encompassed major key components of a stroke scale.

Blood Glucose Evaluation

All LEMSAs recommended evaluation of blood glucose as part of their protocols for patients with suspected strokes (See Table 2). Seventy-three percent recommended a titrated dose of dextrose to correct low blood glucose. The titrated dose ranged from 60 to 80mg/dL.

Supplemental Oxygen

Twenty-one percent of the LEMSAs advised routine use of oxygen regardless of oxygen saturation (See Table 3). Thirty-nine percent of LEMSAs advised a titrated dose of oxygen. The oxygenation goal of titration ranged from 94 to 100%.

Patient Positioning

Three percent of LEMSAs recommend laying the head of bed flat as tolerated. Some (15%) recommend elevating the head of bed, and 21% recommend the lateral decubitus position (See Table 4).

12-lead ECG and Cardiac Monitoring

Fifty-eight percent of LEMSAs recommended cardiac monitoring, and 33% recommended a 12-lead ECG in patients with suspected strokes (See Table 5). Of those, some recommended both and some recommended one or the other.

Normal Saline Administration or Fluid Assessment

Eighteen percent of LEMSAs recommended a normal saline bolus (See Table 6). Almost half (48%) recommended an IV line with minimal fluid. Twelve percent of LEMSAs gave direction about IV line location, gauge, or number of attempts.

Stroke Regionalization

More than half (52%) of LEMSAs directed transport of patient to a stroke center. Eighty-eight percent recommended hospital notification from the field (See Table 7). Eighty-two percent of LEMSAs recommended documentation of duration of symptoms. Of those, most recommended documentation of "last seen normal." Sixty-one percent of LEMSAs gave explicit directive to limit time on the scene, but only nine

Table 1. Use of a stroke scale.

LEMSA	Use of a stroke scale	Type of stroke scale	Emergent large vessel occlusion scale
Alameda County EMS agency	Yes	Cincinnati prehospital stroke scale	No
Central California EMS agency	No	N/A	No
City and County of San Francisco EMS agency	Yes	Cincinnati prehospital stroke scale	No
Coastal Valleys EMS agency	Yes	Cincinnati prehospital stroke scale	No
Contra Costa County	Yes	Cincinnati prehospital stroke scale	No
El Dorado County EMS agency	Yes	Cincinnati prehospital stroke scale	No
Imperial County EMS agency	Yes	LAPSS	
Inland EMS agency	Yes	Modified LAPSS	
Kern County EMS agency	Yes	Cincinnati prehospital stroke scale	No
Los Angeles County EMS agency	Yes	mLAPSS	No
Marin County EMS agency	Yes	Cincinnati prehospital stroke scale	No
Merced County EMS agency	No	N/A	No
Monterey County EMS agency	Yes	BEFAST	No
Mountain Valley EMS agency	Yes	Cincinnati prehospital stroke scale	No

LEMSA, local EMS agencies; EMS, emergency medical services; *LAPSS,* Los Angeles Prehospital Stroke Screen

percent gave a specific time limit.

Interfacility tPA

No LEMSAs commented on tPA during interfacility transport.

CONCLUSION

Stroke is a complicated disease process. The science guiding optimal identification and treatment of stroke patients is evolving. Because of the difficulty in identifying stroke patients and the importance of their rapid transport to stroke centers, stroke presents a complex challenge for prehospital providers. The evidence-based recommendations presented in this paper will inform EMS medical directors and guide creation of protocols for identifying and treating stroke patients.

Table 1. Continued.

LEMSA	Use of a stroke scale	Type of stroke scale	Emergent large vessel occlusion scale
Napa County EMS agency	Yes	Cincinnati prehospital stroke scale	No
Northern California EMS agency	Yes	Cincinnati prehospital stroke scale	No
North Coast EMS agency	No	Motor weakness, paralysis, speech distrubances, aphasia, headache, visual problems altered mental status	
Orange County EMS agency	No	No seizure prior to or during arrival, last seen normal within seven hours, GCS 10 or greater, and pronator drift or facial paresis	No
Riverside County EMS agency	Yes	Cincinnati prehospital stroke scale	No
Sacramento County EMS agency	Yes	Cincinnati prehospital stroke scale	No
San Benito County EMS agency	Yes	If <6 hours, Cincinnati prehospital stroke scale	No
San Diego County EMS agency	Yes	Cincinnati prehospital stroke scale	No
San Joaquin County EMS agency	Yes	Cincinnati prehospital stroke scale	No
San Luis Obispo County EMS agency	Yes	FAST	No
San Mateo County EMS agency	Yes	Cincinnati prehospital stroke scale	No
Santa Barabara County EMS agency	Yes	Cincinnati prehospital stroke scale	No
Santa Clara County EMS agency	Yes	Santa Clara County stroke scale - balance problems, diplopia, facial droop, arm drift, speech abnormalities, time last seen normal <6 hours	
Santa Cruz County EMS agency	Yes	Cincinnati prehospital stroke scale	No
Sierra-Sacramento EMS agency	Yes	Cincinnati prehospital stroke scale	No
Solano County EMS agency	Yes	Cincinnati prehospital stroke scale	No
Tuolumne County EMS agency	No	Weakness or paralysis on one side of the body/ face, slurred speech, speech difficulty, difficulty with balance, inability to understand, difficulty in naming objects, confusion, difficulty swallowing, headache, visual disturbances (double vision, blindness, paralysis of extra-ocular muscles)	No
Ventura County EMS agency	Yes	Cincinnati prehospital stroke scale	No
Yolo County EMS agency	Yes	Cincinnati prehospital stroke scale	No
	85%		

LEMSA, local EMS agencies; EMS, emergency medical services; *mLAPSS,* modified Los Angeles prehospital stroke screen; BEFAST, balance eyes face arm speech time; *GCS,* glasgow coma scale; FAST, face arm speech time

Table 2. Blood glucose in patients with suspected stroke. Glucagon dose in various prehospital protocols is listed in units milliliters and milligrams according to local protocol. We have copied them verbatim to demonstrate variation in presentation and practice.

LEMSA	Advise routine evaluation of BS	Advise titrated dose	Titration dose	Dextrose 10%	Notes
Alameda County EMS agency	Yes	No	N/A	Yes	
Central California EMS agency	Yes	Yes	80mg/dL with persistent AMS	Yes (25g IV)	
City and County of San Francisco EMS agency	Yes	Yes	60mg/dL	No	If BS<60 or known diabetic, dextrose 50%
Coastal Valleys EMS agency	Yes	Yes	60-80mg/dL	Yes (150mL IV of D10)	Glucagon 1mg IM if no IV access; recheck BS if symptoms not resolved; repeat additional dextrose 10% 100mL IV if glucose 60-80 or less; Dextrose 50% 25g IV if glucose 60-80 after 250mL Dextrose 10%. If Dextrose 50% unavailable, repeat Dextrose 10%.
Contra Costa County	Yes	Yes	60mg/dL	Yes	Check and treat if indicated
El Dorado County EMS agency	Yes	Yes	60mg/dL	No	25gm of 50% dextrose, if no IV then 1gm glucagon
Imperial County EMS agency	Yes	Yes	60mg/dL	No	Dextrose 50% 25gm IV or glucagon 1mg IM if no IV
Inland EMS agency	Yes	No	N/A	No	
Kern County EMS agency	Yes	Yes	60-80mg/dL	Yes	Use appropriate protocol to rule out narcosis/hypoglycemia then re-enter CVA protocol if indicated
Los Angeles County EMS agency	Yes	Yes	60mg/dL	No	Oral glucose if awake and alert, 50% 50mL, glucagon if no IV 1mg IM; if BS remains <60, repeat dextrose 50, repeat glucagon Q20min x2
Marin County EMS agency	Yes	No	N/A	No	
Merced County EMS agency	Yes	Yes	75mg/dL	No	25gm IV if BS<75mg/dL, glucagon 1 U IM if no IV; repeat dextrose in 3-5 min if no response and continued hypoglycemia. Oral glucose if known diabetic and intact gag.
Monterey County EMS agency	Yes	Yes	70mg/dL	No	D50% 25gm IV if BS<70
Mountain Valley EMS agency	Yes	Yes	60mg/dL	No	25gms IV push; if BS<60mg/dL, repeat 1x; recheck BS in 5min after each dose; if no IV with BS<60, give glucagon 1U IM, may repeate 1x, recheck BG 5min after each dose
Napa County EMS agency	Yes	Yes	60mg/dL	Yes	Glucose paste 15gm PO if pt able to hold head upright, has gag reflex and can self-administer med; or D10% IV 25g 250mL or if no IV, D10% IO; if symptoms reverse and BS >60, slow D10% to remainder of dose; if no improvement after 5 minutes after D10% and BS still <60, give another D10% in 5g increments at 5-10min intervals reassessing BS levels and mental status every 5min
Northern California EMS agency	Yes	Yes	75mg/dL	No	Glucose paste po if suspected hypoglycemia, adequate gag reflex, hold head upright; check BS, then D50 up to 35 gm IV if BS<75; repeat 25 gm IV x1 in 5min if BS still <75; if altered LOC and BS<75 and no IV, 1mg glucagon IM; no glucose if suspected CVA unless BS<75; if BS>250 treat with 500cc NS

LEMSA, local EMS agencies; *BS,* blood sugar; *EMS,* emergency medical services; *IM,* intramuscular; *CVA,* cerbrovascular accident; *IV,* intravenous; *BG,* blood glucose; *PO,* per os (by mouth)

Table 2. Continued.

LEMSA	Advise routine evaluation of BS	Advise titrated dose	Titration dose	Dextrose 10%	Notes
North Coast EMS agency	Yes	No	N/A	No	
Orange County EMS agency	Yes	Yes	80mg/dL	No	Oral glucose if airway reflexes intact, 50% dextrose 50mL IV, may repeat x1 if BS<80; glucagon 1mg IM if IV unable; IO ok for 50% dextrose if unable IV and no response to glucagon
Riverside County EMS agency	Yes	No	N/A	No	
Sacramento County EMS agency	Yes	No	N/A	No	
San Benito County EMS agency	Yes	Yes	70mg/dL	No	Treat as needed
San Diego County EMS agency	Yes	Yes	60mg/dL	No	If patient awake and gag, give 3 oral glucose tabs or paste (15g total); D50 25gm IV SO if BS<60; if pt remains symptomatic and BS remains <60 MR SO; if no IV, glucagon 1ml IM SO if BS<60
San Joaquin County EMS agency	Yes	Yes	60mg/dL	No	Paste if known diabetic, can hold head upright, can self-administer medication and has intact gag; If BS<60, then D50% 25gm or D10 50cc IV/IO bolus repeated every min until GCS 15; max dose D10 is 10cc/kg
San Luis Obispo County EMS agency	Yes	No	N/A	No	
San Mateo County EMS agency	Yes	Yes	80mg/dL	No	Avoid hyperglycemia
Santa Barabara County EMS agency	Yes	Yes	60mg/dL	Yes	If low BS suspected PO 15 g if BS<60, pt awake and able to swallow safely; if unable to swallow safely, glucagon IM 1 mg; if <60 and not able to swallow, D10W 25 mg IVP, glucagon if no IV; recheck BG 5 min after IV D bolus complete or 10 min after glucagon admin; if still <60, D10 IV 250 cc
Santa Clara County EMS agency	Yes	Yes	80mg/dL	No	If suspected hypoglycemia, 1 tube oral glucose paste, repeat in 5-15 min if no improvement; if BS<80, no oral/can't oral D50 25 gm IVP; if no improvement, repeat dextrose or glucagon 1 mg IM; if no IV, and BS<80 and no improvement, glucagon 1mg IM
Santa Cruz County EMS agency	Yes	Yes	70mg/dL	No	Treat as needed
Sierra-Sacramento EMS agency	Yes	No	N/A	No	
Solano County EMS agency	Yes	Yes	60mg/dL	No	Treat hypoglycemia
Tuolumne County EMS agency	Yes	Yes	75mg/dL	No	25-50 gms IV push; 1 U IM glucagon if no IV access
Ventura County EMS agency	Yes	Yes	60mg/dL	Yes	If low BS suspected, PO 15 gm; If <60, D10W 10gm (preferred), D5W 10gm, D50W 12.5gm; Glucagon 1mg IM if no IV access Recheck BS 5 min after Dex or 10 min after glucagon; if still <60 D10W preferred or D5 or D50
Yolo County EMS agency	Yes	No	N/A	No	
	100%	73%		24%	

LEMSA, local EMS agencies; *BS,* blood sugar; *EMS,* emergency medical services; *IV,* intravenous; *IO,* intraosseous infusion; *SO,* standing orders; *IM,* intramuscular; *GCS,* glasgow coma scale; *PO,* per os (by mouth); *BG,* blood glucose

Table 3. Oxygen administration in patients with suspected stroke.

LEMSA	Advise routine use regardless of SpO2%	Advise titrated dose	Titration dose	Advise against with normal SpO2%	Notes
Alameda County EMS agency	No	Yes	94-99%	No	
Central California EMS agency	Yes	No	N/A	No	Low flow for suspected stroke (6L/min NC)
City and County of San Francisco EMS agency	No	No	N/A	No	Oxygen as indicated
Coastal Valleys EMS agency	No	Yes	94-98%	No	
Contra Costa County	No	Yes	94%	No	Low flow for BLS
El Dorado County EMS agency	No	No	N/A	No	Appropriate rate
Imperial County EMS agency	No	Yes	94%	Yes	
Inland EMS agency	No	No	N/A	No	
Kern County EMS agency	No	Yes	94%	No	Monitor/pulse oximetry
Los Angeles County EMS agency	No	No	N/A	No	As needed
Marin County EMS agency	No	No	N/A	No	
Merced County EMS agency	Yes	No	N/A	No	High flow, as tolerated
Monterey County EMS agency	No	No	No	No	Routine medical care
Mountain Valley EMS agency	No	No	N/A	No	As appropriate
Napa County EMS agency	No	Yes	94-97%	No	
Northern California EMS agency	Yes	No	N/A	No	
North Coast EMS agency	Yes	No	N/A	No	Oxygen therapy
Orange County EMS agency	No	Yes	95%	No	High flow mask if oxygen sat less than 95%
Riverside County EMS agency	No	No	N/A	No	
Sacramento County EMS agency	No	Yes	94%	No	Use lowest flow rate possible
San Benito County EMS agency	No	Yes	95%	No	Treat life threats
San Diego County EMS agency	No	Yes	94-98%	Yes	
San Joaquin County EMS agency	No	No	N/A	No	
San Luis Obispo County EMS agency	No	No	N/A	No	Evaluate for hypoxia
San Mateo County EMS agency	No	No	N/A	No	As indicated
Santa Barabara County EMS agency	Yes	No	N/A	No	High flow for spO2<95%, low flow for >95%
Santa Clara County EMS agency	No	No	N/A	No	
Santa Cruz County EMS agency	No	No	N/A	No	Treat life threats
Sierra-Sacramento EMS agency	Yes	Yes	94-100%	No	2L NC
Solano County EMS agency	Yes	No	N/A	No	High flow as tolerated
Tuolumne County EMS agency	No	No	N/A	No	As appropriate
Ventura County EMS agency	No	Yes	94%	No	
Yolo County EMS agency	No	Yes	94%	No	
	21%	39%			

LEMSA, local EMS agencies; *EMS,* emergency medical services; *NC,* nasal cannula; *BLS,* basic life support

Table 4. Patient positioning.

LEMSA	Recommend elevating head of bed	Lateral decubitus	Head of bed flat as tolerated	Notes
Alameda County EMS agency	No	No	Yes	Transport patient in supine position unless evidence of increasing ICP/intracranial hemorrhage, transport in semi fowlers with no more than 30 degrees head of bed elevation
Central California EMS agency	No	No	No	
City and County of San Francisco EMS agency	No	No	No	Position of comfort
Coastal Valleys EMS agency	No	No	No	
Contra Costa County	No	No	No	
El Dorado County EMS agency	No	No	No	
Imperial County EMS agency	Yes	Yes	No	
Inland EMS agency	No	No	No	
Kern County EMS agency	No	No	No	
Los Angeles County EMS agency	No	No	No	
Marin County EMS agency	No	No	No	
Merced County EMS agency	No	Yes	No	If not contraindicated by injuries, place patient in left lateral decubitus position
Monterey County EMS agency	No	No	No	
Mountain Valley EMS agency	No	No	No	
Napa County EMS agency	No	No	No	
Northern California EMS agency	Yes	No	No	30 degrees
North Coast EMS agency	Yes	Yes	No	Upright if gag reflex intact, left lateral with head elevated if gag reflex absent
Orange County EMS agency	No	No	No	
Riverside County EMS agency	No	No	No	Position patient as clinically indicated to meet physiologic requirements
Sacramento County EMS agency	No	No	No	
San Benito County EMS agency	No	Yes	No	Patients with depressed mentation or decreased gag reflex should be placed in a left lateral position
San Diego County EMS agency	No	Yes	No	If secretion problems place on affected side
San Joaquin County EMS agency	No	No	No	
San Luis Obispo County EMS agency	No	No	No	
San Mateo County EMS agency	Yes (unless spinal immobilization indicated)	No	No	
Santa Barabara County EMS agency	No	No	No	
Santa Clara County EMS agency	Yes	No	No	

LEMSA, local EMS agencies; *EMS,* emergency medical services; *ICP,* intracranial pressure

Table 4. Continued.

LEMSA	Recommend elevating head of bed	Lateral decubitus	Head of bed flat as tolerated	Notes
Santa Cruz County EMS agency	No	Yes	No	If depressed mentation or decreased gag reflex
Sierra-Sacramento EMS agency	No	No	No	
Solano County EMS agency	No	Yes	No	Position of comfort, left lateral decubitus if vomiting
Tuolumne County EMS agency	No	No	No	
Ventura County EMS agency	No	No	No	
Yolo County EMS agency	No	No	No	
	15%	21%	3%	

LEMSA, local EMS agencies; *EMS,* emergency medical services

Table 5. 12 Lead ECG and cardiac monitoring in patients with suspected stoke.

LEMSA	Consider 12 Lead ECG	Advised cardiac monitoring	Notes
Alameda County EMS agency	Yes	No	Obtain 12-Lead ECG when a dysrhythmia or ACS symptoms are present (specifically watch for STEMI and/or A fib)
Central California EMS agency	No	Yes	Treat any arrhythmia
City and County of San Francisco EMS agency	No	No	
Coastal Valleys EMS agency	Yes (if possible)	No	
Contra Costa County	No	Yes	
El Dorado County EMS agency	No	No	
Imperial County EMS agency	Yes (consider)	Yes (consider)	
Inland EMS agency	Yes (consider)	No	
Kern County EMS agency	Yes	Yes	
Los Angeles County EMS agency	Yes (only if arrhythmia on monitor)	Yes	
Marin County EMS agency	No	No	
Merced County EMS agency	No	Yes	Treat rhythm as appropriate
Monterey County EMS agency	No	No	Routine medical care
Mountain Valley EMS agency	No	Yes	
Napa County EMS agency	Yes	No	Treat rhythm as appropriate
Northern California EMS agency	Yes (do not delay rapid transport)	Yes	
North Coast EMS agency	No	Yes	
Orange County EMS agency	No	Yes	
Riverside County EMS agency	No	No	
Sacramento County EMS agency	No	Yes	

LEMSA, local EMS agencies; *ECG,* echocardiogram; *EMS,* emergency medical services; *ACS,* acute coronary syndrome; *STEMI*, ST elevated myocardial infarction

Table 5. Continued.

LEMSA	Consider 12 Lead ECG	Advised cardiac monitoring	Notes
San Benito County EMS agency	No	No	
San Diego County EMS agency	No	Yes	Monitor ECG
San Joaquin County EMS agency	No	Yes	ECG monitoring, Treat rhythm disturbances as appropriate
San Luis Obispo County EMS agency	Yes (consider)	No	
San Mateo County EMS agency	No	Yes	
Santa Barabara County EMS agency	No	Yes	
Santa Clara County EMS agency	No	No	Cardiac monitoring and ECG when medic suspects patient may have cardiac ischemia or any dysrhythmias
Santa Cruz County EMS agency	No	No	
Sierra-Sacramento EMS agency	Yes (if no delay in transport or patient care)	Yes	
Solano County EMS agency	No	Yes	
Tuolumne County EMS agency	No	Yes	ECG monitoring
Ventura County EMS agency	No	Yes	
Yolo County EMS agency	Yes	No	
	33%	58%	

LEMSA, local EMS agencies; *ECG,* echocardiogram; *EMS,* emergency medical services

Table 6. Normal saline administration.

LEMSA	Advise NS bolus	Advise defined bolus quantity	Advised TKO	Location	Notes
Alameda County EMS agency	No	No	Yes	Yes	No more than 1 AC attempt and no more than 2 IV attempts total, 18 GA, no smaller than 20 GA proximal to wrist, AC preferred
Central California EMS agency	No	No	Yes	No	
City and County of San Francisco EMS agency	No	No	Yes	No	NS TKO, If SBP<90 or poor perfusion, NS bolus
Coastal Valleys EMS agency	No	No	Yes	No	
Contra Costa County	Yes (If hypotensive or poorly perfused)	Yes (consider 250-500 cc if hypotensive)	Yes	No	
El Dorado County EMS agency	No	No	Yes	No	Twin cath or a second line is preferred for thrombolytic candidates. Limit IV attempts to two.
Imperial County EMS agency	No	No	No	No	IV prn
Inland EMS agency	No	No	No	No	Vascular Access
Kern County EMS agency	No	No	No	No	IV Line/Saline lock
Los Angeles County EMS agency	No	No	No	No	Venous access prn

LEMSA, local EMS agencies; *NS,* normal saline; *TKO,* to keep open; *EMS,* emergency medical services; *AC,* antecubital; *IV,* intravenous; *GA,* gauge; *SBP,* systolic blood pressure*; prn,* pro re nata (when necessary)

Table 6. Continued.

LEMSA	Advise NS bolus	Advise defined bolus quantity	Advised TKO	Location	Notes
Marin County EMS agency	No	No	No	No	
Merced County EMS agency	Yes	Yes (If SBP less than 90, then 500cc fluid boluses as indicated)	Yes	No	
Monterey County EMS agency	Yes (if appropriate)	No	No	No	
Mountain Valley EMS agency	No	No	Yes	No	
Napa County EMS agency	No	No	Yes	No	
Northern California EMS agency	Yes	No	Yes	No	Don't delay rapid transport to establish IV, SBP at a minimum of 120mmHg, do not exceed 1.5L NS
North Coast EMS agency	No	No	Yes	No	
Orange County EMS agency	No	No	No	Avoid IO and EJ	
Riverside County EMS agency	No	No	No	No	
Sacramento County EMS agency	No	No	No	No	
San Benito County EMS agency	No	No	No	No	
San Diego County EMS agency	Yes	Yes	No	IV/IO adjust *prn*	250cc IV/IO with clear lungs to maintain BP≥120
San Joaquin County EMS agency	No	No	No	No	10cc/kg bolus if signs of shock present, max of 2L
San Luis Obispo County EMS agency	No	No	No	No	Establish vascular access
San Mateo County EMS agency	No	No	No	No	Consider IV/IO
Santa Barabara County EMS agency	Yes (500cc to keep SBP >100, Max 1L)	No	Yes	No	
Santa Clara County EMS agency	No	No	No		18G catheter minimum for CT scan, AC placement if possible. No more than 2 IV attempts
Santa Cruz County EMS agency	No	No	No	No	IVF if suspected shock
Sierra-Sacramento EMS agency	No (May bolus up to 1L)	No	Yes	No	
Solano County EMS agency	No	No	Yes	No	
Tuolumne County EMS agency	No	No	Yes	No	IV if HTN, in unstable IO OK if unable to gain IV access
Ventura County EMS agency	No	No	No	No	IV/IO access
Yolo County EMS agency	No	No	Yes	No	
	18%	9%	48%	12%	

LEMSA, local EMS agencies; *NS,* normal saline; *TKO,* to keep open; *EMS,* emergency medical services; *SBP,* systolic blood pressure; *IO,* intraosseous infusion; *EJ,* external jugular; *IV,* intravenous; *prn,* pro re nata (when necessary); *BP,* blood pressure; *CT,* computed tomography; *AC,* antecubital; *IVF,* intravenous fluids; *HTN,* hypertension

Table 7. Stroke regionalization.

LEMSA	Advise documenting the duration of symptoms	Limit time on the scene	Transport to a stroke center	Hospital prenotification	Notes	Designated primary stroke centers	Comprehensive stroke centers	ReTriage from primary to comprehensive
Alameda County EMS agency	Yes ("Last seen normal")	Yes	Yes	Yes		Yes	No	No
Central California EMS agency	Yes ("Last seen normal")	Yes	No	Yes		No	No	No
City and County of San Francisco EMS agency	No	Yes	Yes	No	If potential stroke is suspected with symptoms for 4.5 hours or less, immediately transport patient to a designated Stroke receiving hospital	No	No	No
Coastal Valleys EMS agency	Yes ("Time of onset" or "last time patient known to be at baseline")	Yes	No	Yes		No	No	No
Contra Costa County	Yes ("Last seen normal")	Yes	Yes	Yes		Yes	No	No
El Dorado County EMS agency	Yes ("Time of onset")	Yes (15 minutes)	Yes	Yes		No	No	No
Imperial County EMS agency	Yes ("Time of onset")	Yes	No	Yes	Take patient to hospital with CT if suspected stroke and alert receiving hospital early.	No	No	No
Inland EMS agency	Yes ("Last seen normal")	Yes	Yes (NSRC)	Yes	Transport Immediately	No	No	No
Kern County EMS agency	Yes ("Onset observed within 4 hours")	No	Yes (appropriate facility)	Yes	Transport to appropriate facility in accordance with stroke policy	Yes	No	No
Los Angeles County EMS agency	Yes ("Time of sypmtom onset" and "last known well time")	No	Yes	Yes		No	No	No

LEMSA, local EMS agencies; *EMS,* emergency medical services; *CT,* computed tomography; *NSRC,* neurovascular stroke receiving center

Table 7. Continued.

LEMSA	Advise documenting the duration of symptoms	Limit time on the scene	Transport to a stroke center	Hospital prenotification	Notes	Designated primary stroke centers	Comprehensive stroke centers	ReTriage from primary to comprehensive
Marin County EMS agency	Yes ("Last known normal"	No	Yes	Yes	Call stroke if last seen normal <4 hours, rapid transport to patient's preferred Primary Stroke Center, PSC as long as the estimated transport time is not more than 15 minutes longer than the nearest PSC; Preferred PSC: patient's preference or PSC with patient's medical records; No preferred PSC: transport to the closest PSC; Early Stroke Notification	No	No	No
Merced County EMS agency	No	Yes	No	No		No	No	No
Monterey County EMS agency	Yes ("Last known well")	Yes (15 minutes)	Yes	Yes		No	No	No
Mountain Valley EMS agency	Yes ("Time of onset")	No	No	No		No	No	No
Napa County EMS agency	Yes ("Time of onset")	Yes	Yes (CVA receiving Center)	Yes		No	No	No
Northern California EMS agency	Yes ("Last seen normal")	Yes	No	Yes		No	No	No
North Coast EMS agency	No	Yes	No	Yes	Transport code 3 if unconscious or conscious with progressive symptoms. Code 2, for others	No	No	No
Orange County EMS agency	Yes ("Time of onset")	No	Yes	Yes		No	No	No
Riverside County EMS agency	Yes ("last known well")	Yes (limit scene time to 10 minutes or less)	Yes	Yes		No	No	No

LEMSA, local EMS agencies; *EMS,* emergency medical services; *CVA,* cerebrovascular accident; *PSC,* primary stroke center

Table 7. Continued.

LEMSA	Advise documenting the duration of symptoms	Limit time on the scene	Transport to a stroke center	Hospital prenotification	Notes	Designated primary stroke centers	Comprehensive stroke centers	ReTriage from primary to comprehensive
Sacramento County EMS agency	Yes ("Last observed to be normal")	No	Yes (if CPSS>0 and time of onset 4 hours or less)	Yes		No	No	No
San Benito County EMS agency	Yes ("Time since symptoms onset/ last time seen in premorbid state")	No	No	Yes		No	No	No
San Diego County EMS agency	Yes ("Last time known normal")	Yes	Yes	Yes	For suspected stroke with major deficit with onset of symptoms <4 hrs, expedite transport	Yes	No	No
San Joaquin County EMS agency	No	Yes	No	Yes		No	No	No
San Luis Obispo County EMS agency	Yes ("Last seen normal")	No	No	Yes		No	No	No
San Mateo County EMS agency	Yes ("Time seen at Baseline")	Yes (if symptoms present for <7 hrs)	No	Yes		No	No	No
Santa Barabara County EMS agency	Yes ("Last time seen normal")	Yes	No	Yes	Consult with ED physician for further treatment measures	No	No	No
Santa Clara County EMS agency	Yes ("Last seen normal")	No	Yes (if last seen normal <6 hrs)	Yes		No	No	No
Santa Cruz County EMS agency	Yes ("Time since symptoms onset/ last time seen in premorbid state")	No	No	Yes		No	No	No
Sierra-Sacramento EMS agency	Yes ("Time of onset of symptoms or when patient last seen normal")	No	Yes (If symptoms <4 hours and within 30 min of stroke receiving center)	Yes		No	No	No

LEMSA, local EMS agencies; *EMS,* emergency medical services; *CPSS,* cincinnati prehospital stroke scale; *ED,* emergency department

Table 7. Continued.

LEMSA	Advise documenting the duration of symptoms	Limit time on the scene	Transport to a stroke center	Hospital prenotification	Notes	Designated primary stroke centers	Comprehensive stroke centers	ReTriage from primary to comprehensive
Solano County EMS agency	Yes ("Time of symptom onset")	Yes	No	Yes		No	No	No
Tuolumne County EMS agency	No	No	No	No		No	No	No
Ventura County EMS agency	Yes ("Time last known well")	Yes	Yes	Yes		No	No	No
Yolo County EMS agency	No	No	Yes (stroke symptoms less than or equal to 4.5 hours and within 45 min of stroke receiving center)	Yes		No	No	No
	82%	61%	52%	88%				

LEMSA, local EMS agencies; *EMS*, emergency medical services

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Factors Associated with First-Pass Success in Pediatric Intubation in the Emergency Department

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Introduction: The objective of this study was to investigate the factors associated with first-pass success in pediatric intubation in the emergency department (ED).

Methods: We analyzed the data from two multicenter prospective studies of ED intubation in 17 EDs between April 2010 and September 2014. The studies prospectively measured patient's age, sex, principal indication for intubation, methods (e.g., rapid sequence intubation [RSI]), devices, and intubator's level of training and specialty. To evaluate independent predictors of first-pass success, we fit logistic regression model with generalized estimating equations. In the sensitivity analysis, we repeated the analysis in children <10 years.

Results: A total of 293 children aged ≤18 years who underwent ED intubation were eligible for the analysis. The overall first-pass success rate was 60% (95%CI [54%-66%]). In the multivariable model, age ≥10 years (adjusted odds ratio [aOR], 2.45; 95% CI [1.23-4.87]), use of RSI (aOR, 2.17; 95% CI [1.31-3.57]), and intubation attempt by an emergency physician (aOR, 3.21; 95% CI [1.78-5.83]) were significantly associated with a higher chance of first-pass success. Likewise, in the sensitivity analysis, the use of RSI (aOR, 3.05; 95% CI [1.63-5.70]), and intubation attempt by an emergency physician (aOR, 4.08; 95% CI [1.92-8.63]) were significantly associated with a higher chance of first-pass success.

Conclusion: Based on two large multicenter prospective studies of ED airway management, we found that older age, use of RSI, and intubation by emergency physicians were the independent predictors of a higher chance of first-pass success in children. Our findings should facilitate investigations to develop optimal airway management strategies in critically-ill children in the ED. [West J Emerg Med. 2016;17(2):129–134.]

INTRODUCTION

Successful airway management is a critical intervention to stabilize and resuscitate severely-ill and injured children in the emergency department (ED). The importance of first-pass success – successful intubation on the first attempt – has been emphasized as the goal of emergency intubation because

studies have demonstrated associations of repeated intubation attempts with higher complication rates.[1,2] Children are known to have a limited physiologic reserve.[3] Therefore, identifying factors associated with first-pass success in this vulnerable population is essential. A few small studies have reported that the intubator's specialty and the use of rapid sequence intubation (RSI) were the factors associated with first-pass success.[4,5] However, in contrast to a study from North America that demonstrated the use of RSI was associated with a higher first-pass success,[5] another study from South Korea found no association between the use of RSI and first-pass success rate.[4] Therefore, despite the apparent clinical importance, predictors of first-pass success among children in the ED remain largely unknown. To address this knowledge gap in the literature, we analyzed the data from two large multicenter studies of emergency airway management to investigate the predictors of first-pass success in children.

METHODS

Study Design and Settings

We conducted a secondary analysis of the data from the Japanese Emergency Airway Network (JEAN) -1 and -2 studies that are designed to characterize current airway management in the EDs across Japan. The study setting, methods of data collection, and measured variables of these studies have been reported elsewhere.[2,6-13] Briefly, the JEAN is a consortium of 17 academic and community EDs from different regions across Japan. These EDs had a median of 30,000 patient visits in the ED per year (range, 4,200-67,000), and pediatric patients were treated in all EDs. All EDs of JEAN-1 and JEAN-2 participating centers were staffed with emergency physicians (EP). The institutional review board at each participating institution approved the study with a waiver of informed consent.

Selection of Participants

The JEAN studies collected information on all patients who underwent intubation attempts in the ED from April 2010 through September 2014. Among these patients, children aged ≤18 years were included in the present study. We excluded children with the use of cricothyroidotomy, tracheostomy, or nasotracheal intubation on the first intubation attempt.[4]

Data Collection and Processing

After each intubation encounter in the ED, the intubator completed a standardized data collection form.[9,14] Measured variables were age, sex, principal indication for intubation, methods of intubation, all medications used to facilitate intubation, intubation devices, intubator's level of training and specialty, intubation success or failure, and intubation-associated adverse events.[2,7-12]

Statistical Analyses

The outcome measure of interest was success on the first intubation attempt (first-pass success). An attempt was successful if it resulted in a tracheal tube being placed through the vocal cords, with confirmation by quantitative or colorimetric end-tidal carbon dioxide monitoring.[9,14] To examine independent predictors of first-pass success, we fit a logistic regression model with the generalized estimating equations accounting for patient clustering within the EDs. Based on clinical plausibility and a priori knowledge, we chose a set of patient-level variables: age, sex, principal indication for intubation, intubation methods, intubation devices, and intubator's training level and specialty.[4,11,15] Age variables were treated as the categorical variable according to a previous study.[4] The significance of clinically meaningful interactions was tested as a group to avoid inflating type I error. Specifically, we tested for (intubator's specialty −×− the use of RSI) interactions using likelihood ratio test; however, preliminary results did not indicate the presence of any effect modifications (data not shown). In the sensitivity analysis, we repeated the analysis in children <10 years based on the literature.[4] Analysis was conducted with JMP version 10.0.2 (SAS Institute Inc., Cary, NC) and R version 3.1.3 (R Development Core Team, Vienna, Austria).[16] We considered two-sided $P<0.05$ statistically significant.

RESULTS

Of the 8,192 patients who underwent emergency airway management during the study period, 7,786 were recorded in the studies (capture rate, 96%). Of these, 300 were children. After excluding seven children who underwent cricothyroidotomy, tracheostomy, or nasal intubation, the remaining 293 children were eligible for the current study.

Overall, the median age of children was six years (IQR, 1-15 years), and 43% were female (Table 1). The intubations for medical indications accounted for two-thirds of intubations. Cardiac arrest (both medical and traumatic arrests) accounted for approximately 30%. Rapid sequence intubation (RSI) was used in approximately one-fourth of children. Direct laryngoscope was used in more than 90% of the first intubation attempts. EPs (including emergency medicine residents) performed approximately 40% of the first intubation attempts. The overall success rate on first intubation attempt was 60% (95% CI, 54%-66%); success rate was lowest in children aged <2 years (50%; 95% CI, 40%-60%).

Table 2 summarizes the results of multivariable analysis. Children aged 10-18 years (adjusted odds ratio [aOR], 2.45; 95% CI, 1.23-4.87), use of RSI (aOR, 2.17; 95% CI, 1.31-3.57), and intubation attempt by an EP (aOR, 3.21; 95% CI, 1.78-5.83) or by another specialty (adjusted OR, 2.63; 95% CI, 1.51-4.55) were significantly associated with a higher chance of first-pass success. In the sensitivity analysis limiting to children aged <10 years, use of RSI (aOR, 3.05; 95% CI, 1.63-5.70) and intubation attempt by an EP (aOR, 4.08; 95% CI, 1.92-8.63) were also significant predictors of first-pass success.

Table 1. Characteristics and airway management of 293 pediatric patients receiving intubation in the emergency department.

Variables	Overall (n=293)	Age <2 years (n=94)	Age 2-9 years (n=87)	Age 10-18 years (n=112)
Patient characteristics				
Age, median (IQR), y	6 (1-15)	0 (0-1)	5 (3-7)	16 (13-17)
Weight, median (IQR), kg	20 (10-50)	7 (4-10)	18 (15-23)	45 (50-60)
Female sex	127 (43%)	46 (49%)	36 (41%)	45 (40%)
Primary indication				
Cardiac arrest	86 (29%)	29 (31%)	22 (25%)	35 (31%)
Medical encounters	138 (47%)	60 (64%)	39 (45%)	39 (35%)
Trauma encounters	69 (24%)	5 (5%)	26 (30%)	38 (34%)
Airway management				
Methods				
Rapid sequence intubation	76 (26%)	21 (22%)	19 (22%)	36 (32%)
Sedation without paralytics	70 (24%)	19 (20%)	28 (32%)	23 (21%)
No medication	134 (48%)	50 (53%)	35 (40%)	49 (44%)
Other*	13 (4%)	4 (4%)	5 (6%)	4 (4%)
Devices				
Direct laryngoscope	276 (94%)	94 (100%)	83 (95%)	99 (88%)
Video laryngoscope	12 (4%)	0 (0%)	3 (3%)	9 (8%)
Others†	5 (2%)	0 (0%)	1 (1%)	4 (4%)
Specialty				
Transitional year resident‡	53 (18%)	16 (17%)	10 (11%)	27 (24%)
Emergency physician§	127 (43%)	21 (22%)	39 (45%)	67 (60%)
Pediatrician	45 (15%)	28 (30%)	14 (16%)	3 (3%)
Other specialty‖	68 (23%)	29 (31%)	24 (28%)	15 (13%)
Number of intubation attempts until success				
1	176 (60%)	47 (50%)	51 (59%)	78 (69%)
2	69 (24%)	26 (28%)	20 (23%)	23 (21%)
3 or more	47 (16%)	20 (21%)	16 (18%)	11 (10%)
Unknown¶	1 (1%)	1 (1%)	0 (0%)	0 (0%)

IQR, interquartile range.
Data were expressed as n (%) unless otherwise indicated.
Percentages may not equal 100 due to rounding.
*Defined as intubation using topical anesthesia or paralytics without sedatives.
†Defined as flexible bronchoscope, or a combination of a gum elastic bougie with direct laryngoscope or video laryngoscope.
‡Defined as post graduate years 1 or 2.
§Including emergency medicine residents and emergency attending physicians.
‖Including anesthesiologists and surgeons.
¶The first intubation attempt was performed and failed in the emergency department, and the subsequent intubation attempts were performed in the operating room.

DISCUSSION

In this analysis based on two multicenter prospective studies of ED airway management, we found that the first-pass success rate in children was 60%. We also found that older age, use of RSI, and intubator's training level (beyond transitional year post-graduate year 1 or 2 resident) and specialty (e.g., EPs) were significant predictors of first-pass success in pediatric intubation. To our knowledge, this is the largest study to have examined children who underwent intubation in the ED. Our data build on previous smaller reports about the predictors of intubation success, a finding of clinical and research importance.

Table 2. Multivariable predictor of first-pass success of emergency intubation in pediatric patients.

	Primary model		Sensitivity analysis (age <10 years)	
Variables	Adjusted odds ratio (95% CI)	P value	Adjusted odds ratio (95% CI)	P-value
Age				
Age <2 years	[reference]	--	[reference]	--
Age 2-9 years	1.45 (0.74-2.84)	0.28	--	--
Age10-18 years	2.45 (1.23-4.87)	0.01	--	--
Age 2-7 years	--	--	1.38 (0.66-2.88)	0.39
Age 8-9 years	--	--	1.52 (0.47-4.89)	0.48
Sex				
Male	[reference]	--	[reference]	--
Female	0.64 (0.41-1.01)	0.05	0.69 (0.38-1.24)	0.21
Primary indication				
Cardiac arrest	[reference]	--	[reference]	--
Medical	0.56 (0.30-1.05)	0.07	0.61 (0.28-1.33)	0.21
Trauma	0.64 (0.29-1.40)	0.26	0.49 (0.17-1.45)	0.20
Methods				
non-RSI	[reference]	--	[reference]	--
RSI	2.17 (1.31-3.57)	0.002	3.05 (1.63-5.70)	<0.001
Devices				
Direct laryngoscope	[reference]		--¶	--
Video laryngoscope	0.31 (0.08-1.23)	0.10	--¶	--
Others*	0.24 (0.03-2.08)	0.20	--¶	--
Specialty				
Transitional year resident†	[reference]	--	[reference]	--
Emergency physician‡	3.21 (1.78-5.83)	<0.001	4.08 (1.92-8.63)	<0.001
Pediatrician	2.07 (0.96-4.47)	0.06	2.36 (1.11-4.97)	0.03
Other specialty§	2.63 (1.51-4.55)	0.001	2.39 (1.32-4.32)	0.004

CI, confidence intervals; *RSI*, rapid sequence intubation.
*Defined as flexible bronchoscope, or a combination of a gum elastic bougie with direct laryngoscope or video laryngoscope.
†Defined as post-graduate-years 1 or 2.
‡Including emergency medicine residents and emergency attending physicians.
§Including anesthesiologists and surgeons.
¶Excluded the intubation device variable from the multivariable analysis as only 4 intubation attempts were performed with video laryngoscope or other device in children aged <10 years.

To date, a body of evidence supports the importance of first-pass success of intubation in the ED.[1-4] Multiple intubation attempts were associated with increased rate of adverse events.[2] These adverse events may be due to children's limited cardiovascular and pulmonary reserves, which result in a limited ability to tolerate extended periods without proper ventilation and oxygenation.[3] Therefore, investigating factors associated with first-pass success becomes critical for children who require emergency airway management in the ED. There have been few studies that evaluated the predictors of first-pass success among children in the ED – older age, the use of RSI, and intubator's specialty were suggested as predictors.

In the present study, the older age was associated with a higher odds of first-pass success, consistent with previous studies.[5,17] We surmise that this finding is related to the increasingly adult-like airway anatomy as children age. In addition, EPs might be less familiar with the intubation for pediatric populations because pediatric ED intubation is an infrequent procedure.[18]

A multicenter study from South Korea (n=281) found no association between RSI use and first-pass success rates.[4] By contrast, a multicenter prospective study from North America (n=156) reported a significant association of RSI use with a higher first-pass success in the ED.[5] This discrepancy might be

attributable to differences in the study design, patient population, setting, training systems, or any combination of these factors. Our multicenter prospective data with the largest sample size and a high capture rate corroborate these findings and extend them by demonstrating the robustness of the associations between the use of RSI and high first-pass success in the ED. The rate of RSI use in the current study, however, was relatively lower compared to those in the previous findings[12,16] because there was a high degree of variation in airway management practices among the EDs in Japan (e.g., the proportion of RSI intubation in non-cardiac-arrest patients ranging from 0% to 79% across the EDs).[9] Nevertheless, to address this concern, we constructed a logistic regression model with the generalized estimating equations accounting for patient clustering within the EDs.

The use of video laryngoscope had a lower odds of first-pass success but was not significant in this study. This result was not consistent with the literature showing the superior effectiveness of RSI and video laryngoscope in the emergency airway management.[19,20] The potential explanation includes the presence of residual confounders between these factors and first-pass success (e.g., individual training level), the limited statistical power owing to the small number of video laryngoscope use, the use of video laryngoscope by novices, and random errors.

We also found that the intubator's training level and specialty was significantly associated with first-pass success. This finding is consistent with the South Korean study that reported intubator's specialty (i.e., EP) had an independent effect on a higher chance of first-pass success.[4] Emergency airway management in children should ideally be performed by a well-trained intubator in the ED. However, studies have reported that resident physicians have neither sufficient opportunity nor training with close supervision to become proficient at intubations because pediatric intubation is less-frequent procedure.[21,22] Attempting to provide the best possible care to children with limited resources in a system is a challenge. The current literature proposes solutions to improve intubation success through the use of video laryngoscope[23] and enhanced training (e.g., simulation-based curricula and supplemental operating room training).[24] However, these measures address only isolated aspects of the critical procedure. Our findings not only facilitate studies to identify optimal airway management strategies but also underscore the importance of continued efforts to improve the quality of emergency airway management in critically-ill children in the ED.

LIMITATIONS

The current study has several potential limitations. First, our data were subject to self-reporting bias. However, we used the previously applied standardized data collection system with uniform definitions and high capture rates.[9,14] Second, as with any observational study, the observed association might be confounded by unmeasured factors, such as underlying comorbidities and difficulty in intubation. Another potential confounding factor is individual intubator's skillset in airway management; however, we did adjust for intubator's level of training and specialty to help account for this possible confounder. Finally, our sample consisted predominantly of academic EDs in Japan; therefore, our inferences may not be generalizable to the other healthcare settings.

CONCLUSION

In summary, on the basis of two multicenter prospective studies of children who underwent emergency airway management in the ED, we found that older age, use of RSI, and intubator's training level and specialty were the independent predictors of first-pass success. Given the relatively lower rates of the use of RSI and video laryngoscope, our results encourage the use of RSI with standardized intubation protocol for pediatric emergency intubation and further investigations for first-pass success (e.g., the use of video laryngoscope). In addition, our findings should facilitate further investigation to improve the ability of clinicians to predict the intubation success and continued efforts to improve training systems, which will, in turn, lead to better outcomes in critically-ill children in the ED.

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Moving Beyond Screening: How Emergency Departments Can Help Extinguish the HIV/AIDS Epidemic

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While great strides have been made in diagnostic and treatment strategies, human immunodeficiency virus (HIV) remains a major public health epidemic. The Centers for Disease Control and Prevention (CDC) Morbidity and Mortality Weekly Report article, "Vital Signs: HIV Diagnosis, Care, and Treatment Among Persons Living with HIV – United States, 2011," highlights current areas of concern regarding HIV diagnosis and care. The CDC estimates that 1.2 million people in the U.S. are living with HIV. Of them, 86% have received a diagnosis (14% remain undiagnosed and unaware), but only 40% are engaged in care and a mere 30% are virally suppressed. Emergency departments (EDs) can play a major role in combatting the HIV epidemic through regular screening and facilitating linkage to chronic HIV care. Universal opt-out screening as recommended by the CDC in 2006 has been shown to be effective but expensive, and has not been widely implemented in EDs nationwide. Cost-effective models and a renewed commitment from ED providers are needed to enhance ED-based HIV containment strategies. [West J Emerg Med. 2016;17(2):135–138.]

CDC MORBIDITY AND MORTALITY WEEKLY REPORT FINDINGS

In the November 28, 2014 issue of the Morbidity and Mortality Weekly Report (MMWR), the Centers for Disease Control and Prevention (CDC) published data and trends concerning human immunodeficiency virus (HIV) diagnosis and care. The report demonstrates that, despite advances in medical therapy that make HIV highly manageable, the proportion of individuals living with HIV who are virally suppressed is unacceptably low.

The CDC found that in 2011, an estimated 1.2 million individuals were living with HIV in the United States. Of those, 86% had been diagnosed, but only 40% were engaged in care, 37% were prescribed antiretroviral therapy (ART), and 30% had achieved viral suppression. Of the 70% who had not achieved viral suppression, 20% were unaware of their HIV status, 66% were diagnosed but were never engaged in care, 4% received care but were never prescribed ART, and 10% were prescribed ART but never achieved viral suppression. Viral suppression was similarly poor among Blacks and Whites but significantly lower in younger adults compared with older individuals.

The MMWR article also reported that of the newly diagnosed individuals in 2011, only 80% were linked to medical care within three months. Even lower linkage rates were observed among younger individuals (73% for those 13-24), and Blacks (76%). Of those who did engage in HIV treatment, 92% were prescribed ART and 76% achieved viral suppression. ART has been shown to decrease the rate of HIV transmission by 96% and dramatically increase life expectancy. An individual diagnosed with HIV at age 20 who immediately starts and continues ART treatment can be expected to live to age 71, approaching the average lifespan of 79. An individual diagnosed at age 20 who does not initiate ART treatment is expected to live only to age 32.[1]

COMMENTARY

Advances in HIV treatment have transformed the natural

history of this illness from one of near-certain death within a decade to one best conceptualized through a chronic care model. So effective are the treatment options that some have audaciously challenged the healthcare system to produce an "Acquired immunodeficiency syndrome (AIDS)-Free Generation,"[2] Although ambitious, we may well have the medical treatments needed to fulfill this challenge. In order for one to be virally suppressed, multiple barriers must be overcome. First, the person must be tested and diagnosed with HIV. Next, he or she must be linked to an HIV care provider and be prescribed ART. Finally the patient must be adherent with medications and routinely monitored for viral suppression. In practice, patients fall off at each step of this "HIV Care Continuum."[3]

In their role as safety net providers, emergency departments (EDs) play a key role in both the diagnosis of HIV and linkage to HIV-specific care. HIV infection is particularly well-suited to screening efforts because 1) it is life-threatening and can be detected long before symptoms develop; 2) rapid, non-invasive and inexpensive tests are available for early detection;[4] 3) if diagnosed and treated, infected people gain decades of life expectancy;[1] 4) mere identification of HIV-infected individuals dramatically reduces risk behaviors and transmission rates;[5] 5) the cost-effectiveness of treatment has been proven;[6] and 6) EDs serve a safety net population that has a high burden of undiagnosed infection and are unlikely to be screened elsewhere.[7]

These features that would tend to favor HIV screening in the ED have been undercut by cost concerns, legal requirements for consent and, perhaps most importantly, social stigma. Stigma surrounding HIV create an impression that HIV infection marks an individual's failure to adhere to sex or drug norms and directly results in shame, embarrassment and isolation. Fear of these stigma causes at-risk people to shun healthcare professionals, lie about risk factors and avoid HIV testing and/or information.[8] For many the stigma of HIV makes asking for the test prohibitive.[9] The World Health Organization cites stigma as a dominant reason for not being tested, not lack of access to the test.[10] These stigma impact physicians as well who may be reticent to offer HIV testing so as not to offend their patients.[11] These issues coupled with legal requirements that demanded significant pre- and post-test counseling made HIV testing in a time-limited setting such as an ED infeasible.

In 2006, the CDC acted to counter these prevailing barriers to screening by calling for non-targeted, "opt-out" HIV screening for all patients aged 13-64 in all settings where the prevalence of undiagnosed HIV was greater than 1 in 1000. (Nearly all EDs meet this threshold.) In calling for non-targeted screening, the CDC was attempting, in part, to remove the embarrassment/stigma associated with asking to provide or receive the test. The proposed mantra became "we test everyone" regardless of risk and being offered the test does not label the patient as "high risk." The CDC further reduced HIV "exceptionalism" by recommending opt-out testing that does not require separate written consent – putting HIV testing in line with almost all other testing practices.[12]

In general, albeit slowly, state legislatures have followed the CDC recommendations, and most states have removed special written consent for HIV testing. California, for example requires only a verbal opt-out consent process that essentially amounts to telling the patient he or she is going to be tested and conducting the test, unless the person specifically declines. Specific counseling or documentation of test acceptance is not required. In such a context, opt-out screening is accepted by over 90% of patients.[13] However, a positive result can cause significant emotional distress, and such results should be disclosed professionally and with psychological and social assistance available.

Despite these powerful guidelines and legal changes, EDs have been slow to implement routine testing. A 2009 survey found that though 82% of EDs offer some type of HIV testing, only 22% do so in a systematic way, and merely 7% do so using the suggested "opt-out" model.[14] Now, the greatest barrier to providing optimal HIV screening cited by EDs is cost.[15] Indeed, the ideal cost model is a matter of significant debate. One estimate shows that universal opt-out screening results in costs of $9,900 per new HIV diagnosis. Though cost-effective by traditional standards (e.g. <$50,000 per quality-adjusted life year saved), this is nonetheless an expensive strategy.[16] Another proposed model uses the Denver HIV risk score. The Denver HIV risk score stratifies patients into risk groups based on demographic characteristics and risk behaviors (which are obtained by structured interview), and diagnostic HIV tests are only performed on those at higher risk. Preliminary data show that this method can detect similar numbers of HIV infections with fewer tests and up to 20% lower costs ($7,800 per new HIV diagnosis) compared to a more universal opt-out strategy.[17] A large multicenter clinical trial is currently underway to test the cost and effectiveness of the two strategies head-to-head. Regardless of which approach prevails, it bears emphasizing that both require screening all patients for HIV. The Denver score simply uses the risk tool as the initial screen and relies less on diagnostic testing, while the universal, opt-out approach relies solely on diagnostic testing.

While diagnosis is a critical first step towards virologic suppression and controlling further infection (once a person is diagnosed with HIV, risk behaviors drop precipitously),[5] it is not sufficient. Linking newly diagnosed patients to care is vital and has been proven to be feasible.[18-20] The precise linkage team composition and services provided will depend on individual ED volume and resources but may include nurses, physicians, case-managers, social workers and/or patient navigators. Ultimately, this team helps deliver positive

test results, provides HIV counseling, offers case management services, assists with transportation, provides social services and facilitates linkage to care with the goal of seeing a provider who can prescribe ART.[19] In fact, designated HIV linkage teams consisting of a nurse practitioner, registered nurse, and social worker successfully linked 93.9% of newly diagnosed patients to long-term care.[20]

Although finding undiagnosed cases remains a centerpiece of combating the HIV epidemic, the overwhelming majority of people with uncontrolled HIV infection are well aware of their condition.[1] ED-based screening programs note that the majority of patients who have a positive HIV test were likewise aware of their HIV status and many were recognized by the treating physicians as having HIV.[21] HIV is a common chronic illnesses seen in the ED (up to 7.8% of the ED population).[21] Seemingly, repeating the HIV test in these circumstances adds little, and efforts to eliminate these wasteful tests should be pursued. However, an additional benefit of opt-out screening with a robust linkage team is that it can be used to re-link known HIV positive individuals who have fallen out of care. In one of the largest ED-based HIV screening programs in the country, investigators in Houston demonstrated that the linkage strategies associated with their opt-out screening program boosted engagement in care from 41.3% to 58.8% among patients with known HIV infection. Retention in care and virologic suppression were likewise substantially enhanced (from 32.6% to 47.1% and 22.8% to 34% respectively). The effect was most pronounced among younger patients (age 16-24) who saw retention in care increase from 15% to 37%.[19] So, while efforts to minimize redundant HIV testing among those known to be HIV positive should be pursued, so should efforts to ensure that those with chronic HIV infection are appropriately linked to care.

Thirty years into the epidemic, HIV is now unquestionably a manageable, chronic disease. However, despite our ability to manage the illness, only 30% of those infected are virologically suppressed and 14% are unaware of their infection.[1] EDs are often the primary or sole healthcare provider for patients with chronic uncontrolled HIV and treat a patient population with a high prevalence of undiagnosed HIV and, as such, must be part of a comprehensive solution to the epidemic. Many questions remain open: Should universal screening be based solely on diagnostic testing or some combination of risk assessment and testing? What is the most cost-effective formulation of a linkage team? How can we best leverage health records to reduce duplicate testing while still targeting out-of-care individuals? What payment models will sustain these efforts? Research is ongoing to answer each of these questions. What can no longer be in question, however, is the need for EDs throughout the nation, particularly those that espouse to serve as safety net providers for vulnerable people, to be, at a minimum, willing partners and, on occasion, leaders in the audacious pursuit of an AIDS-free generation.

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Growing Trend of Alternative Tobacco Use Among the Nation's Youth: A New Generation of Addicts

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The Centers for Disease Control and Prevention (CDC) has published significant data and trends related to the rising epidemic of usage of alternate forms of tobacco among the nation's youth. For the first time ever, the use of the electronic cigarette (e-cigarrette) has surpassed traditional cigarette usage in adolescents. E-cigarettes are battery-operated products designed to deliver aerosolized nicotine and other flavors to the consumer. Most look like conventional cigarettes but some resemble everyday items such as pens, USB drives, and memory sticks.[1] In the following article, we present findings from the CDC's Morbidity and Mortality Weekly Report with commentary on the state of this growing epidemic and barriers to effective screening methods. [West J Emerg Med. 2016;17(2):139–142.]

CDC MMWR Findings

In the April 17,2015 issue of the Morbidity and Mortality Weekly Report (MMWR), the Centers for Disease Control and Prevention (CDC) and Food and Drug Administration (FDA) published data and trends concerning tobacco use among middle (grade 6-8) and high school students (grade 9-12). The report clearly showed that between 2011 and 2014, statistically significant increases were observed among students for the use of electronic cigarettes and hookahs that has offset the overall decrease in more traditional tobacco products such as cigarettes and cigars.

To determine the prevalence and trends of past 30-day use of nine tobacco products (cigarettes, cigars, smokeless tobacco, e-cigarettes, hookahs, tobacco pipes, snus, dissolvable tobacco, and bidis), the CDC and FDA analyzed data from the 2011-2014 National Youth Tobacco Surveys (NYTS). The NYTS is a cross-sectional, school-based, self-administered, written questionnaire administered to students to monitor the impact of comprehensive tobacco control polices and strategies and inform the FDA's regulatory actions. Participants were asked about current usage of any tobacco products. "Current usage" was defined as using a tobacco containing product ≥1 time during the past 30 days. Tobacco use was defined as "any tobacco containing product," and "≥2 tobacco product usage" was defined as use of two or more tobacco products. Orthogonal polynomials were used with logistic regression analysis to test for significant linear and non-linear trends.

The CDC found that in 2014, 24.6% of high school students reported current use of a tobacco-containing product with 12.7% reporting using ≥2 tobacco products. Of all types, e-cigarettes (13.4%) were the most common tobacco products used while only 9.2% used traditional cigarettes. From 2011 to 2014, statistically significant non-linear increases were observed among high school students for current e-cigarette usage (1.5 to >13.4%) while statistically significant linear decreases were observed for current cigarette usage (15.8 to >9.2%) and cigar usage (11.6 to 8.2%). Current usage of any tobacco and ≥2 tobacco products from 2011-2014 did not change significantly and was (24.2 to >24.6%) and (12.5 to >12.7%) respectively. Overall in 2014, of the 4.6 million total middle and high school students using any tobacco product, 2.4 million used e-cigarettes and 1.6 million used hookah. Since 2013, e-cigarette usage has tripled from 4.5% (660,000) to 13.4% (two million) in high school students from 2013-2014, and from 1.1% (120,000) to 3.9% (450,000) in middle school students from 2013-2014. Significant increases were also observed for hookah usage for high school and middle school students from 2013-2014.

Overall, the CDC found statistically significant decreases in in the use of cigarettes, tobacco pipes, bidis, cigars, and

snus. Compounded with the massive increase in usage of e-cigarettes and hookah, this has offset the use of other tobacco products, resulting in no change to the overall current tobacco use among middle and high school students. This was the first time in NYTS that e-cigarette usage surpassed the usage of cigarettes.

The CDC acknowledged three limitations in this report. Data were only collected from youth in attendance in either public or private schools. Secondly, missing responses in the report were included as "non-usage." Lastly, it was believed that the wording and placement questions about the use of e-cigarettes, hookahs, and tobacco pipes may have had an impact on the reported use of these products.[2]

Commentary

It's 8pm and you've smoothly made it through half of your intake shift. The triage nurse brings in your next patient, a 16-year-old male with a complaint of "cough" for three days. He divulges to you a history of mild intermittent asthma and you begin your treatment regimen. Later on your re-evaluation, you find he is feeling much better, his peak flows have improved, and you begin your discharge process. Your electronic medical record prompts you to inquire about tobacco usage, and, expecting a negative answer, you comply. To your astonishment your patient admits to smoking. To your relief you find that his mother is aware of this and they both understand that this is contributing to his worsening asthma. They tell you they are trying to figure out the best way for him to quit and they have even been considering the "e-cigarette" because an aunt told them it was a healthier alternative. You pause and consider your options. You have referred countless adults for tobacco intervention, but never a child, and really how bad are these e-cigarettes anyway?

Emergency physicians (EP) throughout the nation, regardless of location, share the burden of screening for tobacco use in their patients and referring them accordingly. The MMWR is useful in identifying a new trend in the use of non-conventional tobacco products such as e-cigarettes affecting our nation's youth, but provides little insight into clinical significance at the provider level when dealing with adolescents. With up to 46 million Americans using the emergency department (ED) as their primary form of care, the additional volume of patients poses an increased responsibility to address key health issues without sacrificing efficiency,[3]

Each day, over 3,800 adolescents between 12-17 smoke their first cigarette, contributing to the 1.5 million youth who begin to smoke each year,[4,5] Research establishing the effectiveness of prevention and cessation interventions in adolescents is necessary to minimalize immediate adverse health effects in young smokers, such as asthma, decreased lung function, and early atherosclerosis.[6,7] It is estimated that a 26% decrease in adolescent smoking prevalence would result in an annual savings of 100,000 lives and 1.6 million years of human life.[8]

In adults, tobacco screening methods such as the "5 As," (ask, advise, assess, assist, and arrange for treatment) and many well-studied cessation options such as nicotine replacement therapy (NRT), telephone counseling, and FDA-approved psychotropic medications are available for the provider to use at his or her discretion.[9] In adolescents, however, data on methods for screening and intervention are available, but have been far less studied than in adults. The "Surgeon General's Report on Preventing Tobacco Use Among Youth and Young Adults" concluded there is robust evidence for effective strategies for reducing tobacco use among adolescents. This includes efforts of legislature (i.e. taxation, clean air policies, regulations on youth access, advertising bans, product labeling), large community environments (mass media campaigns, community interventions, state level tobacco control programs), and small social environments (clinical settings, school, family, youth programs) where the EP fits in. The Surgeon General concluded that it was the combined global effort from the above sectors that was effective in reducing the initiation, prevalence, and intensity of smoking among youth and young adults.[7]

The 2009 NYTS suggested that physicians as a whole could improve when it comes to screening for tobacco usage in adolescents. These data found that only 21% of adolescents recalled a physician asking them if they smoked in the last 12 months with only 7% of physicians suggesting to stop smoking.[10] One possible reason for reluctance to screen at the provider level could be concern over financial incentive or lack of training. In 2010, the U.S. Department of Health changed the Medicare-approved reimbursement for tobacco cessation counseling to include all tobacco users for sessions longer than three minutes.[11] With the current implementation of the ICD-10, codes for "Nicotine Dependence, other tobacco products" for both asymptomatic and symptomatic patients are now included as billable diagnoses.[12] To assist the provider in addressing tobacco cessation in adolescent patients, in 2008 a Public Health Service (PHS)-sponsored update to the Treating Tobacco Use and Dependence Clinical Practice Guideline was published, which reviewed the effectiveness of tobacco use interventions for adolescent smokers and made the following recommendations:

- Recommendation 1: Clinicians should ask pediatric and adolescent patients about tobacco use and provide a strong message regarding the importance of totally abstaining from tobacco use (Strength of Evidence=C).
- Recommendation 2: Counseling has been shown to be effective in treatment of adolescent smokers. Therefore, adolescent smokers should be provided with counseling interventions to aid them in quitting smoking (Strength of Evidence=B).
- Recommendation 3: Secondhand smoke is harmful to children. Cessation counseling delivered in pediatric settings has been shown to be effective in increasing cessation among parents who smoke. Therefore, to

protect children from secondhand smoke, clinicians should ask parents about tobacco use and offer them cessation advice and assistance (Strength of Evidence=B).[13]

The PHS also stated that regarding pharmacologic therapies, such as NRT and psychotropic medications, due to lack of evidence on effectiveness on promoting long-term smoking abstinence, prescription of these products is not recommended in people younger than 18 years old.[13,14]

Currently, we are seeing a rising trend in the use of non-conventional tobacco products with the e-cigarette surpassing traditional cigarette usage in adolescents for the first time ever. Immune from FDA regulation, these products are not subject to restrictions on marketing, manufacturing, labeling, and distribution. Few case studies have even reported incidences of mechanical bodily injury occurring due to malfunctioning e-cigarettes batteries.[15] Also, without widely accessible information on adverse health risks come incorrect public perceptions on safety. One study found that although adolescents were familiar with the health risks of traditional cigarettes, they were unsure of any associated with e-cigarettes.[16]

Just recently, in 2014 the FDA proposed a rule to extend its control to deem all tobacco-containing products subject to FDA jurisdiction. With this proposal, non-conventional products such as the e-cigarette would be subject to the same provisions as traditional cigarettes in areas such as advertising and ingredient disclosure.[17] If this happens, these products could then be subject to extensive scientific review unmasking harmful health risks.

Although the success of achieving tobacco cessation in our nation's adolescents remains a global effort, EPs can play a vital part simply by asking, advising, and referring their patients to counseling. With the recent MMWR identifying the growing trend in usage of non-conventional tobacco products in our nation's youth, EPs should take on the onus to include screening for non-conventional tobacco products, as well as familiarize themselves with appropriate referrals for counseling.

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Impact of a Dedicated Emergency Medicine Teaching Resident Rotation at a Large Urban Academic Center

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Introduction: In the face of declining bedside teaching and increasing emergency department (ED) crowding, balancing education and patient care is a challenge. Dedicated shifts by teaching residents (TRs) in the ED represent an educational intervention to mitigate these difficulties. We aimed to measure the perceived learning and departmental impact created by having TR.

Methods: TRs were present in the ED from 12pm-10pm daily, and their primary roles were to provide the following: assist in teaching procedures, give brief "chalk talks," instruct junior trainees on interesting cases, and answer clinical questions in an evidence-based manner. This observational study included a survey of fourth-year medical students (MSs), residents and faculty at an academic ED. Surveys measured the perceived effect of the TR on teaching, patient flow, ease of procedures, and clinical care.

Results: Survey response rates for medical students, residents, and faculty are 56%, 77%, and 75%, respectively. MSs perceived improved procedure performance with TR presence and the majority agreed that the TR was a valuable educational experience. Residents perceived increased patient flow, procedure performance, and MS learning with TR presence. The majority agreed that the TR improved patient care. Faculty agreed that the TR increased resident and MS learning, as well as improved patient care and procedure performance.

Conclusion: The presence of a TR increased MS and resident learning, improved patient care and procedure performance as perceived by MSs, residents and faculty. A dedicated TR program can provide a valuable resource in achieving a balance of clinical education and high quality healthcare. [West J Emerg Med. 2016;17(2):143–148.]

INTRODUCTION

In academic emergency departments (ED), formalizing the process to ensure high-quality clinical education for residents and medical students (MS) while also maintaining quality healthcare delivery is difficult. Achieving this balance has been increasingly challenging with ED crowding and a decline in bedside teaching practices. Compared to the 1960s when bedside teaching was common and comprised 75% of total teaching time, current estimates find that bedside teaching accounts for 17% of total teaching.[1,2] While attending physicians believe bedside teaching to be effective, many cite time constraints as a frequent barrier.[3] With the decline of bedside teaching, learner instruction in the ED has become challenging.

ED crowding compounds this challenge; studies have shown mixed results on the effect increasing patient volumes have on MS and resident teaching.[4-9] To combat this issue, a number of institutions have implemented teaching attending physicians.[10,11] Students and residents generally perceived a

positive impact on bedside instruction as a results of these programs. Additionally, many institutions have developed residents-as-teacher (RAT) programs to improve clinical instruction by residents with variable success. While RAT programs have been developed in the ED, there are no outcomes reported on these interventions.[12] A systematic review concluded RAT programs led to increased teaching skills and positive changes in RAT participants' attitudes and perceptions about education.[13] However, no study has examined the perceptions of non-participant ED personnel such as attending physicians, residents, and MSs of the presence of a dedicated teaching resident (TR) on learning and ED flow. Additionally, there is no literature that describes outcomes of a dedicated TR role that focuses only on teaching learners without the compounding variable of simultaneous direct clinical responsibilities.

The purpose of this study was to measure ED personnel's perception on learning and departmental impacts by having a dedicated non-clinical TR in the ED at an urban, academic hospital. We hypothesized that with the presence of the TR, MSs and emergency medicine (EM) residents would indicate greater satisfaction with their learning experiences and ease of performing procedures and residents and attendings would perceive improved patient flow, patient care, and continuity of care with the presence of a dedicated non-clinical TR.

METHODS

Role of the Teaching Resident

The TR role is part of the curriculum for EM trainees at an academic three-year training program. The residency funded the development and staffing of the TR. Post-graduate year (PGY) 2/3 residents assumed the role of the TR; trainees successfully completed a RAT curriculum consisting of didactics and simulation prior to serving in this role. TRs were present in the ED during the busiest hours of operation (12pm to 10pm daily). PGY-2 residents worked two TR shifts per week during their community ED rotations (in addition to 16 standard clinical shifts), and PGY-3 residents worked five TR shifts as part of their "Education/Administration Rotation." (No other shifts are required during this rotation.) During this time the TR's only clinical responsibility was as the on-call flight physician for the hospital's aeromedical transport program. The primary role was fulfilling the following teaching responsibilities: assisting and teaching procedures in the ED, preparing "chalk talks" for learners at the beginning of each shift, and instructing MSs and junior residents on interesting or difficult cases. The TR did not have an individual patient load, protecting their time to fulfill their teaching responsibilities. All 32 out of 32 residents eligible for the role participated.

Study Design

This was an observational study from June 2012 to July 2013 involving the administration of a survey at an academic ED. Surveys were administered to fourth-year MSs performing their required EM clerkship (71 potential respondents), resident trainees in the EM program, including those serving as TR (48 potential respondents), and EM faculty (12 potential respondents). The institutional review board approved this study as consent exempt.

Survey Content and Administration

We developed and piloted a survey instrument; content validity was established via an iterative process of review by EM education experts' revision and piloting with 10 residents, five faculty members, and five MSs who were representative of the intended audience. Items less relevant for specific audiences were deleted, and wording changes were made as needed to reflect differences between MSs, residents, and faculty. Response process was established by reviewing feedback from the pilot implementation and by conducting a read-aloud session among the investigators. The survey included multiple-choice and free-text items. Each survey included either 13 or 14 statements requiring a response characterizing the study subjects' perceptions of resident and MS teaching, patient flow, ease of procedures, and clinical care with and without the presence of the TR. Surveys were distributed using SurveyMonkey Inc. (Palo Alto, CA). These surveys were administered to each of the three subject groups, though the content of each group's survey was slightly different. The link to the survey was distributed via email, allowing an anonymous response. Survey completion was optional with no consequences associated with completion. Only one response from each participant was requested. Two separate follow-up emails were sent to non-responders. The software tracked bounced emails and allowed invitees to opt out. Surveys for MSs, residents and faculty are attached in the Appendix A, B, and C, respectively.

Data Analysis

In comparative statements (those requiring a response on a five-point scale ranging from "Poor" to "Excellent"), responses were converted to ordinal numbers (i.e. 1 = "Poor," 5 = "Excellent") for analysis. We calculated the mean and standard deviation. Additionally, we reported the difference between the means with and without the TR and the 95% percent confidence interval. Significance was determined in comparing statements with and without the presence of the TR using unpaired, two-tailed Student's t-tests. We considered a p-value of less than 0.05 statistically significant. In statements requiring a response on a five-point Likert scale, the number of responses for "Somewhat Agree" and "Agree" were combined and reported as the percentage and absolute number of respondents indicating agreement. We performed all statistical analyses using Stata 12.1 (StataCorp, College Station, TX).

RESULTS

The survey given to MSs yielded a 56% (40/71)

Table 1. Medical student evaluation of emergency medicine clerkship experiences with and without the presence of the teaching resident (TR). Five-point scale responses were converted to ordinal numbers where 1="Poor" and 5="Excellent". Values are reported as mean (SD). P values were determined by a two-tailed, unpaired Student's t-test. The response rate was 40/71 (56%).

	Without TR	With TR	Difference [95% CI]	P-value
Overall learning	3.50 (0.94)	3.93 (1.11)	0.43 [-0.02, 0.88]	NS
Ease of procedures	2.23 (1.10)	4.33 (1.10)	2.10 [1.61, 2.59]	p<0.001
Number of procedures	3.02 (1.00)	2.76 (0.97)	-0.23 [-0.70, 0.16]	NS
Number of patients	4.12 (0.94)	2.60 (1.01)	-1.52 [-1.95, -1.10]	p<0.001

response rate. MSs perceived a greater ease of procedures (Table 1, 2.23 vs. 4.33, p<0.001) and reported seeing fewer patients with the presence of the TR (Table 1, 4.12 vs 2.60, p<0.001). No statistical differences were found between their perception of their overall learning or the number of procedures they performed with the addition of the TR. Thirty students (75%) agreed or somewhat agreed they had a better overall educational experience during their clerkship with the TR, and 33 (82.5%) agreed or somewhat agreed the TR was a valuable educational experience. Eighteen students (45%) agreed or somewhat agreed the TR helped meet the needs of the fields into which they were matching (Table 2a).

The survey given to EM residents yielded a 77% (37/48) response rate. Residents perceived improved patient flow (2.24 vs 2.97, p<0.001), ease of procedures (2.76 vs 4.32, p<0.001), and MS learning (3.22 vs 4.25, p<0.001) with the presence of the TR (Table 3). Twenty-eight residents (75.6%) agreed or somewhat agreed the TR's presence improved overall patient care (Table 2a/b). Nineteen residents (51.3%) agreed or somewhat agreed the TR improved the continuity of care. Thirty-one residents (83.8%) agreed or somewhat agreed the TR's availability in the ED increased learning for the resident. Additionally, 28 residents (75.6%) agreed or somewhat agreed the TR added value to the ED team. Finally, isolating data gathered from residents who did not serve as the TR (PGY-1s) demonstrated that their perceptions were representative of the data gathered from all residents (Table 2a/b).

The survey given to EM attending physicians yielded a 75% (8/12) response rate. Attending physicians perceived significant increases in resident (3.38 vs 4.38, p<0.01) and MS learning with the TR (3.13 vs 4.50, p<0.01) (Table 4). They did not perceive change with patient flow through the department with the addition of the TR. All responding attending physicians (100%) agreed the TR aided with procedures in the department. Seven attending physicians (87.5%) agreed or somewhat agreed the TR improved patient care and 6 (75%) believed the TR added value to the ED team. Four (50%) believed the TR improved continuity of care in the ED (Table 2a).

We did not analyze qualitative results from the free-text portion of the survey secondary to the lack of a robust response rate and content.

DISCUSSION

The addition of a dedicated TR without clinical duties at an urban, academic medical center ED improved perceptions of resident learning, procedural ease, and patient care by fourth-year MSs, EM residents, and EM attending physicians, validating some of our original hypotheses. A dedicated teaching attending program similarly improved perceptions of bedside teaching among residents and faculty.[10] We believe a TR program such as this can help ballast a strong clinical education for learners in the ED by offering individual instruction and observation at academic institutions across the country, especially in institutions unable to offer dedicated teaching attending shifts.

As bedside teaching declines, dedicated TR shifts or rotations can help to improve the quality and quantity of bedside teaching for learners, especially resident trainees. MSs did not perceive the TR to enhance their overall learning, though they indicated the TR was overall a valuable educational experience. In a similar study, Hill et al. identified consistent findings after students instructed by a teaching-trained resident did not have superior outcomes to those who did not have a trained resident on an objective measure of clinical performance in their surgery clerkship.[14]

A majority of attending physicians and residents perceived the TR helped improve the quality of patient care within the ED, though this was unable to be objectively assessed. We hypothesize this perception is due to the direct impact of teaching procedures, critical thinking skills, and medical knowledge to learners. Many of our results focus on level one of Kirkpatrick's model of evaluating training programs;[15] assessing higher levels of training and evaluation would be of great interest in future studies of dedicated TR programs.

There were many perceived benefits from the addition of the TR in our institution. One unintended consequence of the TR for MSs during their EM clerkship was a perceived decrease in the number of patients seen. However, we are unclear if this is actually a negative consequence, as the goal of the MS rotation is to learn the basic tenets of EM. We speculate that the decreased number of patients is secondary to TRs spending more time instructing students on their current patients.

Limitations

While this study shows the perceived effects of a TR on

Table 2a. Subject agreement with characteristics of the teaching resident (TR) position and its effects on the emergency department (ED) - overall view. Values reported as percentage (absolute number) of responses in each response option.

	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree
Emergency medicine attending physicians					
Improves patient care	0% (0)	0% (0)	12.5% (1)	62.5% (5)	25% (2)
Improves continuity of care	12.5% (1)	12.5% (1)	25% (2)	25% (2)	25% (2)
Aids with procedures	0% (0)	0% (0)	0% (0)	0% (0)	100% (8)
Adds value to the ED team	0% (0)	0% (0)	25% (2)	37.5% (3)	37.5% (3)
Emergency medicine residents					
Improves patient care	0% (0)	5.4% (2)	18.9% (7)	29.7% (11)	45.9% (17)
Improves continuity of care	16.2% (6)	13.5% (5)	18.9% (7)	18.9% (7)	32.4% (12)
Improves learning for the resident	2.7% (1)	2.7% (1)	10.8% (4)	29.7% (11)	54.1% (20)
Adds value to the ED team	0% (0)	8.1% (3)	16.2% (6)	29.7% (11)	45.9% (17)
Emergency medicine residents (Non-TRs)					
Improves patient care	0% (0)	8.3% (1)	16.7% (2)	25% (3)	50% (6)
Improves continuity of care	8.3% (1)	16.7% (2)	25% (3)	41.7% (5)	8.3% (1)
Improves learning for the resident	0% (0)	0% (0)	8.3% (1)	25% (3)	66.7% (8)
Adds value to the ED team	0% (0)	8.3% (1)	16.7% (2)	25% (3)	50% (6)
Fourth year medical students					
Better experience with TR	2.5% (1)	7.5% (3)	15% (6)	32.5% (13)	42.5% (17)
Meets needs for field of interest	10% (4)	10% (4)	35% (14)	27.5% (11)	17.5% (7)
Valuable educational experience	2.5% (1)	5% (2)	10% (4)	32.5% (13)	50% (20)

Table 2b. Subject agreement with characteristics of the teaching-resident (TR) position and its effects on the emergency department (ED) – comparison response view. Values reported are percentage (absolute number) of respondents indicating "somewhat agree" or "agree" on a Likert scale. "#" indicates this group was not asked this question on their survey.

	EM attending physicians	EM residents	EM residents (Non-TRs)	Fourth year medical students
Improves patient care	87.5% (7)	75.7% (28)	75% (9)	#
Improves continuity of care	50% (4)	51.4% (19)	50% (6)	#
Aids with procedures	100% (8)	#	#	#
Adds value to the ED team	75% (6)	75.7% (28)	75% (9)	#
Improves learning for the resident	#	84.8% (31)	91.7% (11)	#
Better experience with TR	#	#	#	75% (30)
Meets needs for field of interest	#	#	#	45% (18)
Valuable educational experience	#	#	#	82.5% (33)

EM, emergency medicine

Table 3. Emergency medicine resident evaluation of emergency department experiences with and without the presence of the teaching resident (TR). Five-point scale responses were converted to ordinal numbers where 1="Poor" and 5="Excellent". Values are reported as mean (SD). P-values were determined by a two-tailed, unpaired Student's t test. The response rate was 37/48 (77%).

	Without TR	With TR	Difference [95% CI]	P-value
Patient flow	2.24 (0.72)	2.97 (0.96)	0.73 [0.34,1.12]	p<0.001
Ease of procedures	2.76 (0.54)	4.32 (0.81)	1.55 [1.24,1.87]	p<0.001
Medical student learning	3.22 (0.87)	4.25 (0.69)	1.03 [0.66,1.40]	p<0.001

Table 4. Emergency medicine attending physician evaluation of emergency department experiences with and without the presence of the teaching resident (TR). Five-point scale responses were converted to ordinal numbers where 1="Poor" and 5="Excellent". Values are reported as mean (SD). P-values were determined by a two-tailed, unpaired Student's t-test. The response rate was 8/12 (75%).

	Without TR	With TR	Difference [95% CI]	P-value
Patient flow	2.50 (0.76)	3.13 (0.99)	0.63 [-0.32, 1.57]	NS
Resident learning	3.38 (0.52)	4.38 (0.74)	1.00 [0.31, 1.69]	p<0.01
Medical student learning	3.13 (0.83)	4.50 (0.76)	1.38 [0.52, 2.23]	p<0.01

the learning and flow of an ED, it does have some limitations. At an institutional level, each RAT program has the ability to individually define the goals and objectives for the rotation within the ED; therefore, the perceived benefits we detected in our study may not be seen at different institutions. The sample size in this study, especially that of attending physicians, and the response rate of the MS group also limits the potential generalizability. Additionally, because we chose only to survey faculty, residents, and students, we considered the possibility for coverage error, as we did not seek other important stakeholders' perceptions, such as ED nursing or staff. Also, the administration of the survey was not prior to the implementation of the TR; rather, it asked respondents to compare items before and after the implementation of this program, potentially introducing bias. Further, we were unable to determine if the perceptions detected in our results can actually be translated to objective educational and clinical outcomes in the ED. Also, the TR staffed the busiest hours of the ED and it is possible the position would be perceived as more or less impactful at other times of the day. Finally, this is a relatively small single institution study.

In order to continue demonstrating the clinical and educational impact of a dedicated TR, subsequent studies will have to measure Kirkpatrick level 2-4 outcomes among stakeholders in the ED. Additionally, future investigations can also focus on the potential benefit of a dedicated TR rotation to the resident serving in this role.

CONCLUSION

This study is the first to examine the perceptions of a dedicated non-clinical TR program on the workings of an ED, in addition to the learning for MSs and residents in this environment. While more research is warranted to examine how these perceptions manifest in educational and clinical practice, this work demonstrates TRs are received with high acceptability among fourth-year MSs, EM residents, and EM attending physicians. Additionally, our study demonstrates a cost-benefit ratio for the addition of a TR, as the addition of a dedicated teaching position offers increased opportunities for education without impairing perceived patient flow in the ED. Instituting more programs such as this may help to encourage quality medical education for learners in the ED, or any challenging clinical environment, at busy academic medical centers.

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Can Simulation Measure Differences in Task-Switching Ability Between Junior and Senior Emergency Medicine Residents?

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Introduction: Work interruptions during patient care have been correlated with error. Task-switching is identified by the Accreditation Council for Graduate Medical Education (ACGME) as a core competency for emergency medicine (EM). Simulation has been suggested as a means of assessing EM core competencies. We assumed that senior EM residents had better task-switching abilities than junior EM residents. We hypothesized that this difference could be measured by observing the execution of patient care tasks in the simulation environment when a patient with a ST-elevation myocardial infarction (STEMI) interrupted the ongoing management of a septic shock case.

Methods: This was a multi-site, prospective, observational, cohort study. The study population consisted of a convenience sample of EM residents in their first three years of training. Each subject performed a standardized simulated encounter by evaluating and treating a patient in septic shock. At a predetermined point in every sepsis case, the subject was given a STEMI electrocardiogram (ECG) for a separate chest pain patient in triage and required to verbalize an interpretation and action. We scored learner performance using a dichotomous checklist of critical actions covering sepsis care, ECG interpretation and triaging of the STEMI patient.

Results: Ninety-one subjects participated (30 postgraduate year [PGY]1s, 32 PGY2s, and 29 PGY3s). Of those, 87 properly managed the patient with septic shock (90.0% PGY1s, 100% PGY2, 96.6% PGY 3s; p=0.22). Of the 87 who successfully managed the septic shock, 80 correctly identified STEMI on the simulated STEMI patient (86.7% PGY1s, 96.9% PGY2s, 93.1% PGY3s; p=0.35). Of the 80 who successfully managed the septic shock patient and correctly identified the STEMI, 79 provided appropriate interventions for the STEMI patient (73.3% PGY1s, 93.8% PGY2s, 93.8% PGY3s; p=0.07).

Conclusion: When management of a septic shock patient was interrupted with a STEMI ECG in a simulated environment we were unable to measure a significant difference in the ability of EM residents to successfully task-switch when compared across PGY levels of training. This study may help refine the use of simulation to assess EM resident competencies. [West J Emerg Med. 2016;17(2):149–152.]

INTRODUCTION

Interruption of physicians during task performance has been well documented.[1] These distractions to patient care occur more frequently in the emergency department (ED)

than in outpatient settings.[2] Both an increase in time-to-task completion and failure to return to task are correlated with interruptions.[3] Previous studies have observed a difference in the ability to manage a simulated patient when comparing between participants' level of experience.[4,5] Task-switching is identified as a patient care competency in the Accreditation Council for Graduate Medical Education (ACGME) Next Accreditation System Milestones project.[6] Simulation has been proposed as a method of assessing these milestones.[7] We assumed that level of training affects emergency medicine (EM) resident physicians' ability to execute required patient care tasks and hypothesized that this effect could be measured in the simulation environment when the care of a septic shock patient was interrupted by a second patient with an ST-elevation myocardial infarction (STEMI).

METHODS

We performed a multicenter, prospective, observational cohort study on a convenience sample of residents in their first three years of training at three ACGME-accredited EM residency programs. At each site all eligible residents were enrolled. Participating sites included Loma Linda University Medical Center, UMass Memorial Medical Center and The University of New Mexico Hospital. Sites were selected during a Medical Education Research Certificate Program session at a Council of EM Residency Directors meeting by virtue of having a pre-existing simulation program and faculty members interested in measuring resident task-switching abilities. Institutional review board approval was obtained at each of the participating sites. Data collection occurred in the spring at all sites. Prior to data collection, residents at each of the study sites regularly participated in simulation as part of their residency curriculum, and all sites had previously covered sepsis and STEMI in didactic educational sessions. The three investigators collaborated to develop an immersive simulated patient encounter with the primary objective being the application of task-switching in order to address a time-sensitive distraction while caring for a critically ill patient. Prior to being used with study subjects each investigator piloted the simulated patient encounter and the data collection sheet by observing American Board of EM–eligible attending physicians managing the simulation. Subsequently, issues with the simulated case were resolved by discussion and consensus among the principal investigators. We assessed for baseline differences in electrocardiogram (ECG) interpretation skills by having each subject provide written interpretations to a series of ECGs in the weeks prior to the simulation testing. The STEMI ECG used in the simulation testing was incorporated among the ECGs for the written test, and each subject's interpretation of the STEMI ECG was recorded for later analysis. This allowed subjects to serve as their own controls with respect to ECG interpretation abilities.

For the simulations, all sites used a high-fidelity mannequin in an environment that closely resembled an ED patient care area by having typical equipment, personnel, and systems found in the ED present for the simulation activity. The three investigators administered the simulation using a script with predetermined verbal responses and physiologic changes to interventions. Each study subject was presented with a 61-year-old diabetic male complaining of cough, fever, and shortness of breath with initial vital signs consistent with sepsis. Chest radiograph and physical exam findings were consistent with right lobar pneumonia. In each case the septic patient became hypotensive immediately after the chest radiograph was interpreted. At this point in the simulation each study subject was given a STEMI ECG of a separate chest pain patient presenting to triage and asked by the ECG technician for an interpretation and next action. Using a standardized data collection sheet with dichotomized responses, data were collected on the subjects' treatment of the septic shock patient and on recognition and treatment of the STEMI patient. Acceptable interventions for the septic shock patient were defined as administration of appropriate empiric antibiotics, intravenous (IV) fluids, and pressors per early goal-directed therapy standards. Acceptable interventions for the STEMI patient were defined as performing any of the following actions after being given the STEMI ECG: activation of the cardiac catheterization lab, verbalizing their intent to personally evaluate the STEMI patient immediately, or verbalizing a request for another physician to evaluate the STEMI patient immediately.

We used the Cochran-Mantel-Haenszel contingency table analysis to analyze whether the number of years of training predicted the ability of a resident to properly manage sepsis while being presented with the STEMI ECG. We used logistic regression to analyze if the number of years of training predicts the ability of a resident to properly interpret a STEMI ECG while managing a septic shock patient.

RESULTS

Ninety-one subjects participated: 30 post-graduate year (PGY)1s, 32 PGY2s, and 29 PGY3s. Eighty-seven subjects properly managed the patient with septic shock: 90.0% PGY1s, 100% PGY2s, and 96.6% PGY3s (p=0.22). Four subjects did not properly manage the patient with septic shock. One PGY1 did not appropriately order IV fluids and three PGY1s and one PGY3 did not appropriately order antibiotics.

Of the 87 who successfully managed the septic shock, 80 correctly identified STEMI on the simulated STEMI patient (86.7% PGY1s, 96.9% PGY2s, and 93.1% PGY3s; p=0.35). Of the 80 who successfully managed the septic shock patient and correctly identified STEMI on the simulated STEMI patient, 79 provided appropriate interventions for the STEMI patient (73.3% PGY1s, 93.8% PGY2s, 93.8% PGY3s; p=0.07). Both of the subjects who failed to provide appropriate interventions for the simulated STEMI patient correctly identified the STEMI in the simulation session but failed to identify the STEMI in the written test given prior to the simulation session. The

Table and Figure provide resident testing characteristics by number of years of training.

DISCUSSION

When we used simulation to measure EM resident physicians' ability to task-switch between management of septic shock, and responding to a STEMI ECG, we observed no statistically significant difference between groups with different years of EM residency training.

We considered two possible interpretations of this data: (1) EM residents acquire the task-switching skills needed to concurrently execute sepsis and STEMI-related patient care tasks during their first year of EM residency; (2) our simulation scenario lacked the discriminatory power needed to measure task-switching ability differences between different years of EM residency training.

The first proposed interpretation contradicts prior research showing that resident year of training and EM residents' scores on a multi-tasking assessment tool can explain variability in resident work efficiency.[8] It also contradicts the authors' anecdotal experiences after more than 20 collective years of supervising EM residents. Expert performance is mediated in part by highly structured and richly interconnected domain-specific knowledge.[9] Dynamic decisions are real-time decisions that are interdependent and highly constrained by the decision-making environment.[10]

The second proposed interpretation of our data seems more in accord with the authors' experiences and the aforementioned literature. The EM Milestone Project lists a series of multi-tasking (task-switching) milestones (subcompetency number 8) that residents are expected to achieve during training. Our data failed to show a difference between junior and senior EM residents in regards to ability to task-switch between different patients–a level 2 milestone.[6] It seems most plausible that our scenario was unable to differentiate resident physicians' abilities to manage patients amidst distraction because the simulation scenario did not require behaviors described in the level 3-5 milestones.

LIMITATIONS

Our study has several limitations: (1) Inter-rater reliability was not assessed; (2) the study was performed in the simulation environment so the conclusions may not be applicable to the ED; (3) the number of residents who did not successfully perform the critical actions required for the patient in septic shock or the patient with a STEMI was small. Assuming that 60% of PGY1s would manage both patients correctly, our study had an 80% power to detect a 29% difference between PGY1 and PGY2-3s ability to manage both patients correctly. Because 73% of PGY1s managed both cases correctly, more than 100% of PGY2-3s would have to manage the case correctly in order for our study to measure a difference, the impossibility of this highlights the main limitation of our study–that the cases were not difficult enough to differentiate learners' abilities. It is unknown how many distractions

Table. Resident testing characteristics by number of years of training (n=91).

	PGY-1 (%)	PGY-2 (%)	PGY-3 (%)	Total (%)	P-value[a]
Correctly identify STEMI on ECG					
Number of residents (n)	30	32	29	91	
Standard written test	18 (60.0)	28 (87.5)	25 (86.2)	71 (78.0)	0.01
Simulation center	26 (86.7)	31 (96.9)	27 (93.1)	84 (92.3)	0.35
P-value	0.67[b]	0.71[b]	0.56[b]	0.66[b]	
Critical actions					
Properly managed septic shock	27 (90.0)	32 (100.0)	28 (96.6)	87 (95.6)	0.22
Ordered IV fluids appropriately	29 (96.7)	32 (100.0)	29 (100.0)	90 (98.9)	0.22
Ordered antibiotics appropriately	27 (90.0)	32 (100.0)	28 (96.6)	87 (95.6)	0.22
Acted on STEMI	25 (83.3)	30 (93.8)	27 (93.1)	82 (90.1)	0.21
Activated cardiac catheter lab	12 (40.0)	18 (56.3)	9 (31.0)	39 (42.9)	0.50
Attempts to personally see patient	3 (10.0)	2 (6.3)	8 (27.6)	13 (14.3)	0.06
Asks 2nd MD to see STEMI patient	8 (26.7)	8 (25.0)	8 (27.6)	24 (26.4)	0.94
Properly managed septic shock, identified STEMI, & acted on STEMI	22 (73.3)	30 (93.8)	26 (100.0)	78 (85.7)	0.07

PGY, post graduate year; *STEMI*, ST segment elevation myocardial infarction; *ECG*, electrocardiogram; *MD*, medical doctor
[a]p-value determined by Cochran-Mantel-Haenszel Contingency Table Analysis.
[b]p-value determined by Repeated Measures Logistic Regression.

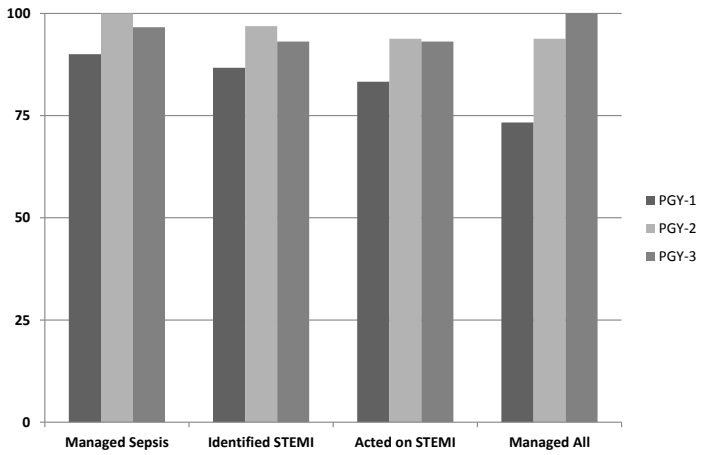

Figure. Resident performance on distraction study tasks by years of training.
PGY, post graduate year; *STEMI*, ST segment elevation myocardial infarction

per hour would be needed to see a difference in residents at different levels of training if such a difference exists. Interestingly, while not obtained in the data collection tool, each researcher observed that with the less experienced subjects there appeared to be a trend towards a longer time period between verbalization of the ECG as a STEMI and performing appropriate interventions. It is possible that a time-to-action metric may have captured these differences; this would correlate with multi-tasking milestone level 3. This may be an additional area for future fruitful research as studies in other domains have demonstrated decreased decision-making performance by individuals performing dynamic tasks when under time constraints compared to static task performance under time constraints.[11,12]

CONCLUSION

When management of septic shock was interrupted with a STEMI ECG in a simulation environment we observed no significant difference in completion of sepsis therapy or treatment of STEMI when compared between years of training. In our study 73% of PGY1s effectively task-switched between patients, while 94% of PGY2s and PGY3s demonstrated this ability. This observation supports the expectation that most EM residents achieve level 2 of the task-switching milestone by the end of their PGY1 year and nearly all should achieve level 2 by the end of their PGY2 year. This study suggests that future attempts to use simulation to measure differences in EM resident abilities, when comparing years of training, must incorporate skills at or above the level 3 milestone descriptors.

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Impact of Mental Health and Substance Use Disorders on Emergency Department Visit Outcomes for HIV Patients

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Introduction: A disproportionate number of individuals with human immunodeficiency virus (HIV) have mental health and substance-use disorders (MHSUDs), and MHSUDs are significantly associated with their emergency department (ED) visits. With an increasing share of older adults among HIV patients, this study investigated the associations of MHSUDs with ED outcomes of HIV patients in four age groups: 21-34, 35-49, 50-64, and 65+ years.

Methods: We used the 2012 Nationwide Emergency Department Sample (NEDS) dataset (unweighted n=23,244,819 ED events by patients aged 21+, including 115,656 visits by patients with HIV). Multinomial and binary logistic regression analyses, with "treat-and-release" as the base outcome, were used to examine associations between ED outcomes and MHSUDs among visits that included a HIV diagnosis in each age group.

Results: Mood and "other" mental disorders had small effects on ED-to-hospital admissions, as opposed to treat-and-release, in age groups younger than 65+ years, while suicide attempts had medium effects (RRR=3.56, CI [2.69-4.70]; RRR=4.44, CI [3.72-5.30]; and RRR=5.64, CI [4.38-7.26] in the 21-34, 35-49, and 50-64 age groups, respectively). Cognitive disorders had medium-to-large effects on hospital admissions in all age groups and large effects on death in the 35-49 (RRR=7.29, CI [3.90-13.62]) and 50-64 (RRR=5.38, CI [3.39-8.55]) age groups. Alcohol use disorders (AUDs) had small effects on hospital admission in all age groups (RRR=2.35, 95% CI [1.92-2.87]; RRR=2.15, 95% CI [1.95-2.37]; RRR=1.92, 95% CI [1.73-2.12]; and OR=1.93, 95% CI [1.20-3.10] in the 21-34, 35-49, 50-64, and 65+ age groups, respectively). Drug use disorders (DUDs) had small-to-medium effects on hospital admission (RRR=4.40, 95% CI [3.87-5.0]; RRR=4.07, 95% CI [3.77-4.40]; RRR=4.17, 95% CI [3.83-4.55]; and OR=2.53, 95% CI [2.70-3.78] in the 21-34, 35-49, 50-64, and 65+ age groups, respectively). AUDs and DUDs were also significantly related to the risk of death, and DUDs had a small effect on the risk of discharge against medical advice in the 35-49 and 50-64 age groups.

Conclusion: The high prevalence of MHSUDs and their significant roles in ED visit outcomes in patients with HIV provide support for integrated care for these patients outside the ED to reduce their ED visits and costly hospital admissions and institutional care that follows, especially for the increasing numbers of older adults with HIV. [West J Emerg Med. 2016;17(2):153–164.]

INTRODUCTION

Hospital emergency departments (ED) are one of the most frequent sources of medical care for many individuals with human immunodeficiency virus (HIV), and ED patients with HIV use significantly more ED resources than patients without HIV.[1,2] A study based on the National Hospital Ambulatory Medical Care Survey (NHAMCS) estimated that persons with HIV made about five in 1,000 ED visits, with the highest visit rates found among those aged 45-54, Blacks, those with public medical insurance, and residents of metropolitan areas.[3] Compared to patients without HIV, those with HIV also had a longer duration of ED stays (5.4 hours vs. 3.6 hours) and were more likely to be admitted to a hospital (28% vs. 15%) despite no recorded difference in the acuity level of the two groups' presenting problem(s).[3]

Previous research shows that a disproportionate number of individuals with HIV have mental health and substance-use disorders (MHSUDs) and that ED visits by persons with HIV are significantly associated with MHSUDs.[4-6] The most common mental health problems in persons living with HIV are major depression (20-35%), anxiety disorders (19-37%), post-traumatic stress disorders (PTSD) (15-26%), and severe mental illnesses (5-23%; schizophrenia, schizoaffective disorder, bipolar disorder, and other Axis 1 disorders).[6,7] Substance (alcohol and/or drug) use disorders were also found among 7-16% of persons living with HIV.[6,7] MHSUDs have been linked to delayed access and non-adherence to highly active antiretroviral therapy (HAART) or combination antiviral therapy (cART), treatment dropout, and worse disease outcomes; and higher symptom severities were associated with lower HAART adherence rates.[6-10] Depression may be linked to non-adherence to treatment through low motivation to seek care, loss of interest in continuing with care, and feelings of hopelessness about the future; anxiety and PTSD may negatively affect treatment because they may hamper concentration; and SUDs are likely to negatively affect treatment because they impair memory, concentration, impulse control, and the patient-provider relationship.[6] Health crises stemming from MHSUDs or from MHSUD-influenced delays in receiving HIV treatment, poor treatment adherence, and treatment cessation are likely to increase the need for ED visits. Compared to the general population, individuals with HIV also have higher (3+ times) rates of suicidal ideation and attempts, and ideators and attempters with HIV have higher rates of MHSUDs.[11,12]

Of individuals who have HIV, those with MHSUDs tend to have lower socioeconomic status and more complex care needs for HIV and other comorbid medical issues; as a result, they have increased healthcare utilization and costs of care compared to HIV patients in general, although access to care among those with MHSUDs is often suboptimal.[13,14] Life expectancy of individuals with HIV has increased due to HAART. Persons aged 55+ years accounted for 26% (313,200) of the estimated 1.2 million people living with HIV infection in the United States in 2011, and there were an estimated 8,575 new HIV diagnoses among people aged 50+, with 44% (n=3,747) of them among those aged 50-54.[15] MHSUDs may further complicate care and affect care outcomes of older individuals with HIV because they are more likely to have other chronic illnesses, including metabolic dysregulation, cardiovascular disease, and chronic pulmonary disease, than younger people with HIV.[16,17]

Research on ED visits by people with HIV and MHSUDs has generally not considered potential age group difference. The present study investigated ED outcomes among four groups of adults with HIV, with and without a diagnosis of MHSUD: those aged 21-34 years; 35-49 years; 50-64 years, and 65+ years. Our hypotheses were that (1) ED visits by older (aged 50-64 and 65+ years) than younger adults with HIV will be more likely to result in hospital admission and/or other outcomes than treat-and-release; and (2) HIV patients with MHSUDs in each age group will be more likely to result in hospital admission or other outcomes than treat-and-release.

METHODS

Data and Sample

Data came from the 2012 Nationwide Emergency Department Sample (NEDS) sponsored by the Agency for Healthcare Research and Quality. This publicly available dataset is part of the Healthcare Cost and Utilization Project and is the largest all-payer ED database. In 2012 NEDS contained information on 31 million ED visits at 950 hospitals in 30 states and approximated a 20% stratified sample of all hospital-based EDs in the United States.[18] Stratification was based on geographic region, trauma center designation, hospitals' urban or rural location, teaching hospitals, and hospital ownership/control (public, for-profit, and not-for-profit). The 31 million ED events contained in the 2012 NEDS are weighted to represent the estimated 134 million ED events nationwide in that year.[18] In this study, we focused on the 23,244,819 ED events by patients aged 21+ (representing 100,329,568 weighted events or 74.7% of all 134 million ED visits by all age groups). We excluded the under-21 age group as HIV diagnosis was found in just 0.02% (n=1,677) of all visits by this age group. Of the 23,244,819 ED events, 115,656 events (representing 489,285 weighted events) were by persons with HIV.

NEDS data elements include patient demographics (age and gender); patient location (in counties by population size); patient zip code area income (in national quartiles); diagnostic and procedure codes from the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM), as well as the clusters/categories of diagnoses in the Clinical Classifications Software (CCS) system;[19] chronic condition indicator (ICD-9-CM diagnoses that last 12 months or longer and place limitations on self-care/independent living/social interactions and/or result in the need for ongoing intervention with medical products/services/special equipment); E Codes

(for external causes of injury and poisoning: self-inflicted, intentional; unintentional; and assault-related); total charges; and ED dispositions/outcomes.

Measures

HIV diagnosis was identified from the single-level CCS diagnosis (i.e., HIV infection) classification as long as it was listed as a diagnosis, ranging from the primary to the fifteenth diagnosis. Of the visits with HIV diagnosis, it was the 1st diagnosis for 9.9%; 2nd for 31.0%; 3rd for 20.6%; 4th for 12.8%; 5th for 8.4%; 6th for 5.5%; 7th for 3.5%; 8th for 2.5%; 9th for 1.7%; 10th for 1.2%; 11th for 0.8%; 12th for 0.7%; 13th for 0.5%; 14th for 0.3%; and 15th for 0.6%.

MHSUDs were identified from the single-level CCS diagnosis classifications including 12 mental health disorders (suicide is one of them) and two substance use disorders—alcohol use disorders (AUDs) and drug use disorders (DUDs)—as long as they were listed as a diagnosis (ranging from the primary to the fifteenth diagnosis). We further collapsed the 12 mental health disorders into five: (1) anxiety disorders; (2) mood disorders; (3) delirium/dementia, amnestic, and other cognitive disorders (collectively referred to as cognitive disorders hereafter); (4) other mental health disorders (adjustment disorders; attention deficit, conduct, and disruptive behavior disorders; developmental disorders; impulse control disorders; personality disorders; schizophrenia and other psychosis; and other miscellaneous disorders); and (5) suicide or suicide attempt.

ED outcomes were (1) treat-and-release; (2) admission to the same hospital or transfer to a short-term hospital as an inpatient (and did not die); (3) death either in the ED or in the hospital; (4) transfer to a skilled nursing facility, intermediate care facility, or other such facility (transfer to another facility); or discharge with initiation of home healthcare services (HHC); (5) discharge against medical advice (AMA); and (6) other/discharge with an unknown destination. Transfer to another facility and HHC were combined because of small sample size in each category.

Potential confounders included: (1) gender (2) patient zip code area income (lower 50%, missing, and upper 50% [reference category]); (3) the following 11 clusters of diagnosed physical illnesses, in addition to infectious (since all patients with HIV have this condition) and parasitic diseases, based on the single-level CCS diagnosis classifications (yes=1, no=0 for each): a) neoplasms; b) endocrine, nutritional, and metabolic diseases and immunity disorders; c) diseases of blood and blood-forming organs; d) diseases of the nervous system and sense organs; e) diseases of the circulatory system; f) diseases of the respiratory system; g) diseases of the digestive system; h) diseases of the genitourinary system; i) diseases of the skin and subcutaneous tissues; j) diseases of the musculoskeletal system and connective tissue; and k) other conditions; and (4) any non-suicidal external injury from the E codes.

Data Analysis

We conducted analyses with Stata/MP 14's svy function to account for NEDS's multi-stage, stratified sampling design. Stata's subpop command was used for all subsample analyses of visits by individuals aged 21+ to ensure that variance estimates incorporate the full sampling design. All estimates presented are weighted to discharges in the universe except for sample sizes (i.e., number of visits). Standard errors for all study variables show stable estimates. First, we ued χ^2 tests to describe patient characteristics first by HIV status (no diagnosis vs. diagnosis) and second by age group among patients with HIV. Second, multinomial logistic regression analyses were used to examine associations between ED outcomes (the dependent variable, with treat-and-release as the base outcome) and age group and MHSUDs among all visits that included a HIV diagnosis, with the potential confounders described above. We excluded the ED outcome of "other/unknown" (n=78 for all visits with HIV diagnosis) due to its small sample size. Third, age-group separate multinomial logistic regression analyses were used to examine associations between MHSUDs and ED outcomes within each of the 21-34, 35-49, and 50-64 age groups. The ED outcome of death (n=127) was excluded for the 21-34 age group as the number of covariates exceeded the recommended guideline for the sample exhibiting these outcomes to degrees of freedom ratio (10:1).[20] Fourth, for the 65+ age group, we used binary logistic regression analysis with ED outcomes of hospital admission versus treat-and-release because the numbers of ED events with other outcomes in this age group were small (n=121 for death; n=95 for transfer/home healthcare; and n=60 for discharge AMA) and resulted in model overfitting. We did not include an interaction term between MH and SUD diagnoses (i.e., any MH disorder and AUD and/or DUD) in final regression models as the interaction effect was not statistically significant (i.e., $p>0.20$) in our preliminary analysis.

Variance inflation factor diagnostics (using a cut-off of 2.50),[21] indicated that multicollinearity among the predictors was not a concern. Given the overall large sample size, we followed Chen, Cohen, and Chen's cutoffs for odds ratios (OR): OR<0.60 or OR=1.68 as equivalent to cutoffs for a small effect size (Cohen's d=0.2) and OR=3.47 and OR=6.71 as equivalent to cutoffs for medium (d=0.5) and large (d=0.8) effect sizes, respectively.[22]

RESULTS

Patient Characteristics by HIV Diagnosis Status

Table 1 shows that 115,656 of the 23 million ED visits by patients 21+ years old, or 0.49% (95% confidence interval=0.48-0.49), had a recorded diagnosis of HIV infection (0.30% of all visits in the 21-34 age group, 0.83% in the 35-49 age group, 0.78% in the 50-64 age group, and 0.09% of in the 65+ age group). Of the visits by patients with HIV, 18.4% were by the 21-34 age group, 42.7% by the 35-49 age group, 34.6% by the 50-64 age group, and 4.3% by the 65+

age group. Thus, almost 40% of the visits by adults (aged 21+) with HIV were by those aged 50+ years. Of the visits by patients without HIV, 30% were by the 21-34 age group, 25.2% were by the 35-49 age group, 21.7% were by the 50-64 age group, and 23.1% were by the 65+ age group.

Compared to visits by those without HIV, visits by those with HIV included higher proportions of men, those with Medicaid as the primary payer, and residents of lower income

Table 1. Characteristics of patient visits by human immunodeficiency virus (HIV) diagnosis status (%).

Characteristics	No HIV diagnosis (%) 99.51%; N=23,129,163	HIV diagnosis (%) 0.49%; N=115,656
Age group (years)		
21-34	30.02	18.38
35-49	25.16	42.73
50-64	21.71	34.61
65+	23.11	4.29
Gender		
Male	42.67	62.24
Female	57.33	37.76
Primary expected payer		
Medicare	28.89	29.73
Medicaid	19.42	40.06
Private insurance	26.70	11.74
Self-pay	18.85	14.31
Other	5.43	3.36
No charge	0.71	0.80
Median household income in patient's zip code (national quartile)		
Q1 (<$39,000)	32.86	45.24
Q2 ($39,000-$47,999)	25.53	19.40
Q3 ($48,000-$62,999)	22.53	13.43
Q4 ($63,000+)	17.06	6.70
Missing	2.20	15.23
Diagnosis of physical conditions/diseases		
Infectious and parasitic diseases	8.16	100
Neoplasms	5.37	7.34
Endocrine, nutritional, metabolic and immunity disorders	28.66	36.97
Blood and blood-forming organs	7.63	19.29
Nervous system and sense organs	21.29	25.80
Circulatory system	38.41	47.69
Respiratory system	22.69	35.96
Digestive system	20.73	27.56
Genitourinary system	33.80	42.79
Skin and subcutaneous tissues	6.10	9.75
Musculoskeletal system and connective tissues	20.87	18.21
Other conditions[1]	37.47	46.65
External injury (nonsuicidal)	23.46	15.31

No HIV diagnosis: 99.51% (95% CI [99.51-99.52]). HIV diagnosis: 0.49% (95% CI [0.48-0.49]).
[1]Syncope, fever of unknown origin, lymphadenitis, gangrene, shock, nausea and vomiting, abdominal pain, malaise and fatigue, allergic reactions, rehabilitation care, administrative/social admission, and other.
All age group differences are significant at p<0.0001.

Table 1. Continued.

Characteristics	No HIV diagnosis (%) 99.51%; N=23,129,163	HIV diagnosis (%) 0.49%; N=115,656
Diagnosis of mental health conditions (MH)		
Anxiety disorders	5.36	5.77
Mood disorders	7.08	15.62
Cognitive disorders	2.63	1.55
Suicide attempt	0.77	2.39
Other mental disorders[2]	2.76	6.20
Diagnosis of substance abuse conditions (SUD)		
Alcohol use disorders (AUD)	3.34	7.45
Drug use disorders (DUD)	2.66	13.75
Co-occurring mental health and substance-use disorders[3]	1.92	7.62

No human immunodeficiency virus (HIV) diagnosis: 99.51% (95% CI [99.51-99.52]). HIV diagnosis: 0.49% (95% CI [0.48-0.49]).
[2]Disorders of adjustment, attention deficit, conduct, and disruptive behavior, developmental nature, impulse control, personality, schizophrenia and other psychosis, and other miscellaneous disorders.
[3]Any mental disorder and AUD and/or DUD, SE=0.0001 for all visits.
All age group differences are significant at p<0.0001.

areas. Visits by those with HIV also included higher proportions of all physical illnesses, except musculoskeletal system and connective tissue problems and non-suicidal external injuries. Mood (15.6% vs. 7.1%) and other mental disorders (6.2% vs. 2.8%), including a diagnosis of schizophrenia or other psychosis (4.4% vs. 1.48%) were more than twice as high in visits with HIV than those without. Suicide attempt was more than three times higher in visits with HIV (2.4% vs. 0.8%). On the other hand, cognitive disorders were lower among the visits with HIV, most likely due to the lower proportion of visits by those aged 65+ in the HIV group compared to the number of visits by those aged 65+ without HIV. SUD rates were also significantly higher in visits by those with HIV. AUD was more than twice as high (7.5% vs. 3.3%), and DUD was almost seven times higher (13.8% vs. 2.7%).

Table 2 shows that fewer visits by those with HIV than those without HIV were treat-and-release (57.3% vs. 77.3%), while more were ED-to-hospital admission (38% vs. 18.9%), death in the ED or during the related hospital admission (1.1% vs. 0.7%), and discharge AMA (2.3% vs. 1.7%). The rate of transfer to another facility/HHC was nearly identical (1.4% and 1.5%). Data also show that differences between those with and without HIV were significant in each age group, though regardless of HIV status, younger groups had higher treat-and-release rates and older groups had higher ED-to-hospital admission rates.

Patients with HIV Diagnosis: Characteristics by Age Group

Table 3 shows that visits by the 35-49 age group included a higher proportion of women, and visits by the 65+ age group included a higher proportion of men than visits by the other age groups. Visitors aged 65+ also appear to have come from neighborhoods with slightly higher incomes than the younger groups. As expected, however, visits by the 65+ age group included higher proportions of all physical illnesses except skin and subcutaneous tissue conditions, followed by visits by the 50-64 age group. The 21-34 age group had the highest rate of skin conditions. Visits by those aged 65+ also included the highest rate of cognitive disorders but the lowest rates of other MHSUDs, while visits by those aged 35-49 had the highest MHSUD rates followed by visits by the 50-64 age group.

Additional analyses show that HIV infection as the first, second, or third diagnosis was highest in visits by the 21-34 age group (68.7%) and lowest in the 65+ age group (50.4%). Conversely, HIV infection as the 6th through 15th diagnosis was highest in visits by the 65+ age group (28.7%) and lowest in the 21-34 age group (11.3%); thus, the 65+ age group had other more acute physical health and injury-related problems. Regardless of age group, visits in which HIV was either the primary or the 6th through 15th diagnosis were more likely to result in hospital admission than visits in which HIV was the second through the fifth diagnosis.

Associations of MHSUDs with ED Outcomes Among All Visits with an HIV Diagnosis

Multinomial logistic regression results in Table 4 show that age group's effects on ED outcomes of hospital admission, death, and discharge AMA, though statistically significant, did not appear to be clinically meaningful after adjusting for confounding variables. However, compared to visits by those aged 21-34, visits by those aged 65+ were associated with an increased risk of transfer to another facility/HHC (relative risk ratio [RRR]=3.08, 95% confidence interval CI [2.36-4.02]). Mood and other mental disorders had small effects (RRR=1.81, 95% CI [1.72-1.90]), and cognitive disorders (RRR=4.52, 95% CI [3.80-5.37]), suicide attempts (RRR=4.35, 95% CI [3.84-4.94]), and DUD (RRR=4.15, 95% CI [3.94-4.37]) had medium

effects on increasing the risk of hospital admission. Cognitive disorders had a medium effect (RRR=5.86, 95% CI [4.20-8.17]) and AUD had a small effect (RRR=1.71, 95% CI [1.33-2.19]) on increasing the risk of death while anxiety disorders were

Table 2. ED outcome by age group and HIV diagnosis status (%).

	Treat-and-release	Hospital admission	Death at ED/hospital	Facility transfer/HHC	Discharge AMA
All adults age 21+[1]					
No HIV diagnosis	77.29	18.87	0.65	1.60	1.72
HIV diagnosis	57.25	38.01	1.06	1.41	2.26
Age 21-34					
No HIV diagnosis	90.02	7.02	0.07	0.87	2.03
HIV diagnosis	66.51	29.13	0.61	1.29	2.45
Age 35-49					
No HIV diagnosis	84.76	11.93	0.19	1.04	2.09
HIV diagnosis	59.21	36.24	0.80	1.45	2.33
Age 50-64					
No HIV diagnosis	74.09	22.14	0.63	1.28	1.87
HIV diagnosis	51.87	43.05	1.48	1.41	2.19
Age 65+					
No HIV diagnosis	55.65	38.75	1.93	2.87	0.80
HIV diagnosis	41.59	53.09	2.30	1.82	1.20

ED, emergency department; *HHC,* home healthcare; *AMA,* against medical advice; *HIV,* human immunodeficiency virus
[1]N=23,100,490 visits without HIV diagnosis and N=115,578 visits with HIV diagnosis; other/unknown outcomes (0.13% of total without HIV and 0.06% of total with HIV) were excluded from analysis.
Differences by HIV diagnosis status in each age group are significant at p<0.0001.

Table 3. Visits by patients with human immunodeficiency virus diagnosis: characteristics by age group (%).

	21-34 years 18.38%; N=21,200	35-49 years 42.73%; N=49,267	50-64 years 34.61%; N=40,122	65+ years 4.29%; N=5,067
Gender				
Male	62.19	59.85	64.47	68.29
Female	37.81	40.15	35.53	31.71
Primary expected payer				
Medicare	14.35	26.48	34.91	86.19
Medicaid	40.68	42.19	41.44	5.20
Private insurance	12.73	11.85	11.87	5.35
Self-pay	27.67	14.99	7.98	1.38
Other	3.53	3.54	3.25	1.73
No charge	-	-	-	-
Median household income in patient's zip code (national quartile)				
Q1 (<$39,000)	45.52	45.83	44.70	42.47
Q2 ($39,000-$47,999)	21.34	19.94	17.82	18.42
Q3 ($48,000-$62,999)	15.14	13.21	12.95	12.21
Q4 ($63,000+)	6.52	6.62	6.68	8.60
Missing	11.48	14.40	17.86	18.29

21-24 years: 18.38% (95% CI [18.15-18.61]); 35-49 years: 42.73% (95% CI [42.43-43.02]); 50-64 years: 34.61% (95% CI [34.33-34.89]); 65+ years: 4.29% (95% CI [4.17-4.41]).
All age group differences are significant at p<0.0001.

Table 3. Continued.

	21-34 years 18.38%; N=21,200	35-49 years 42.73%; N=49,267	50-64 years 34.61%; N=40,122	65+ years 4.29%; N=5,067
Diagnosis of physical conditions/diseases				
Neoplasms	4.11	6.44	9.22	14.88
Endocrine, nutritional, metabolic and immunity disorders	22.03	32.93	46.46	64.66
Blood and blood-forming organs	16.34	18.55	20.89	26.40
Nervous system and sense organs	21.57	26.30	27.16	27.95
Circulatory system	25.42	43.27	60.75	81.63
Respiratory system	30.28	35.34	39.12	41.06
Digestive system	25.60	26.77	28.82	33.68
Genitourinary system	38.63	40.82	45.43	59.00
Skin and subcutaneous tissues	11.39	9.71	9.13	8.17
Musculoskeletal system and connective tissues	12.39	17.67	21.36	22.97
Other conditions[1]	44.96	46.66	47.32	48.48
Diagnosis of mental health conditions (MH)				
Anxiety disorders	5.91	6.10	5.52	3.87
Mood disorders	13.97	17.36	15.00	10.40
Cognitive disorders	0.47	1.02	2.19	6.20
Suicide attempt	2.64	2.91	1.85	0.47
Other mental disorders[2]	6.69	6.66	5.72	3.36
Diagnosis of substance abuse conditions (SUD)				
Alcohol use disorders (AUD)	4.26	8.07	8.86	3.63
Drug use disorders (DUD)	11.38	15.01	14.36	5.44
Co-occurring MHSUD[3]	6.85	8.96	7.16	2.39

21-24 years: 18.38% (95% CI [18.15-18.61]); 35-49 years: 42.73% (95% CI [42.43-43.02]); 50-64 years: 34.61% (95% CI [34.33-34.89]); 65+ years: 4.29% (95% CI [4.17-4.41]).

MHSUD, mental health and substance-use disorder

[1]Syncope, fever of unknown origin, lymphadenitis, gangrene, shock, nausea and vomiting, abdominal pain, malaise and fatigue, allergic reactions, rehabilitation care, administrative/social admission, and other.

[2]Disorders of adjustment, attention deficit, conduct, and disruptive behavior, developmental nature, impulse control, personality, schizophrenia and other psychosis, and other miscellaneous disorders.

[3]Any mental disorder and AUD and/or DUD, SE=0.0001 for all visits.

All age group differences are significant at p<0.0001.

associated with a decreased risk (RRR=0.35, 95% CI [0.22-0.57]) of death. Anxiety, mood, and other mental disorders and DUD had small effects on increasing the risk of transfer to another facility/HHC, and cognitive disorders (RRR=6.18, 95% CI [4.44-8.60]) and suicide attempts (RRR=15.77, 95% CI [13.05-19.07]) had medium and large effects, respectively. Suicide attempts decreased the risk of discharge AMA (RRR=0.40, 95% CI [0.21-0.78]), while DUD had a marginal effect (RRR=1.66, 95% CI [1.45-1.90]) on increasing the risk.

Associations of MHSUDs with ED Outcomes within Each Age Group

Table 5 shows that within the 21-34, 35-49, and 50-64 age groups, mood and other mental disorders and AUD had small effects; cognitive disorders had medium-to-large effects (e.g., RRR=3.70, CI [2.87-4.77] in the 50-64 age group and RRR=11.11, CI [4.60-26.84] in the 21-34 age group); suicide attempts had medium effects (e.g., RRR=3.56, CI [2.69-4.70] in the 21-34 age group and RRR=4.44, CI [3.72-5.30] in the 35-49 age group); and DUD medium effects (e.g., RRR=4.40, CI [3.87-5.00] in the 21-34 age group and RRR=4.17, CI [3.83-4.55] in the 50-64 age group) on increased risk of hospital admission.

Cognitive disorders had a large effect on death in the 35-49 (RRR=7.29, CI [3.90-13.62]) and 50-64 (RRR=5.38, CI [3.39-8.55]) age groups, and AUD had small effect on death in the 35-49 (RRR=2.15, CI [1.95-2.37]) and 50-64 (RRR=1.71, CI [1.22-2.39]) age groups. Mood and other mental disorders had small-to-medium effects, cognitive disorders had medium to large effects, and suicide attempts had large effects on the

Table 4. Associations of age group and mental health and substance use disorders with emergency department (ED) outcomes among ED visits by persons with HIV diagnosis: Relative risk ratios (RRR) and 95% confidence intervals (CI) from multinomial logistic regression analysis.

	Treat-and-release vs.			
	Hospital admission RRR (95% CI)	Death RRR (95% CI)	Transfer to facility/HHC RRR (95% CI)	Discharge AMA RRR (95% CI)
Age group				
(21-34 years)	-	-	-	-
35-49 years	0.99 (0.95-1.04)	0.97 (0.78-1.20)	1.22 (1.61-1.66)*	1.01 (0.90-1.13)
50-64 years	1.06 (1.01-1.11)*	1.30 (1.04-1.62)*	1.58 (1.34-1.85)‡	1.01 (0.90-1.14)
65+ years	1.27 (1.17-1.30)‡	1.48 (1.10-1.97)†	3.08 (2.36-4.02)‡	0.66 (0.49-0.88)†
Anxiety disorders	1.26 (1.17-1.36)‡	0.35 (0.22-0.57)‡	1.72 (1.44-2.05)‡	1.14 (0.94-1.38)
Mood disorders	1.81 (1.72-1.90)‡	0.70 (0.56-0.88)†	2.73 (2.40-3.12)‡	0.88 (0.76-1.01)
Cognitive disorders	4.52 (3.80-5.37)‡	5.86 (4.20-8.17)‡	6.18 (4.44-8.60)‡	1.31 (0.76-2.26)
Other mental disorders	2.21 (2.05-2.38)‡	1.23 (0.87-1.73)	3.72 (3.20-4.32)	0.94 (0.76-1.15)
Suicide attempt	4.35 (3.84-4.94)‡	0.58 (0.08-4.13)	15.77 (13.05-19.07)‡	0.40 (0.21-0.78)†
Alcohol use disorders	2.00 (1.87-2.14)‡	1.71 (1.33-2.19)‡	1.18 (0.98-1.42)	1.12 (0.94-1.35)
Drug use disorders	4.15 (3.94-4.37)‡	1.57 (1.26-1.96)‡	1.86 (1.60-2.16)‡	1.66 (1.45-1.90)‡

HHC, home healthcare; *AMA,* against medical advice; *HIV,* human immunodeficiency virus

Note: The following potential confounders were included but not reported in the table: gender, zip code area median income (lower 50% and missing as opposed to upper 50%), and physical health diagnoses (neoplasms; endocrine, nutritional, metabolic and immunity disorders; blood and blood-forming organs; nervous system and sense organs; circulatory system; respiratory system; digestive system; genitourinary system; skin and subcutaneous tissues; musculoskeletal system and connective tissues; other conditions; and nonsuicidal external injuries).

Model F (96,31090759)=320.55; design df=31,090,854; p<0.0001. N=115,570 visits by all HIV-diagnosed persons aged 21+ years, representing 488,967 weighted ED events.

*p<0.03.

†p<0.01.

‡p<0.0001.

risk of transfer to another facility/HHC in the 21-34, 35-49, and 50-64 age groups. In addition, anxiety had a small effect in the 50-64 age group and DUD had small effects in the 35-49 and 50-64 age groups on the risk of transfer to another facility/HHC. DUD had a marginal effect on increased risk of discharge AMA in the 35-49 age group. Cognitive disorders and DUD also had small effects on increased risk of discharge AMA in the 50-64 age group.

Table 5 also shows that in the 65+ age group, cognitive disorders had medium effects (OR=6.09, CI [4.03-9.22]), and AUD and DUD had small effects (OR=1.93, CI [1.20-3.10] for AUD and OR=2.53, CI [1.70-3.78] for DUD) on increased risk of hospital admission.

DISCUSSION

Given the higher rates of MHSUDs and ED utilization among people living with HIV than those without HIV, it is important to examine associations between MHSUDs and ED outcomes among HIV patients. Also, given increasing numbers of older individuals with HIV, healthcare providers need better understanding of potential age-group difference in the association between MHSUDs and healthcare outcomes. Using a nationally representative sample of ED visits, we examined such association in different age groups of ED patients with HIV.

Consistent with the NHAMCS,[3] the present study found that about five in 1,000 ED visits by U.S. adults age 21+ included an HIV diagnosis and that ED-to-hospital admission was twice as high among those with HIV diagnosis than those without. The present study also shows that more than 77% of ED visits by individuals with HIV were by those aged 35 to 64 years, compared to 47% of ED visits by individuals without HIV. Those aged 65+ constituted only 4% of all ED visits by adults with HIV in 2012, while they were 23% of all ED visits by adults without HIV. However, the large presence of the 50-64 age group (35%) in ED visits by those with HIV signals an upward trajectory of ED visits by older adults with HIV in the future. In the present study, 43% and 53% of ED visits by the 50-64 and 65+ age groups, respectively, with HIV (compared to 22% and 39% for those without HIV) were admitted to the hospital. With age- and HIV-related health/mental health problems, the growing number of older adults with HIV are likely to require more intensive care than their peers without HIV.

Corroborating previous studies,[6,7,11] this study found

Table 5. Associations of mental health and substance-use disorders with ED outcomes within each age group: Relative risk ratios (RRR) or odds ratios (OR) and 95% confidence intervals (CI) from multinomial or binary logistic regression analysis.

	Treat-and-release vs.			
	Hospital admission RRR/OR[1] (95% CI)	Death RRR (95% CI)	Transfer to facility/HHC RRR (95% CI)	Discharge AMA RRR (95% CI)
Visits by persons 21-34 years old with HIV diagnosis (N=21,067 visits, representing 89,338 weighted ED events)				
Anxiety disorders	1.17 (0.98-1.39)	-	2.11 (1.42-3.15)§	1.17 (0.80-1.71)
Mood disorders	1.91 (1.68-2.17)§	-	3.97 (2.81-5.61)§	1.05 (0.77-1.43)
Cognitive disorders	11.11 (4.60-26.84)§	-	13.44 (2.71-69.10)	#
Other mental disorders	2.44 (2.07-2.89)§	-	3.80 (2.71-5.33)§	0.63 (0.38-1.04)
Suicide attempt	3.56 (2.69-4.70)§	-	12.20 (7.98-18.66)§	0.27 (0.07-1.11)
Alcohol use disorders	2.35 (1.92-2.87)	-	0.79 (0.44-1.42)	1.57 (0.99-2.50)
Drug use disorders	4.40 (3.87-5.00)§	-	1.57 (1.07-2.33)*	1.47 (1.04-2.08)
Visits by persons 35-49 years old with HIV diagnosis (N=49,219 visits, representing 208,874 weighted ED events)				
Anxiety disorders	1.25 (1.11-1.40)§	0.36 (0.17-0.77)†	1.44 (1.10-1.89)†	1.12 (0.84-1.50)
Mood disorders	1.81 (1.69-1.95)§	0.74 (0.52-1.06)	2.91 (2.38-3.56)§	0.87 (0.71-1.07)
Cognitive disorders	5.09 (3.76-6.90)§	7.29 (3.90-13.62)§	5.03 (2.42-10.44)§	0.70 (0.17-2.93)
Other mental disorders	2.51 (2.25-2.80)§	1.08 (0.59-1.98)	3.48 (2.77-4.38)§	0.95 (0.70-1.29)
Suicide attempt	4.44 (3.72-5.30)§	1.65 (0.23-12.03)	16.76 (12.79-21.95)§	0.56 (0.25-1.26)
Alcohol use disorders	2.15 (1.95-2.37)§	2.15 (1.41-3.27)§	1.28 (0.98-1.67)	1.12 (0.86-1.46)
Drug use disorders	4.07 (3.77-4.40)§	1.30 (0.90-1.87)	1.71 (1.37-2.14)§	1.65 (1.35-2.02)§
Visits by persons 50-64 years old with HIV diagnosis (N=40,093 visits, representing 169,228 weighted ED events)				
Anxiety disorders	1.37 (1.20-1.56)§	0.40 (0.20-0.79)†	2.21 (1.66-2.95)§	1.17 (0.83-1.65)
Mood disorders	1.77 (1.62-1.92)§	0.59 (0.40-0.87)†	2.06 (1.65-2.57)§	0.71 (0.54-0.93)*
Cognitive disorders	3.70 (2.87-4.77)§	5.38 (3.39-8.55)§	5.96 (2.87-4.78)§	1.89 (1.03-3.48)*
Other mental disorders	1.90 (1.66-2.17)§	1.32 (0.81-2.15)	3.70 (2.87-4.78)§	1.09 (0.79-1.52)
Suicide attempt	5.64 (4.38-7.26)§	#	14.82 (10.33-2.26)§	0.18 (0.02-1.28)
Alcohol use disorders	1.92 (1.73-2.12)§	1.71 (1.22-2.39)†	1.29 (0.96-1.72)	0.94 (0.70-1.27)
Drug use disorders	4.17 (3.83-4.55)	1.53 (1.12-2.09)†	2.31 (1.82-2.91)†	1.70 (1.35-2.14)§

HHC, home healthcare; *AMA*, against medical advice; *ED*, emergency department; *HIV*, human immunodeficiency virus

[1]RRR for the 21-34, 35-49, and 50-64 age groups and OR for the 65+ age group.

Note: In all models, the following potential confounders were included but not reported in the table: gender, zip code area median income (lower 50% and missing as opposed to upper 50%), and physical health diagnoses (neoplasms; endocrine, nutritional, metabolic and immunity disorders; blood and blood-forming organs; nervous system and sense organs; circulatory system; respiratory system; digestive system; genitourinary system; skin and subcutaneous tissues; musculoskeletal system and connective tissues; other conditions; and nonsuicidal external injuries).

#: Denotes cases of complete or quasi-complete separation due to low or non-existent combinations of an outcome category and one or more independent variable (e.g., there were no visits by 50-64 year olds who attempted suicide and died). These parameters were not interpreted due to deflated standard errors for which there is no maximum likelihood estimate.

Model F (66,31070953)=144.50, design df=31,071,018, p<0.0001for the 21-34 age group.

Model F (88,31090892)=147.79, design df=31,090,892, p<0.0001 for the 35-49 age group.

Model F (88,31090824)=1155.80, design df=31,090,911, p<0.0001 for the 50-64 age group.

*p<0.04.

†p<0.01.

§p<0.0001.

Table 5. Continued.

	Treat-and-release vs.			
	Hospital admission RRR/OR[1] (95% CI)	Death RRR (95% CI)	Transfer to facility/HHC RRR (95% CI)	Discharge AMA RRR (95% CI)
Visits by persons 65+ years old with HIV diagnosis (N=4.689 visits, representing 19,863 weighted ED events)				
Anxiety disorders	1.30 (0.87-1.95)	-	-	-
Mood disorders	1.44 (1.07-1.95)*	-	-	-
Cognitive disorders	6.09 (4.03-9.22)§	-	-	-
Other mental disorders	1.13 (0.68-1.87)	-	-	-
Suicide attempt	1.77 (0.52-6.01)	-	-	-
Alcohol use disorders	1.93 (1.20-3.10)†	-	-	-
Drug use disorders	2.53 (1.70-3.78)§	-	-	-

HHC, home healthcare; *AMA*, against medical advice; *ED*, emergency department; *HIV*, human immunodeficiency virus
[1]RRR for the 21-34, 35-49, and 50-64 age groups and OR for the 65+ age group.
Note: In all models, the following potential confounders were included but not reported in the table: gender, zip code area median income (lower 50% and missing as opposed to upper 50%), and physical health diagnoses (neoplasms; endocrine, nutritional, metabolic and immunity disorders; blood and blood-forming organs; nervous system and sense organs; circulatory system; respiratory system; digestive system; genitourinary system; skin and subcutaneous tissues; musculoskeletal system and connective tissues; other conditions; and nonsuicidal external injuries).
Model F (22,30593748)=50.37, design df=30,593,769, p<0.0001 for the 65+ age group.
*p<0.04.
†p<0.01.
§p<0.0001.

higher rates of MHSUDs among persons living with HIV compared to persons without HIV. Mood disorders, "other" mental disorders, and AUDs were more than twice as high in ED visits by those with HIV than those without; DUDs were more than five times higher; and co-occurring MHSUDs were nearly four times higher. The suicide attempt rate, which is three times higher among those with than without HIV, is also a serious public health concern.

Multivariate analyses showed that among ED visitors younger than age 65 with HIV, mood and "other" mental disorders had small effects on ED-to-hospital admission, as opposed to treat-and-release, and cognitive disorders and suicide attempt had medium-to-large effects on hospital admission as well as transfer to another facility/HHC. Cognitive disorders also had medium effects on the risk of death in the 35-49 and 50-64 age groups. In the 65+ age group, only cognitive disorders had medium effects on hospital admission. With respect to substance use disorders, both AUDs and DUDs had small-to-medium effects on hospital admission in all age groups. Additionally, AUDs had a small effect, and DUDs had a marginal-to-small effect on the risk of discharge AMA in the 35-49 and 50-64 age groups, suggesting that drug addiction may be a barrier to receiving both HIV treatment[9] and healthcare in general.

An important and consistent finding is the role of cognitive disorders in increasing the likelihood of hospital admissions and transfer to another facility/HHC in all age groups, with the largest effect in the 21-34 age group, and in death in the 35-49 and 50-64 age groups. It is not clear if cognitive disorders among the younger and middle-aged groups are neurocognitive sequelae from alcohol and illicit drug use (which may have contributed to contracting HIV) and/or HIV-associated neurocognitive impairments (HAND). In the older age groups, cognitive disorders may also be age-related dementia and/or HAND.[23-25] Although cART therapy has significantly reduced HAND, mild cognitive disorders are highly prevalent among HIV-positive people.[26-28] One study also found a high prevalence of neurocognitive dysfunction in Romanian young adults growing up with HIV.[29] Our findings indicate that cognitive disorders are less likely in younger than in older ED patients with HIV, but they can be more detrimental to health and healthcare outcomes in younger adults.

LIMITATIONS

Our study has several limitations due to NEDS data constraints. First, data on substance misuse were limited to diagnoses of alcohol and drug use disorders. Adverse effects of substance misuse that do not meet diagnostic criteria may also precipitate ED use among people with HIV given their multiple physical and mental health problems. Future research should examine the effects of at-risk and binge/heavy drinking and drug misuse to provide more insight into their effects. Second, HIV diagnosis may not have been recorded in short treat-and-release visits for acute problems

that may be unrelated to HIV, while it was more likely to have been recorded in visits that led to hospital admissions or other facility-based care. Third, despite the significant likelihood of frequent ED visits among patients with HIV and MHSUD,[2] the effects of MHSUD on return visits by the same individuals could not be examined because observation units were visits, not individuals. Fourth, cross-sectional data allowed estimation of associations but not causality. Future research should investigate both longitudinal and reciprocal effects of MHSUDs on the health status, healthcare utilization, and health outcomes of people with HIV. Fifth, even though the overall number of ED visits by persons with HIV was large, the small sample sizes for combinations of an outcome category and one or more independent variables with low base rates (e.g., discharge AMA by 21-34 years with cognitive disorders) hampered interpretation of the multivariate regression results.

CONCLUSION

Despite these limitations, the study findings provide significant clinical, research, and policy implications. First, the high prevalence of MHSUDs and their significant roles in ED visit outcomes in patients with HIV provide support for integrated care for these patients[30] to reduce their ED visits and costly hospital admissions and institutional care that follows. HIV patients' complex care needs are not likely to be met at EDs unless a holistic care approach that takes into account physical, mental, and social comorbidities (e.g., poverty, lack of consistent access to primary care, and socioeconomic deprivations such as unstable housing[31]) is provided outside the ED. Community resources for psychiatric treatment especially for suicide risk prevention and substance use disorders and case management for unmet needs in other areas should be made available and easily accessible. Second, more research on the relationship between cognitive disorders, other mental disorders, and substance use disorders in patients with HIV and their effects on ED outcomes is needed. Both among younger and older ED patients with HIV, screening and interventions for cognitive disorders are necessary to reduce costly healthcare. Third, in the face of significant shifts in HIV demographics (i.e., graying of HIV patients), systemic efforts to meet the physical and mental health needs of older adults with HIV are necessary. Preventive healthcare and treatment for MHSUD conditions may lead to better HAART/cART adherence and contribute to improving the quality of life for people with HIV while using healthcare dollars more efficiently and effectively.

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Managing Agitation Associated with Schizophrenia and Bipolar Disorder in the Emergency Setting

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Introduction: Patient agitation represents a significant challenge in the emergency department (ED), a setting in which medical staff are working under pressure dealing with a diverse range of medical emergencies. The potential for escalation into aggressive behavior, putting patients, staff, and others at risk, makes it imperative to address agitated behavior rapidly and efficiently. Time constraints and limited access to specialist psychiatric support have in the past led to the strategy of "restrain and sedate," which was believed to represent the optimal approach; however, it is increasingly recognized that more patient-centered approaches result in improved outcomes. The objective of this review is to raise awareness of best practices for the management of agitation in the ED and to consider the role of new pharmacologic interventions in this setting.

Discussion: The Best practices in Evaluation and Treatment of Agitation (BETA) guidelines address the complete management of agitation, including triage, diagnosis, interpersonal calming skills, and medicine choices. Since their publication in 2012, there have been further developments in pharmacologic approaches for dealing with agitation, including both new agents and new modes of delivery, which increase the options available for both patients and physicians. Newer modes of delivery that could be useful in rapidly managing agitation include inhaled, buccal/sublingual and intranasal formulations. To date, the only formulation administered via a non-intramuscular route with a specific indication for agitation associated with bipolar or schizophrenia is inhaled loxapine. Non-invasive formulations, although requiring cooperation from patients, have the potential to improve overall patient experience, thereby improving future cooperation between patients and healthcare providers.

Conclusion: Management of agitation in the ED should encompass a patient-centered approach, incorporating non-pharmacologic approaches if feasible. Where pharmacologic intervention is necessary, a cooperative approach using non-invasive medications should be employed where possible. [West J Emerg Med. 2016;17(2):165–172.]

INTRODUCTION

Individuals with bipolar disorder or schizophrenia are vulnerable to episodes of agitation, which can be defined as excessive verbal and motor behavior, especially during exacerbations of their disease.[1] Agitation associated with psychosis is a frequent reason for emergency department (ED) visits by patients with psychiatric disorders, and requires immediate action to prevent escalation to a level that could put patients, staff, and others at risk.[1] As specialist psychiatric support other than social work services is often not available in the emergency setting, agitated patients may often need to be medically evaluated and treated by emergency physicians.

The physician should, where possible, identify the underlying etiology of the agitation – whether due to an underlying non-psychiatric medical condition or primarily due to a mental disorder – before deciding on an appropriate course of action and possible pharmacologic intervention.[2]

In the past, standard practice for intervening with an agitated patient frequently involved restraint and seclusion; however, this approach is associated with many negative outcomes.[3] From the patient's perspective, the approach does not recognize that many affected individuals are frightened, fragile, and vulnerable, with a history of traumatic experiences; while for others, their presentation in the ED may be their first experience in mental healthcare systems. A negative experience at this stage can potentially influence their future cooperation with healthcare workers and jeopardize future management of a potentially serious underlying condition. For the medical profession, the restraint and seclusion approach, although perceived by many to be efficient, is resource intensive as there is a requirement for one-to-one observation of a restrained or sedated patient. In addition, it is often associated with staff injuries, and it increases the length of time that individuals remain in the ED, compounding problems of overcrowding and boarding.[3,4] The process of the "takedown" to place an individual in restraints may take a substantial amount of time, during which staff are at high risk of assaults and injuries. Furthermore, sedation can mask an underlying condition, thereby hindering accurate diagnosis.[2]

Guidelines are available to direct clinicians in all aspects of agitation management from triage through to pharmacologic choices. When pharmacologic intervention is deemed necessary, an array of therapeutic options administered via different routes now exists, providing both the patient and physician with treatment alternatives. The aim of this narrative review is to raise awareness of best practices for the management of agitation in the ED, and to consider the role of new pharmacologic interventions for patients with agitation associated with bipolar disorder or schizophrenia. It is recognized that physicians working in the ED must also deal with agitation occurring in association with dementia, delirium, and drug abuse, however, these areas are beyond the scope of this review.

METHODS

The content of this narrative review was based on information contained within the Best practices in Evaluation and Treatment of Agitation (BETA) guidelines with the addition of data on new pharmacologic interventions that were identified through literature searches of PubMed using combinations of the search terms "agitation," "bipolar," "schizophrenia," "emergency care," and "emergency department." Articles were then hand searched. Additional data included in the review are based on product prescribing information.

DISCUSSION

Guideline Overview

Various guidelines exist for the management of agitation,[5] some of which provide direction for agitation associated with a particular disorder, such as bipolar disorder,[6] or occurring in a particular setting, such as the intensive care unit.[7] In 2012, the Project BETA guidelines were published by the American Association for Emergency Psychiatry,[1] providing detailed guidance on various aspects of patient management including medical evaluation and triage, psychiatric assessment, verbal de-escalation of the agitated patient, psychopharmacologic approaches, and the use and avoidance of seclusion and restraint.[2,3,8-10] In addition, the Centers for Medicaid Services Conditions of Participation for Hospitals include mandatory regulations on the use of seclusion and restraint.

Medical Evaluation and Triage

Agitation can be caused by disparate medical and psychiatric conditions including head trauma, infection, thyroid disease, substance abuse/withdrawal, psychotic disorders, and depression.[10] Identifying the etiology therefore represents a significant challenge, which is made more difficult by the immediate need to calm the patient to avoid escalation.

Rating scales have been developed to measure agitation, including the single-item Behavioral Activity Rating Scale (BARS), the five-item Positive and Negative Syndrome Scale (PANSS) Excited Component (EC), and the more complex Overt Agitation Severity Scale.[11-18] PANSS-EC and BARS have been successfully used as primary outcome measures in the commercial development of several agents for the indication of agitation associated with schizophrenia and/or bipolar mania. BARS is simple to use and does not require the participant/patient to answer questions, so it is favored for purely pragmatic purposes and is also useful in a non-medical setting.

For agitated patients presenting in the ED, medical evaluation and triage should include a brief history and vital signs.[10] Where possible, oxygen levels and blood glucose levels should also be obtained. Patients with loss of memory or disorientation, severe headache, extreme muscle stiffness or weakness, heat intolerance, unintentional weight loss, new-onset psychosis, or difficulty in breathing should be immediately evaluated by a clinician.[10] Abnormal vital signs, overt trauma, slurred speech, unequally dilated pupils, lack of coordination, seizures, or hemiparesis also warrant immediate evaluation.[10]

If feasible, attempts at de-escalation should be made at this stage in order to gain the patient's cooperation and participation in the evaluation. There may, however, be instances where patients require medication during the assessment to calm them enough to allow a thorough evaluation. Some patients may require medication, restraint, and increased behavioral support if the risk of violent behavior becomes high and a patient remains uncooperative.[10]

Determining whether there is a known psychiatric illness is an important aspect of triage and initial evaluation, as an underlying condition would influence subsequent treatment decisions. Agitation arising from a general medical condition should be suspected for cases of new-onset agitation and for patients with a concerning past medical history, or if the onset is outside the normal ranges of psychiatric disease. A workup for a general medical condition should aim to identify the most likely underlying causes.[10]

Psychiatric Assessment

Severe agitation can preclude the ability for emergency physicians to conduct a complete psychiatric evaluation at the outset; however, a brief evaluation should be conducted to establish the most likely cause of the agitation.[9] In many cases, the initial assessment can be conducted through visual observation of the patient during attempts at de-escalation, combined with verbal reports from other team and family members.[9] Next, attempts should be made to establish if the patient has delirium, other cognitive impairment, intoxication or withdrawal, a known psychiatric condition, or another cause. When the patient is calm enough – either as a result of verbal de-escalation or initial medication – a formal psychiatric evaluation should be conducted.[9] Of note, the goal of an emergency psychiatric assessment is not necessarily to obtain a definitive diagnosis, but instead it should aim to establish a reasonable differential diagnosis, identify issues related to safety of the patient and others, and develop a suitable treatment and disposition plan.[9]

Non-Pharmacologic Management

An important underlying principle of the Project BETA guidelines is that seclusion and restraint should be avoided, as this approach is associated with many negative outcomes.[3,8] For patients and staff, injuries – both physical and psychological – often occur during restraint, which can have negative consequences that extend beyond the period during which the patient is restrained. Furthermore, restraint can damage short- and long-term patient–physician relationships.

Restraining patients can also result in additional resource use and a longer time spent in the ED. For example, in a prospective evaluation of over 1,000 adults treated in the ED, use of restraint resulted in patients spending an additional 4.2 hours in the ED compared with those not requiring restraint.[4] Reduced ED boarding can increase hospital revenue if bed capacity is effectively managed.[19] The need for additional staff for the restraint procedure and subsequent observation is time consuming, costly, and stops staff from performing other duties. Patients who have been sedated also spend longer in the ED, as it can be more challenging to admit or transfer a recently restrained patient or one who has been sedated.

Instead of restraint, where possible, initial attempts to calm the patient should focus on non-coercive approaches involving verbal engagement, establishment of collaborative relationship, and verbal de-escalation (Table 1).[3] Key aspects of de-escalation include: respecting a patient's personal space; avoiding provocation; establishing verbal contact and providing orientation and reassurance; communicating simply and concisely; identifying the patient's wants and feelings; listening to what the patient is saying; setting clear limits; offering choices and optimism; and debriefing the patient if involuntary intervention has been necessary.[3] As part of this strategy, non-verbal interventions, e.g. voluntary medication and environment planning, can also be useful. As discussed later, in situations where medication is taken voluntarily, some of the newer modes of administration – inhalation and rapid-onset oral medications – may be more acceptable to patients than traditional injectable formulations.

Implementation of non-coercive approaches may require changes in organizational culture and staff training;[8,20] however, the benefits are widespread, including reduced resource use, costs, and staff and patient injuries, and better patient–physician relationships.[4,19] The advantages and disadvantages of non-pharmacologic approaches are outlined in Table 2.

Pharmacologic Management

Management of agitation is multifaceted and pharmacologic interventions represent only one part of the overall approach. In some cases, agitation can be managed through non-pharmacologic approaches, such as verbal interventions and de-escalation; however, for many individuals some pharmacologic treatment will be necessary.[2] When choosing the optimal treatment, the provisional diagnosis should be taken into account (intoxication, psychiatric illness, delirium, head trauma, infection, etc.) and where possible the underlying etiology should be targeted. Consideration should also be given to the timing and extent of medication. Elderly patients pose special challenges in terms of potential comorbidities and potential drug–drug interactions, necessitating dosage adjustments.

Early and excessively aggressive pharmacologic intervention can mask underlying conditions, delaying and impeding accurate diagnosis.[2] However, delays in medication use can allow the agitation to escalate, putting the patient, staff, and others at increased risk of harm. Furthermore, if the agitation becomes markedly more pronounced, higher doses and more frequent administration of medication may become necessary. Taking these factors into account, the goal of pharmacologic intervention should be to calm the patient to allow assessment, avoiding sleep if possible. Sleeping or over-sedated patients can require additional monitoring, which increases the burden on available resources (such as the need for one-to-one observation, assistance in toileting, etc.), and can delay appropriate disposition. The Project BETA guidelines recommend that patients should be involved in the process of selecting the drug type and

Table 1. Behavioral interventions for different scenarios involving patient agitation.

Behavioral intervention	Patient scenario
Verbal de-escalation	Should be attempted in all patients
Quiet unlocked room	Patients in whom de-escalation alone was insufficient to reduce dangerousness enough to allow to remain in general care areas, and/or may need more time to regain control away from other patients
Locked seclusion	If patients are considered an imminent danger to others but not themselves, and cannot tolerate or remain in a quiet unlocked room
Restraint	If patients are considered an imminent danger to themselves, and cannot remain in a locked seclusion room without actively trying to injure themselves.

Table 2. Advantages and disadvantages of non-pharmacologic interventions for agitation.

Advantages	Disadvantages
• Facilitates better short- and long-term patient–physician relationships • Reduces staff and patient injuries associated with restraint and sedation • Reduces resource (clinical and staff) use	• May not be effective in all patients • Requires some co-operation from the patient

administration route if possible. If the patient is able to cooperate with taking oral medications, these are preferred over intramuscular formulations.[2]

Medications commonly used in the management of acute agitation include first- and second-generation antipsychotics, and benzodiazepines. Not all interventions and/or formulations have received U.S. Food and Drug Administration (FDA) approval for this use, and they also vary in terms of strength of the experimental evidence supporting their use. For patients with agitation associated with a psychiatric disorder, such as bipolar disorder or schizophrenia, antipsychotics are preferred over benzodiazepines because they address the underlying psychosis.[2] If, however, an initial dose of an antipsychotic does not control the agitation, the addition of a benzodiazepine is recommended over an increased dose of the same antipsychotic or addition of a second antipsychotic.[2] Moreover, in the case of acute withdrawal from alcohol or benzodiazepines the preferred medication intervention is a benzodiazepine, e.g. lorazepam; this is not a trivial consideration, as it is estimated that approximately half of all patients with schizophrenia have a comorbid drug- or alcohol-abuse problem.[21]

Desirable features of antipsychotics are rapid onset, control of aggressive behavior, reliability, and preservation of the physician–patient relationship.[22,23] Intramuscular injection enables direct entry of the active agent into the systemic circulation through the muscle's vasculature, providing the potential for rapid onset of action. The first-generation injectable antipsychotic haloperidol has long been used in the treatment of agitation in schizophrenia.[2] When delivered via intramuscular injection, peak plasma levels of haloperidol are reached in ~20 minutes (Table 3).[24] This rapid onset of action must be balanced against haloperidol's adverse-event burden, including lengthened electrocardiogram QTc interval, extrapyramidal symptoms, and akathisia.[23] Dystonic reactions, including laryngospasm, oculogyric crisis, and torticollis, are particularly frightening for patients, and can occur 12–24 hours after administration.[25] The occurrence of adverse effects such as these is an important consideration because they can complicate management and compromise future care as patients may be less willing to take medicines, particularly if they have experienced an acute dystonic reaction.

Intramuscular preparations of the second-generation antipsychotics ziprasidone,[26] olanzapine,[27] and aripiprazole[28] have more favorable extrapyramidal side-effect profiles than haloperidol while providing similar effect sizes for the reduction of agitation.[2,29] Intramuscular injections of these agents are approved by the FDA for treatment of acute agitation associated with schizophrenia (aripiprazole, olanzapine, and ziprasidone)[26–28] and bipolar mania (olanzapine and aripiprazole)[27,28] and they are now recommended over the first-generation antipsychotics in guidelines.[2]

One of the key disadvantages of intramuscular injections is that patients may resist, resulting in the need for manual immobilization, risking injury to healthcare providers, including inadvertent needlestick injuries. Furthermore, the use of force to immobilize the patient can result in mental trauma that has the potential to negatively affect immediate and future patient–physician relationships.

The disadvantages of intramuscular injections have led to the recommendation that non-invasive formulations should be used in situations where the patient is able to cooperate.[2] Non-invasive formulations require at least some cooperation from patients but have the potential to prevent escalation and improve the experience of patients, and could be considered when negotiation is possible. Oral formulations of most first- and second-generation

Table 3. Advantages and disadvantages of different routes of administration.

Administration route	Advantages[32]	Disadvantages[32]	Examples	Time to peak plasma concentration
Intramuscular	Rapid systemic entry; patient cooperation not necessary	Invasive; can damage patient–physician relationship	Haloperidol[24] Olanzapine[27] Aripiprazole[28] Ziprasidone[26]	~20 minutes 15–45 minutes 1–3 hours 60 minutes
Inhaled	Less invasive than intramuscular route and can improve patient experience. Enters alveoli for rapid entry into arterial circulation	Requires patient cooperation Bronchospasm/ respiratory distress	Loxapine[31]	2 minutes
Oral				
Standard tablets/ capsules/ solution	Less invasive than intramuscular route and can improve patient experience	Require patient cooperation; slow onset of action; enter systemic circulation via portal system resulting in potential for erratic absorption; can be diverted ("cheeking")	Haloperidol[24] Olanzapine[27] Risperidone[30] Aripiprazole[28] Ziprasidone[26]	2–6 hours 5–8 hours ~1 hour 3–5 hours 6–8 hours
Orally disintegrating tablets	Less invasive than intramuscular route and can improve patient experience. Less potential for diversion ("cheeking") vs standard tablets/capsules; suitable for patients with dysphagia	Slow onset of action; enter systemic circulation via portal system resulting in potential for erratic absorption	Olanzapine[27] Risperidone[30,33,34] Aripiprazole[28]	~6 hours 1–2 hours 3–5 hours
Buccal/ sublingual	Less invasive than intramuscular route and can improve patient experience; rapid absorption; avoids first-pass metabolism	Requires patient cooperation; needs to be taken correctly so that it is not swallowed, mitigated in part by the friability of the tablet	Sublingual asenapine[35]	0.5–1.5 hours
Intranasal	Less invasive than intramuscular route and can improve patient experience; rapid absorption; avoids first-pass metabolism	Requires patient cooperation.	Intranasal midazolam[32]	10 minutes

antipsychotics are available; however, administration results in entry to the systemic circulation via the portal system, absorption can be erratic, and onset of action is slower than for agents administered via intramuscular injection (Table 3).

Orally disintegrating formulations of olanzapine, risperidone, and aripiprazole have been developed, which dissolve with saliva in the mouth and can be swallowed without additional liquid.[27,28,30] This can be beneficial for patients with dysphagia and also in patients who might divert the medication. However, this method of administration does not improve time to onset as the medication must still be swallowed, with absorption taking place lower in the gut.[32] All three of these orally disintegrating antipsychotic formulations are bioequivalent to the regular oral tablets and provide similar efficacy and safety at the same doses.[27,28,33,34]

Another orally disintegrating tablet formulation of an atypical antipsychotic that is available is sublingual asenapine,[35] which is approved by the FDA for the treatment of schizophrenia and for manic/mixed episodes associated with bipolar disorder. In contrast to the orally disintegrating tablets of olanzapine, risperidone, and aripiprazole, sublingual asenapine is absorbed in the oral mucosa and peak plasma concentration is reached in 30–60 minutes.[35] Administration via this route has the advantage of avoiding first-pass metabolism; however, as with all oral medications, treatment requires patient cooperation. In a randomized, double-blind, placebo-controlled trial for acute agitation, sublingual asenapine was efficacious, with an effect size comparable to that observed in prior studies of intramuscular second-generation antipsychotics.[36] However, sublingual asenapine is not approved by the FDA for acute agitation and its use for this indication would be considered off label.[35]

A recent addition to the armamentarium is inhaled loxapine, which is approved by the FDA for the acute treatment of agitation associated with schizophrenia or bipolar I disorder.[31] Loxapine is a first-generation antipsychotic, which has been available for many years as an oral formulation and has an established safety and efficacy profile.[37] It has recently been reformulated at a lower dose as an inhaled powder that can be directly administered to the lungs. This results in rapid absorption into the systemic circulation with peak plasma levels being reached within two minutes of administration.[31] The efficacy and safety of inhaled loxapine for acute agitation were demonstrated in two Phase III clinical trials, one in schizophrenia and the second in bipolar mania.[38,39] In these studies, the effect sizes were comparable to those observed in analogous studies of intramuscular injection of antipsychotics or

lorazepam.[40] Of note, clinical effects, as measured by separation from placebo on the PANSS-EC, were observed as early as 10 minutes after inhalation, the first time point that this was measured.[38,39] Inhaled loxapine was generally well tolerated, with dysgeusia being the most common spontaneously reported adverse event. Extrapyramidal adverse events and akathisia were relatively rare; however, spirometry studies indicated inhaled loxapine can cause bronchospasm that has the potential to lead to respiratory distress and respiratory arrest. For this reason, inhaled loxapine is restricted to use in hospitals with access to facilities to deal with acute bronchospasm, and is only available through a restricted program under a risk-evaluation and mitigation strategy. It is worth noting that as inhaled loxapine is self-administered under medical supervision, it is unlikely to be suitable in situations where patients are actively refusing treatment.[1] However, even a patient in restraints could conceivably use voluntarily self-administered medications, if one arm can be safely released.

Midazolam – a water-soluble, fast-acting benzodiazepine – can be administered through various routes, including intranasally. Although not FDA approved for acute agitation, there has been interest in the potential use of this formulation for this indication.[32] Intranasal midazolam is absorbed by the nasal mucosa and avoids first-pass metabolism. In children, intranasal midazolam induced calming within 15 to 20 minutes.[41] A caveat is that midazolam is chiefly used for sedation and has no antipsychotic effects; thus, like lorazepam, it would not ameliorate hallucinations or delusions, and will not treat the underlying psychosis that may be engendering the agitation. Although using a sedation agent alone might temporarily relieve agitation, there is the risk that upon awakening, if the psychotic symptoms still persist, agitation might quickly return.

CONCLUSION

Agitation represents a significant challenge in the ED, a setting in which medical staff are working under extreme pressure and dealing with a diverse range of medical emergencies. The potential for agitation to escalate into aggressive behavior, putting patients, staff, and others at risk, means that it is important to address the behavior rapidly and efficiently to ensure the safety of all involved. Time constraints and limited access to specialist psychiatric support have in the past led to the somewhat draconian strategy of "restrain and sedate, ' which was believed to represent the optimal approach. It is increasingly recognized that more humane, patient-centered approaches result in improved short- and long-term outcomes, including fewer injuries, better therapeutic alliance, improved throughput, and reduced resource use and costs. The Project BETA guidelines address the complete management of agitation, including triage, diagnosis, interpersonal calming skills, and medicine choices. Since their publication in 2012, there have been further developments in pharmacologic approaches for dealing with agitation, including both new agents and new modes of delivery, which increase the options available to patients and physicians. Older interventions, such as intramuscular haloperidol, are – in the authors' opinion – essentially now obsolete, because effective, yet more benign, FDA-approved injectable treatments are available instead.[42,43] However, despite the availability of these injectable agents, non-invasive formulations, such as sublingual, inhaled, or intranasal agents, although requiring cooperation from patients, should be used whenever possible to improve the overall patient experience, thereby potentially improving future cooperation between patients and healthcare providers. At the present time inhaled loxapine is the only non-injectable option specifically approved by the FDA for this purpose; however, evidence is also available for sublingual asenapine and intranasal midazolam.

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Care of Psychiatric Patients: The Challenge to Emergency Physicians

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Psychiatric patients frequently present to the emergency department (ED) for care when they are in crisis. Recent studies demonstrate about 10% of all ED patients present with psychiatric illness.[1] However, this is not an adequate estimate of the number of patients because many of these patients do not have a psychiatric diagnosis. Two recent studies have demonstrated that 45% of adults and 40% of pediatric patients who present to the ED with non-psychiatric complaints have undiagnosed mental illness.[2-3] These studies did not determine whether these psychiatric illnesses affected the patients' presentation. The purpose of this article is to discuss disparity and challenges in caring for these patients.

Psychiatric patients who present to the ED are just like other patients, or are they? For what other patient types do we have consultants outside of our medical facility come to evaluate the patient and determine the need for admission? For what other patient types are emergency physicians (EPs) uncomfortable ordering their home medications? What other patient types have to wait for an inpatient bed or to be transferred to another facility without receiving any treatment? What other patient type do our attitudes affect their outcome so significantly? Why do we focus on improving care for trauma, cardiac, stroke, pediatric, geriatric patients but not psychiatric ones? Is this an issue of benign neglect, lack of outcome satisfaction, unpleasantness of these patients, countertransference issues or something else that compels us to limit our interest in patient care, research, and learning more about these patients.

EDs do a good job of determining how to improve the care of the medical patient but they have done little addressing the unique needs of the psychiatric patients. Patient care surveys usually focus on evaluating the patient care experience of non-psychiatric patients in the ED. These customer service surveys have identified many priorities for patient care and satisfaction in the ED, need for improvement, and, for some physicians, determines a component of their bonuses. However, psychiatric patients have a unique set of preferences that differ from the non-psychiatric patients. They want verbal interventions, use of oral medications, input regarding their medication experiences and preferences, peer support services, improved discharge planning, a better triage process, reduced wait time for treatment and more privacy.[4]

EPs frequently have negative attitudes towards patients seen in the ED but it is most pronounced for psychiatric patients. They do not realize that their attitudes towards the psychiatric patient may lead to poor patient outcomes. It is noted that patients with intentional self-harm and substance use/abuse pose the most challenge for EDs.[5] Stefan noted that emergency care providers regard psychiatric patients as problems or nuisances.[6] There are a number of contributing factors to these findings including societal attitudes and personal biases, inadequate educational preparation, organizational climate, safety concerns, crowding, caregiver lack of confidence, and lack or guidelines.[6] Although not studied in EDs, studies have noted that suicidal behavior appears to elicit mostly negative feelings among staff members.[7] If not acknowledged and properly handled, these attitudes may lead to premature discharge. ED staff need to understand, contain and work through their negative feelings towards patients.

EPs have little training in behavioral emergencies in emergency medicine (EM) residencies. Education and experience is a problem when few EM programs provide experience or training in emergency psychiatry. This deficit is compounded by the fact that The American Board of Emergency Medicine board certification exam has 4% or less of the questions pertain to behavioral issues.[8] EPs complain about gaps in detecting patients with substance use disorder, lack of education in care of psychiatric patients and a shortage of services to treat these patients.[6] Nurses have issues with these patients as well. Nurses perceive lack of knowledge, skills and expertise, problems with triage risk assessment, frustration with frequent psychiatric patient visits, insufficient resources, ongoing patient and staff safety concerns, feeling of

helplessness and perception of a broken mental health system.[6]

How do we resolve these challenges? We need more staff education and experience, care standards, better triage process, improved evaluation, enhanced treatment protocols and reduced wait time and boarding. There is a need for improved education and experience for psychiatric patients in EM. There are post-graduate fellowship programs in pediatric, geriatric, and critical care patients but few, if any, current fellowships in emergency psychiatry. Few programs have EM residents rotate on the consultation liaison psychiatric service or in a psychiatric ED. The solution to this deficit is to put a greater emphasis on psychiatric emergencies in residency, more questions on the EM board exam, and provide continuing medical education (CME) courses on psychiatric emergencies. Although many have expressed concern with "merit badges," is it time to have a course for psychiatric emergencies like advanced trauma life support (ATLS), advanced cariovascular life support (ACLS), and pediatric advanced life support (PALS)? Whether there is a merit badge or not, there is a need for standardization in the care for patients with psychiatric emergencies. There is a need for a similar endeavor in the evaluation and treatment of the suicidal, depressed, psychotic or bipolar patient.

As we know, the role of the EP is to determine if the patient has a life- or limb-threatening problem, and to treat the acute symptoms and signs. The psychiatric patient has every bit the risk of some of our sickest medical patients. EPs must identify medical problems that mimic psychiatric illness, including metabolic, endocrine, infectious or substance induced that can put the patient's life in immediate jeopardy. Furthermore, psychiatric patients are at some or even high risk for homicide, suicide or inability to perform self-care. Therefore, it is not an appropriate rationalization that psychiatric patients are any less deserving of a complete and thoughtful evaluation.

The triage process in the ED is skewed to patients with medical problems over those with psychiatric problems. Emergency Severity Index (ESI) triage system published by Agency for Health Quality Research (AHQR) is a five-tiered system that prioritizes patients presenting primarily with medical complaints, but is weak for triage of psychiatric patients in the ED. The Australian Triage Scale (Figure 1) and the Canadian Emergency Department Triage system for psychiatric patients are better tools, since they focus on properly assessing psychiatric patients.[9] The Australasian mental health triage scale not only determines priority based on behavioral presentation but also places time parameters on the evaluation of a mental health patient. The ESI triage tool needs revision to reflect the needs of the psychiatric patient or adoption of another tool needs to be considered.

The evaluation process for psychiatric patients in the ED is problematic. Many EPs do not think that there is a need to perform a psychiatric evaluation. Not only is there a cost for an outside service to evaluate these patients, but also these do not eliminate a physician's responsibility for appropriate disposition or reduce their liability exposure. EPs may not be able to continue to delegate their psychiatric evaluation to an outside source. Market forces from Accountable Care Organizations (ACO) to limit costs and admissions may force EPs to do this. Unfortunately for some, the ACOs may also determine need for admission.

A psychiatric evaluation is not as daunting as one might think. To differentiate medical illness or medical mimics from a psychiatric illness, an appropriate history, physical examination, mental status examination and clinically indicated testing are used. The medical clearance checklist (Figure 2) is one means to systematically perform and document this process. The other part of the psychiatric evaluation is determination of the need for a psychiatric inpatient admission. Unlike other medical illness this is not an exact science. Rather, diligence and good clinical judgement are the most valuable tools. Patients who have suicidal ideation need a risk assessment based on dynamic and static risk factors and protective components. The patient is placed into one of three risk categories: low (can be discharged home); moderate/(needs further psychiatric assessment); and high (inpatient psychiatric admission indicated).

A similar risk assessment is done for homicidal patients, which includes prior history, collateral information, means and a plan. It is easier to determine the patient's ability to care for himself based on his clinical condition and ability to provide for his own needs. This assessment is performed by understanding insight and judgment of their mental illness and their ability to self-care for both medical and psychiatric illnesses.

Better treatments protocols are needed for psychiatric patients in crisis in the ED. All too frequently, these patients are given the same medication for agitation regardless of cause. However, best practices in evaluation and treatment of agitation (BETA) expert guidance recommends that medication be determined by the most probable etiology.[10] We no longer treat all pneumonia patients with the same antibiotic, but assess their most likely etiology. Treatment of psychiatric illness should be similarly tailored to the patient and situation as detailed in Figure 3.

Mental Health Triage Scale

Triage Category	Patient Description	Treatment Acuity
2 "Emergency"	Patient is violent, aggressive or suicidal, or is danger to self or others, requires police escort	Within 10 minutes
3 "Urgent"	Very distressed or acutely psychotic, likely to aggressive, may be a danger to self or others	Within 30 minutes
4 "Semi Urgent"	Long-standing or semi-urgent mental health disorder and/or has supporting agency/escort present	Within 1 hour
5 "Non-urgent"	Patient has a long-standing or non-acute mental disorder/problem but has no supportive agency/escort - may require a referral to an appropriate community Resource.	Within 2 hours

*It is considered advantageous to "up-triage" mental health patients with carers present because carers' assistance facilitates more rapid assessment.

Source: Smart, D., Pollard, C. & Walpole, B. (1999). Mental health triage in emergency medicine. Australian and New Zealand Journal of Psychiatry, 33:57-66.

Figure 1. Australian mental health triage scale.

APPENDIX A

Psychiatric Medical Clearance Checklist

	Yes	No
1. Does the patient have new psychiatric condition?	☐	☐
2. Any history of active medical illness needing evaluation?	☐	☐
3. Any abnormal vital signs prior to transfer	☐	☐
Temperature >101°F		
Pulse outside of 50 to 120 beats/min		
Blood pressure systolic <90 or>200; diastolic >120		
Respiratory rate >24 breaths/min		
(For a pediatric patient, vital signs indices outside the normal range for his/her age and sex)		
4. Any abnormal physical exam (unclothed)	☐	☐
a. Absence of significant part of body, eg, limb		
b. Acute and chronic trauma (including signs of victimization/abuse)		
c. Breath sounds		
d. Cardiac dysrhythmia, murmurs		
e. Skin and vascular signs: diaphoresis, pallor, cyanosis, edema		
f. Abdominal distention, bowel sounds		
g. Neurological with particular focus on:		
i. ataxia iv. paralysis		
ii. pupil symmetry, size v. meningeal signs		
iii. nystagmus vi. reflexes		
5. Any abnormal mental status indicating medical illness such as lethargic, stuporous, comatose, spontaneously fluctuating mental status?	☐	☐
If no to all of the above questions, no further evaluation is necessary. Go to question #9		
If yes to any of the above questions go to question #6, tests may be indicated.		
6. Were any labs done?	☐	☐
7. What lab tests were performed? _____		
What were the results? _____		
Possibility of pregnancy ?	☐	☐
What were the results? _____		
8. Were X-rays performed?	☐	☐
What kind of x-rays performed? _____		
What were the results? _____		
9. Was there any medical treatment needed by the patient prior to medical clearance?	☐	☐
What treatment? _____		
10. Has the patient been medically cleared in the ED?	☐	☐
11. Any acute medical condition that was adequately treated in the emergency department that allows transfer to a state operated psychiatric facility (SOF)?	☐	☐
What treatment? _____		
12. Current medications and last administered? _____		
13. Diagnoses: Psychiatric _____		
Medical _____		
Substance abuse _____		
14. Medical follow-up or treatment required on psych floor or at SOF: _____		
15. I have had adequate time to evaluate the patient and the patient's medical condition is sufficiently stable that transfer to ___SOF or ___ psych floor does not pose a significant risk of deterioration. (check one)		

_____MD/DO
Physician Signature

Figure 2. Psychiatric medical clearance checklist. *ED,* emergency department

RECOMMENDATIONS REGARDING MEDICATIONS

Psychiatrists on the task force and with substantive experience in managing the acutely decompensated psychiatric patient report using the following medications:

- Acutely agitated (non-psychotic) patients - oral benzodiazepine
- Acutely agitated (not psychotic) and uncooperative with oral medications - IM benzodiazepine
- Acutely agitated, psychotic, cooperative - dissolving oral antipsychotic (Zyprexa Zydis or Risperdal M tabs)
- Acutely agitated, psychotic, uncooperative - injection of Zyprexa IM or haldoperidol IM
- Psychiatric history, without agitation but with other presenting symptoms such as irritability or anxiety - benzodiapine for anxiety or antipsychotic for psychotic symptoms

Finally, the Task Force notes that the use of benztropine whenever haloperidol is given to reduce the possibility of a dystonic reaction. Although the occurrence rate is low, it can be such an unpleasant experience for the patient that it may discourage them from future medication use.

Figure 3. Recommendations for acute treatment of emergency department patients with agitation.

Boarding is more frequently seen in psychiatric patients than medical patients.[11] This is primarily related to inadequate inpatient beds and outpatient resources. The boarding problem leads to iatrogenic worsening of their clinical condition and agitation. EPs need to explore alternatives to admission, rapid treatment and stabilization protocols, placement in a crisis stabilization unit and greater use of community resources.

EM has advocated for the care of the myocardial infarction, trauma, septic, pediatric and geriatric patients. It is time to advocate for the psychiatrically ill patient in the ED. We need to push for more training, establishment of standards of care, reduced wait times and find alternatives to boarding.

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Electronic Vapor Cigarette Battery Explosion Causing Shotgun-like Superficial Wounds and Contusion

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INTRODUCTION

Electronic vapor cigarettes (E-cigarettes) were created in 2003 as an alternative to traditional tobacco cigarettes. E-cigarettes have been available in the United States since 2006.[1] The typical E-cigarette consists of a cartridge that contains liquid, an atomizer that heats the liquid (i.e. acts as a vaporizer), as well as a battery. The liquid contained within the cartridge contains nicotine, propylene glycol and/or glycerol as well as flavorings. The consumer uses an E-cigarette through either pushing a button or inhalation, which triggers heating and therefore aerosolizes the liquid within the cartridge, emulating cigarette "smoke." The newest E-cigarettes are larger than nicotine cigarettes and employ stronger, rechargeable batteries as a power source.[2,3]

These new devices allow for custom modifications instituted by the user, including various options for cartridges and for the heating temperature of the atomizer. This creates the opportunity for mismatched components, leading to overheating. The current literature is limited on both the long-term health impact of E-cigarette use as well as the mechanical safety of these devices.[2,3] We present the second documented case of burn injury due to explosion of an E-cigarette, and the first instance of the explosion occurring during usage of the device.[4]

Case Report

A 26-year-old man presented to the emergency department (ED) via ambulance with purported burns to his left shoulder and chest. Thirty minutes prior, the patient had been smoking an E-cigarette at his house. The patient is a paid tester for an E-cigarette company, and the cigarette he was using was an experimental model. The cigarette was a customizable, large device powered by a lithium-ion battery. The patient denied misuse of the cigarette at the time of injury. The E-cigarette exploded while the patient was using it and the battery subsequently disintegrated into diffuse shrapnel. This material, as well as the ejected battery, struck the patient diffusely on the upper abdomen, left shoulder and chest. The patient further noted that across the room was a three-inch hole in the drywall about five feet above the floor, and 8-10 feet from him. It was unclear which part of the device became the projectile that damaged the wall.

There was no reported loss of consciousness, and the patient denied headache and head or neck injury. The patient did not fall to the ground. There was no resulting fire or significant smoke concerning for inhalation injury.

The patient has a history of smoking tobacco and marijuana, but does not use other drugs or alcohol. The patient had no other past medical/surgical history. Review of systems was otherwise negative.

On physical exam, the patient's vital signs were the following: temperature 36.9C, HR 50bpm (sinus bradycardia), RR 16/minute, BP 131/85 and O_2 saturation of 98% on room air. The patient had soot in his nares and skin of his neck, but otherwise had no evidence of facial burns. He had no soot in the oropharynx, and nasal/facial hair was not singed. He had broad peppering of the skin on the left chest, abdomen and anterior/medial left arm with a small area of second-degree burn versus foreign body penetration in the left upper quadrant of the abdomen and the anterior chest superior to the left nipple. The patient also had soot over the left hand, with which he had been holding the device, with small penetrating foreign bodies in the palmar surface of the thumb. The patient had superficial skin pain over these sites.

Heart and lung sounds were normal. His abdomen was soft with mild to moderate tenderness over the contused areas but no rebound or guarding. His extremities had full range of motion, no deformity, and no apparent penetration of foreign bodies into any joint. An extended-focused assessment of sonography of trauma (E-FAST) revealed appropriate lung sliding and was negative for free fluid in the peritoneum and pericardium.

Representative photographs of the patient's injury are presented in Figures 1, 2, and 3, and the device and battery in

Figures 4 and 5.

The patient tested positive for tetra-hydra-cannabinol (THC) but toxicology screen was otherwise negative. All other lab results were unremarkable. Initial chest radiograph showed no significant abnormalities. Despite the shrapnel-like appearance of the skin injury, there were no radio-opaque foreign bodies. Computed tomography (CT) of the abdomen/pelvis showed soft tissue contusion anterior-superiorly in the midline subcutaneous fat but no evidence of acute intra-abdominal injury. Pulmonary CT angiography showed multiple soft tissue contusions and skin thickening anteriorly, but no acute intrathoracic injury. There was no pneumothorax, pulmonary contusion, solid organ injury or peritoneal fluid.

The patient did not have debridement of foreign bodies from the skin while in the ED, as there did not appear to be any discrete removable fragments. He was discharged home from the ED after approximately six hours of observation with recommendations for daily wound care and follow up with the burn clinic in two weeks.

At the patient's follow-up appointment, he endorsed continued use of the E-cigarette. The patient expressed concerns about scarring but denied pain or discomfort. He was back at work without difficulty. Physical exam showed scattered tattoo residue from the explosion on the chest and left upper arm, but good healing of lesions. There was a midline, tender 2.5x3.5cm abdominal wall nodule with some ecchymosis, which may be a retained foreign body. The patient was scheduled for a return visit in 4-6 weeks.

DISCUSSION

This patient presented with extensive soft tissue lesions on the chest, abdomen and upper arm due to explosion of a lithium-ion battery while using an E-cigarette. At this time, E-cigarettes are sold with minimal oversight from any regulatory body, and there are limited data on both long-term and immediate health risks.[2,3] A majority of E-cigarette users believe them to be a safer alternative to nicotine cigarettes, and view them as a path to smoking cessation or reduction.[5] While there has been speculation regarding long-term effects, including carcinogenesis of some heated liquid components, there has been minimal consideration of mechanical risks.

Lithium-ion batteries, commonly used to power these devices, are a known explosion hazard. Lithium-ion batteries in laptops and cellphones have been implicated in incidents similar to the presented case.[6] Lithium-ion batteries may overheat during charging or when exposed to the liquid in the E-cigarette cartridge, leading to "thermal runaway," an unregulated increase in internal battery temperature. Exposure of the lithium-ion batteries to elevated temperatures can lead to explosion.[7] Various engineering strategies have been proposed to mitigate the risk, but without regulatory oversight or standardized manufacturing, there is great variation in materials and processes that produce E-cigarettes.[3,6] Our patient's device advertises on its website, "venting holes to reduce battery heat by 60%," and "maximum copper contact to battery surface area." The device retails for $120 and the battery for $10.

These risks are largely uncharacterized in the medical and even lay media due to recent advent of this technology. However, there have been at least five media reports in the past three months of overheating battery explosions in the U.S., causing shrapnel injuries, facial burns, penetrating injuries to the leg, facial and cervical spine fractures, tongue lacerations and contusions, broken teeth and an amputated index finger. In California, there are media reports of three personal injury lawsuits filed by November 2015.

One paper recommended against using E-cigarettes as an alternative to tobacco smoking in patients with chronic obstructive lung disease on home oxygen due to risk of fire.[8] However, there were no other citations on the topic of the explosive or burn injury dangers of E-cigarettes in a PubMed search.

Accordingly, physicians treating E-cigarette users should advise patients of these risks. From a public health/safety standpoint, the E-cigarette industry should take these risks into consideration during manufacturing and advertising, so as to protect and inform consumers.

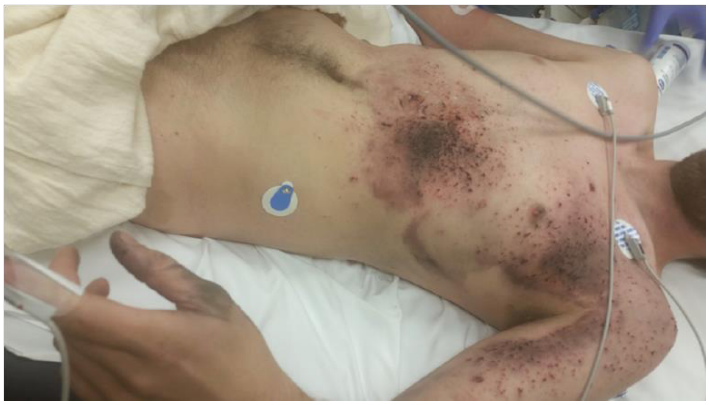

Figure 1. Shrapnel-like superficial skin penetration and contusion from exploding lithium-ion battery from an electronic vapor cigarette.

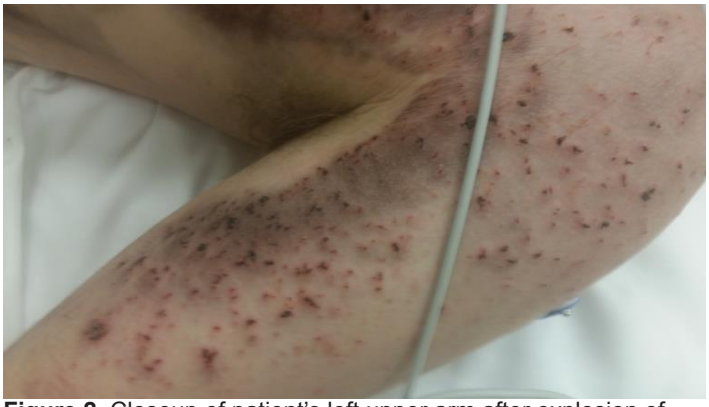

Figure 2. Closeup of patient's left upper arm after explosion of the lithium-ion battery from an electronic vapor cigarette, with superficial schrapnel-like wounds.

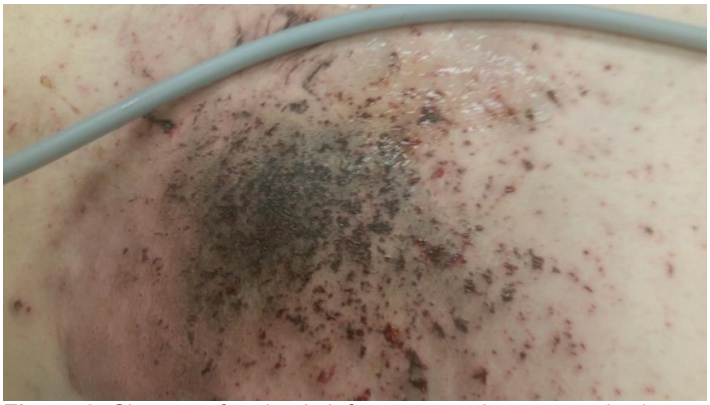

Figure 3. Closeup of patient's left upper quadrant contusion/ schrapnel-like injury after explosion of electronic vapor cigarette lithium-ion battery.

Figure 4. Electronic vapor cigarette cartridge device that exploded in use by patient (2.4cm in diameter and 10cm in length).

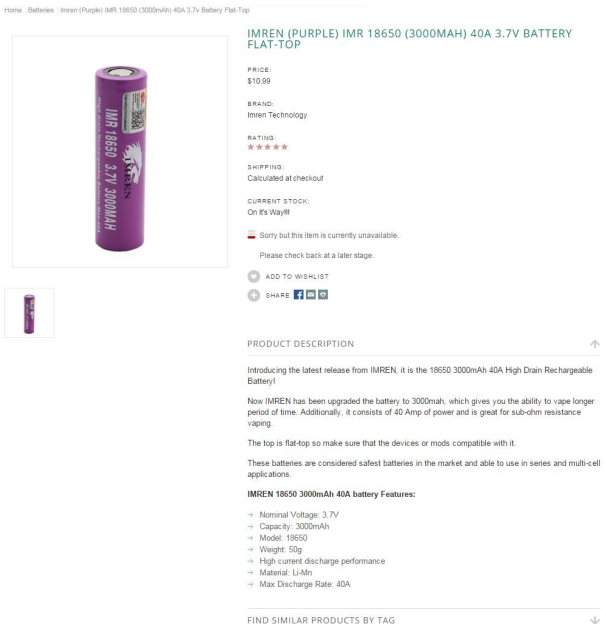

Figure 5. Lithium-ion battery contained in electronic vapor cigarette device that exploded with patient use.

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Salicylate Toxicity from Genital Exposure to a Methylsalicylate-Containing Rubefacient

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Methylsalicylate-containing rubefacients have been reported to cause salicylate poisoning after ingestion, topical application to abnormal skin, and inappropriate topical application to normal skin. Many over-the-counter products contain methylsalicylate. Topical salicylates rarely produce systemic toxicity when used appropriately; however, methylsaliclyate can be absorbed through intact skin. Scrotal skin can have up to 40-fold greater absorption compared to other dermal regions. We report a unique case of salicylate poisoning resulting from the use of a methylsalicylate-containing rubefacient to facilitate masturbation in a male teenager. Saliclyate toxicity has not previously been reported from the genital exposure to methylsaliclyate. [West J Emerg Med. 2016;17(2):181–183.]

INTRODUCTION

Many over-the-counter products are available to treat common musculoskeletal aches and pains. Often these products are in the form of ointments, liniments, and rubefacients. Methylsalicylate is an active ingredient in many of the over-the-counter rubefacients. Methylsalicylate-containing rubefacients have been reported to cause salicylate poisoning after ingestion, topical application to abnormal skin, and inappropriate topical application to normal skin.[1-5] Many over-the-counter products contain methylsalicylate because of its mild analgesic and anti-inflammatory properties. These over-the-counter products may contain up to 30% methylsalicylate. In the United States, drug preparations containing >5% methylsalicylate must bear a label warning against misdirected use and that the product should be kept out of the reach of children.[6] We present a unique case of salicylate poisoning caused by genital exposure to a methylsalicylate-containing rubefacient used to facilitate masturbation in a teenager.

CASE REPORT

A 14-year-old male presented to the emergency department (ED) complaining of shortness of breath, chest pain, lightheadedness, vomiting, and malaise. He noticed the symptoms earlier in the day when he was preparing for school. The patient was afebrile with heart rate of 100 beats per minute, blood pressure of 100/60mmHg, respiratory rate of 30 per minute, and a pulse oximetry measurement of 100% on room air. The remainder of the physical examination was pertinent for tachypnea with clear lungs. The cardiovascular and gastrointestinal examinations were normal. Laboratory evaluation revealed a serum glucose of 290mg/dL, serum bicarbonate of 15mEq/L, and an anion gap of 21. The patient was presumed to have new-onset diabetes with diabetic ketoacidosis. He was given a normal saline bolus, started on an insulin infusion, and transferred to a pediatric hospital. Upon arrival to the referral hospital, the patient had normal glucose measurements, and the insulin infusion was stopped. An arterial blood gas measurement revealed a pH of 7.44, pCO_2 of 18mm/Hg, and a bicarbonate of 12mEq/L. As a result of his acid-base status and tachypnea, there was concern for salicylate poisoning as the source of the abnormalities. A salicylate concentration was ordered and returned at 68mg/dL. Since there was no history of salicylate exposure, the measurement was repeated about four hours later and returned at 63mg/dL. A bicarbonate infusion was started to treat salicylate poisoning while further questioning of the patient ensued.

On direct questioning, the patient denied ingesting aspirin or salicylate-containing products but eventually admitted to

using an entire 60-gram tube of BENGAY®, which contains methylsalicylate, to facilitate masturbation the day prior to the ED presentation. The patient was successfully treated with a sodium bicarbonate infusion and supportive care for the salicylate poisoning. There was no indication for hemodialysis. The patient was discharged four days after initial presentation in stable condition.

DISCUSSION

Salicylic acid is a cellular poison that indiscriminately impairs cellular metabolism in overdose.[7] The clinical presentation of salicylate poisoning is related to stimulation of the central nervous system respiratory center, disturbance of lipid and carbohydrate metabolism, and disturbance of intracellular respiration.[8] Symptoms can include hyperpnea, tachypnea, tinnitus, hyperpyrexia, and diaphoresis.[8] Additional signs are dehydration, electrolyte disturbances, serum glucose abnormalities, and mixed acid-base disturbances.[8] More severe toxicity can result in acute lung injury, lethargy, coma, seizures, cerebral edema, and death.[8] Treatment of salicylate poisoning consists of general supportive care, gastrointestinal decontamination with activated charcoal in cases of salicylate ingestion, and monitoring of serum salicylate concentrations. Enhanced elimination of salicylate is achieved by a sodium bicarbonate infusion with maintenance of serum potassium homeostasis or hemodialysis if the bicarbonate infusion is ineffective or cannot be performed.

Methylsalicylate, also known as oil of wintergreen, is widely available in many over-the-counter ointments, lotions, and salves for the relief of musculoskeletal aches and pains.[9] The table provides examples of products that contain various concentrations of methylsalicylate. In vivo, methylsalicylate is hydrolized to salicylic acid. Five milliliters of oil of wintergreen is approximately equal to 7,000mg of salicylate or twenty-two 325mg aspirin pills.[9] Topical salicylates rarely produce systemic toxicity when used appropriately; however, methylsaliclyate can be absorbed through intact skin.[10] Exercise and heat exposure can enhance percutaneous absorption of methylsaliclyate.[11] At least one death has been reported in an athlete using an excessive amount of a methylsalicylate-containing rubefacient.[5] There can be increased absorption of methylysalicylate with abnormal skin such as psoriasis, erythroderma, and burns.[12,13] There can also be increased aborption of methylsalicylate when applied to large areas of skin, if other products (such as menthol or camphor) are used concurrently, or if an occlusive dressing is used.[5,14,15] Scrotal skin has been shown to have up to a 40-fold greater absorption of certain substances compared to other dermal regions.[16]

There are websites and internet-based discussion forums describing the use of various products, including those containing methylsalicylate, to enhance sensation during male masturbation. Emergency physicians, as part of our practice awareness, have to be knowledgeable of uncommon presentations of common diseases, popular culture and practices, and practices within subcultures. This includes the knowledge of the potentially dangerous use of methylsalicylate-containing rubefacients as described in this case report. The case we report may also have implications in sports medicine. Because methylsalicylate-containing rubefacients are used to treat muscle aches and pains, trainers and sports physicians may consider cautioning athletes to avoid scrotal contamination with methylsalicylate-containing rubefacients when treating upper leg and groin muscle injuries.

We present a unique case of salicylate poisoning resulting from the use of a methylsalicylate-containing rubefacient in a teenaged boy to facilitate masturbation. Saliclyate toxicity has not previously been reported from the genital exposure to methylsaliclyate.

Table. Over-the-counter products containing methylsalicylate.[17]

Product name	Methylsalicylate %
Ultra strength BENGAY® cream	30
Greaseless BENGAY® pain relieving cream	15
Maximum strength Flexall® plus pain relieving gel	10
ICY HOT® pain relieving cream	30
ICY HOT® pain relieving stick	30
ICY HOT® pain relieving balm	29
Thera-Gesic® maximum strength pain relieving creme	15

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Traumatic Arthrotomy with Pneumarthrosis on Plain Radiograph of the Knee

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An eight-year-old boy presented to the emergency department (ED) with a 2cm-long laceration over the prepatellar region of his left knee after falling over and cutting his knee on broken glass. Physical examination demonstrated the laceration breached the dermis but otherwise there was no obvious defect in the deep fascial layer. He had a free range of motion of his knee and clinically his extensor mechanism was intact; however, a plain lateral radiograph showed that he had pneumarthrosis of his knee joint. Within six hours of injury the wound was formally explored in the operating room and a small breach in the knee capsule was found. The wound edges were debrided, the knee joint irrigated and the skin closed primarily. Following surgery he received 24 hours of antibiotic coverage with a first-generation cephalosporin.

Gas in the joint or "pneumarthrosis" in the context of trauma is not uncommon around superficial joints such as the knee and indicates that there is a penetrating wound with intra-articular extension.[1] This implies that the joint has been inoculated with bacteria and pyoarthrosis is possible if not managed appropriately.[1] The standard treatment for a traumatic arthrotomy is antibiotic coverage and prompt surgical debridement in the operating room with lavage of the soft tissues and joint.[2] In the absence of gross contamination primary closure can be performed.[2]

Even innocuous-looking lacerations adjacent to or overlying superficial joints can lead to a traumatic arthrotomy. Plain radiographs should be obtained and a high suspicion for intra-articular extension maintained. For lacerations around superficial joints there should be a low threshold for exploring and washing these wounds out in the operating room rather than closing primarily in the ED.

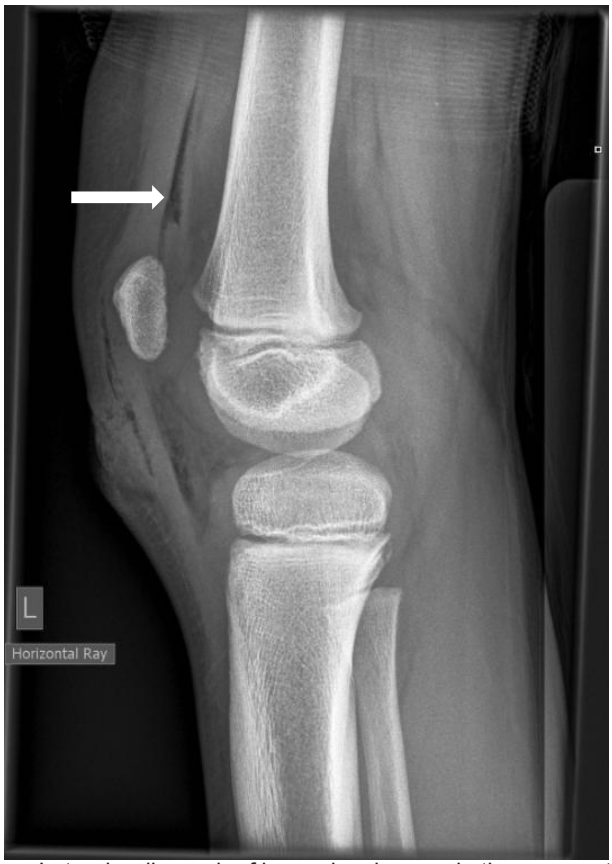

Figure. Lateral radiograph of knee showing gas in the suprapatellar pouch of the joint capsule.

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Young Woman with a Fever and Chest Pain

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A 26-year-old female presented to the emergency department with three days of subjective fevers, dry cough and pleuritic chest discomfort. On exam, her vital signs were significant for a heart rate of 106/minute and oxygen saturation of 95% on room air. Her lung exam revealed decreased breath sounds at the right base. A bedside lung ultrasound and a chest radiograph were performed (Figure 1a, Figure 2, and Video).

DIAGNOSIS: COMMUNITY ACQUIRED PNEUMONIA

Community acquired pneumonia (CAP) is a common disease in the United States and represents the seventh leading cause of death.[1]

While chest computed tomography (CT) is the gold standard diagnostic tool for CAP, its use is limited by both cost and radiation exposure.[2] Unfortunately, chest radiography has poor sensitivity (43.5%) for the diagnosis of CAP when compared to CT (Figure 2).[3] Lung ultrasound (LUS) has been shown to have superior sensitivity (80-95%), has no ionizing radiation, and is easy to perform at the bedside.[2,4]

On LUS, pneumonia has similar echogenicity to the liver with hyper-echoic foci, representing air bronchograms (Figure 1a). Consolidation allows transmission of ultrasound waves through the lung enabling visualization of the thoracic spine; this is known as the "spine sign." In contrast, in a normal lung, air molecules scatter sound waves limiting their transmission and thus the spine is not visualized above the diaphragm (Figure 1b).

While it is underutilized, point-of-care LUS is a rapid, accessible, safe, and low-cost imaging tool for the diagnosis of pneumonia.[2,4] LUS may be particularly useful in patients with high likelihood of a pneumonia but with a negative radiograph and for children to minimize radiation exposure. Practicing LUS in patients with a known infiltrate on radiograph may help providers increase their confidence and skills in the use of this growing diagnostic tool.

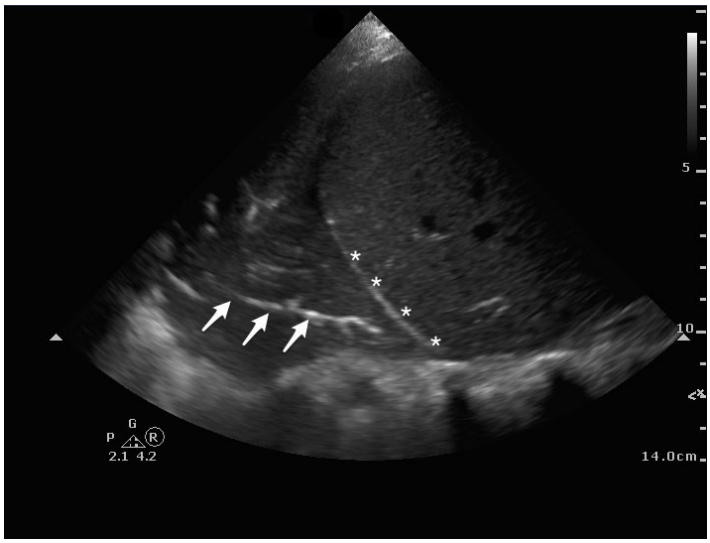

Figure 1a. Ultrasound of lung with pneumonia: Linear, bright (hyper-echoic) foci represent air bronchograms (arrows) above the diaphragm (asterisks).

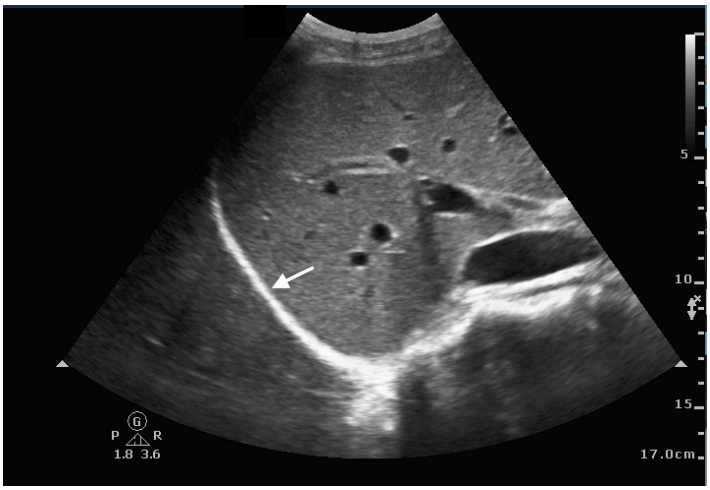

Figure 1b. Ultrasound of normal lung: note the mirror image artifact: appearance of liver above and below the diaphragm (arrow) and the absence of a spine sign.

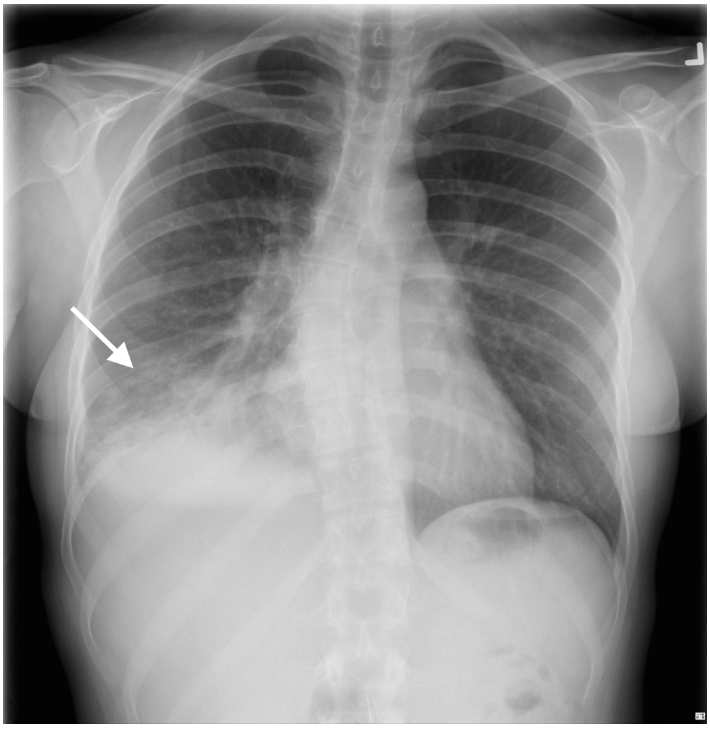

Figure 2. Anteroposterior portable chest radiograph: right lower lobe pneumonia.

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Video. Pneumonia on lung ultrasound.

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Bullosis Diabeticorum

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CASE

A 63-year-old female with insulin-dependent type II diabetes mellitus and end-stage renal disease presented to the emergency department with spontaneous blistering to the tips of her left index and middle fingers. The blisters had gradually become tense and mildly painful over the preceding 10 days. She denied burn injury, trauma, fever, or new medications. On physical exam, the patient was noted to have a tense, nontender bullae on the pad of the left middle finger, and a collapsed, hemorrhagic bullae on the left index finger. There were no signs of inflammation or infection. A radiograph of the left hand, complete blood count, and basic metabolic panel were unremarkable. The diagnosis of bullosis diabeticorum was made, and supported by a consulting endocrinologist.

DISCUSSION

Bullosis diabeticorum is a rare cutaneous complication in those with diabetes mellitus. The condition was first recognized in 1930, and the name coined in 1967. It usually arises in those with longstanding diabetes, and affects 0.5% of the diabetic population in the U.S. in a 2:1 male-to-female ratio.[1] It erupts spontaneously mainly on acral surfaces of the upper and lower extremities, but may also involve the trunk. The exact etiology is not fully known, but thought to involve poor vascular supply and increased venous pressure that leads to splitting of the dermal-epidermal junction at the level of the lamina lucida.[2] It has not been shown to be related to level of glycemic control. These lesions may be confused with a burn injury; however, they only require supportive management and usually heal without intervention in 2-6 weeks, though affected areas should be monitored for secondary infection.[3]

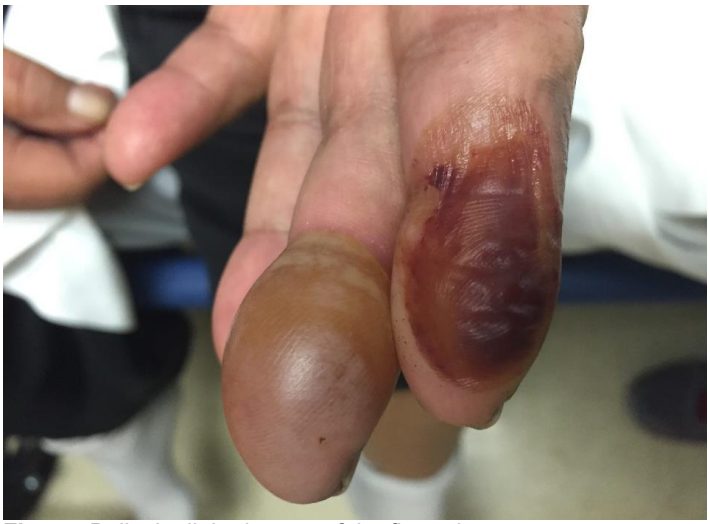

Figure. Bullosis diabeticorum of the fingertips.

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Turbid Peritoneal Fluid

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CASE

A 58-year-old female with a past medical history of hepatitis C virus-induced cirrhosis presented to the emergency department with three days of increasing abdominal pain, chills, and nausea and vomiting. Abdominal physical examination revealed gross ascites with fluid wave. Diagnostic paracentesis resulted in the aspiration of approximately 60mL of white turbid peritoneal fluid (Figure).

DISCUSSION

The differential diagnosis of turbid peritoneal fluid includes spontaneous bacterial peritonitis, chylous ascites, and pseudochylous ascites. Spontaneous bacterial peritonitis is suggested by a predominance of polymorphonuclear cells, a positive Gram stain or a positive culture.[1] Chylous ascites refers to increased concentration of triglycerides (>200mg/dL)[2] in the peritoneal fluid, typically the result of traumatic lymphatic obstruction, tumor, tuberculosis, filariasis, congenital abnormalities or nephrotic syndrome.[1,2] Cirrhosis may cause up to 11% of atraumatic chylous ascites.[3] Pseudochylous ascites results from degeneration of leukocytes or tumor cells without high levels of triglycerides or active infection.[4] Chylous and pseudochylous ascites may be differentiated by triglyceride levels.[1]

Given the patient's established history of chronic liver disease, the inpatient team focused on spontaneous bacterial peritonitis as the potential etiology for the turbid peritoneal fluid. The patient was treated empirically with antibiotics. Formal abdominal ultrasonography affirmed a cirrhotic liver with large volume ascites and no evidence of mass. Peritoneal fluid cultures were negative for bacterial growth, suggesting that the fluid represented sterile ascites. Triglyceride assays were not performed. Repeat paracentesis on hospital day 3 revealed straw-colored peritoneal fluid. The patient was discharged home on hospital day 4 after clinical improvement.

Figure. Peritoneal fluid aspirated from diagnostic paracentesis.

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There's an App for That? Highlighting the Difficulty in Finding Clinically Relevant Smartphone Applications

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Introduction: The use of personal mobile devices in the medical field has grown quickly, and a large proportion of physicians use their mobile devices as an immediate resource for clinical decision-making, prescription information and other medical information. The iTunes App Store (Apple, Inc.) contains approximately 20,000 apps in its "Medical" category, providing a robust repository of resources for clinicians; however, this represents only 2% of the entire App Store. The App Store does not have strict criteria for identifying content specific to practicing physicians, making the identification of clinically relevant content difficult. The objective of this study is to quantify the characteristics of existing medical applications in the iTunes App Store that could be used by emergency physicians, residents, or medical students.

Methods: We found applications related to emergency medicine (EM) by searching the iTunes App Store for 21 terms representing core content areas of EM, such as "emergency medicine," "critical care," "orthopedics," and "procedures." Two physicians independently reviewed descriptions of these applications in the App Store and categorized each as the following: Clinically Relevant, Book/Published Source, Non-English, Study Tools, or Not Relevant. A third physician reviewer resolved disagreements about categorization. Descriptive statistics were calculated.

Results: We found a total of 7,699 apps from the 21 search terms, of which 17.8% were clinical, 9.6% were based on a book or published source, 1.6% were non-English, 0.7% were clinically relevant patient education resources, and 4.8% were study tools. Most significantly, 64.9% were considered not relevant to medical professionals. Clinically relevant apps make up approximately 6.9% of the App Store's "Medical" Category and 0.1% of the overall App Store.

Conclusion: Clinically relevant apps represent only a small percentage (6.9%) of the total App volume within the Medical section of the App Store. Without a structured search-and-evaluation strategy, it may be difficult for the casual user to identify this potentially useful content. Given the increasing adoption of devices in healthcare, national EM associations should consider curating these resources for their members. [West J Emerg Med. 2016;17(2):191–194.]

INTRODUCTION

As the adoption rates for personal mobile devices such as smartphones and tablets in the consumer space continue to rise,[1] we are witnessing similar adoption trends amongst healthcare providers.[2,3] It is estimated that 82-85% of physicians in the U.S. own a smartphone,[3,4] representing an increase of 64% over only a few years ago.[4] The computing power of these devices, despite their small size, and their constant connectivity to the Internet is contributing to their increased usage as clinical decision-making tools, quick-reference tools, and sources

of medical education content. Much of the aforementioned functionality of these devices lies in their applications, or "apps" with approximately 30-50% of medical professionals using apps in clinical care environments. Given the fast-paced nature of emergency medicine (EM), rapid access to medical data contained in the apps could be particularly useful to the practicing emergency physician.

Smartphone applications can be found online in two locations – the iTunes App Store, which features apps for Apple products such as the iPhone, iPod, iPad, and iPad mini, and the Google Play Store featuring apps for the Android operating system. Each of these two stores offers a "Medical" category; however, upon a cursory review of the content it is evident that the category covers a wide range of topics including general health and wellness information; there is no categorization of apps for healthcare professionals. Physicians and medical students have anecdotally noted difficulty in identifying clinical relevant apps and this has led to the popularity of medical-app review websites. One of the most widely recognized review websites is iMedicalApps; this website uses a team of medical student and physician reviewers to curate and review clinically relevant apps across a variety of medical specialties.[5] Apple, Inc. later published an "Apps for Healthcare Professionals" category on its App Store, although there was some critique about the breadth of apps, review criteria for identifying these selected apps, and frequency of updates.

The ability to locate apps clinically relevant to EM is seemingly more difficult than other specialties, such as dermatology or ophthalmology, since the scope of our practice also covers the acute management of diseases and conditions found in every medical specialty. While many websites contain listings of "top apps" in EM, there is not a commonly accepted or definitive collection of apps to our knowledge.

In the literature, prior studies have described app uses by percent of use of different types of apps,[3] while other studies have discussed the need for a broader discussion across accrediting bodies to ensure ability to use high quality evidence-based apps.[6] However, our literature review showed no prior studies that attempted to categorize clinical and non-clinical applications and quantify the number of apps available. The objective of our study was to quantify and categorize the characteristics of existing medical applications in the iTunes App Store that could be used by physicians, residents and medical students.

METHODS

While medical apps can be found in the iTunes and Android app stores, we chose to only review apps from the iTunes Store as data suggests that a larger percentage of healthcare providers prefer to use Apple devices over other competing devices.[3]

Data collection was conducted in April 2014 by two independent reviewers: ST and DK, both EM residents. Using the iTunes application for Windows/Mac Operating Systems, the reviewers conducted a series of Boolean searches using 21 search terms. The search terms used were the following: "Anesthesia," Critical Care," "Dermatology," "Emergency," "Emergency Medicine," "Geriatrics," "Gynecology," "ICU," "Intensive Care," "Medicine," "Neurology," "Obstetrics," "Orthopedics," "Pediatrics," "Pharmacology," "Procedures," "Psychiatry," "Radiology," "Surgery," "Toxicology" and "Ultrasound." These terms were chosen to represent the main content themes of EM training.[7] Terms such as "Pediatrics" and "Orthopedics" were used with the intention of finding specialty-specific content possibly relevant to EM that may not have been represented in an EM- specific app. Searches were conducted in the iTunes App to ensure that search results for both iPad and iPhone would be included in the analysis.

Each app listed in the search results was categorized as Clinically Relevant, Book/Published Source, Non-English, Study Tools/Reference, or Not Clinically Relevant based on review of the app's information page and associated sample images (Table 1). Reviewers were instructed only to review the information page and not download the app, as this preliminary review mimicked app downloading behaviors described by an informal focus group of medical students and residents.[8] A third reviewer (AB) audited any discrepancies in categorization. We then calculated descriptive statistics.

RESULTS

At the time of data collection in Spring 2013, the iTunes App Store contained approximately one million apps, with an estimated 20,000 apps comprising the "Medical" Category (2% of the total app volume).[9]

We found a total of 7,699 apps from the 21 search terms, of which 1,372 (17.8% were clinical, 738 (9.6%) were based on a book or published source, 126 (1.6%) were non-English, 55 (0.7%) were clinically relevant patient-education resources, and 372 (4.8%) were study tools. We considered 4,994 (64.9%) not relevant to medical professionals (Figure). Clinically relevant apps make up approximately 6.9% of the App Store's "Medical" category and 0.1% of the overall App Store. Two reviewers did the initial review of these apps, and disagreed 0.7% of the time, at which point a third reviewer settled the disagreement.

Due to the methods used to search for apps there is some overlap in the results, which likely caused a false elevation of the numbers. As a result, the true numbers are actually even lower and further highlight the difficulty of finding quality content.

DISCUSSION

Clinically relevant apps represent only a small percentage (6.9%) of the apps within the "Medical" category" and an even smaller percentage (0.1%) of the apps in the entire iTunes App Store. Even with a structured search-and-evaluation strategy, it is evident that healthcare

Table 1. Definition of the variables used for categorization of iTune medical apps.

Variable	Definition	Example
Clinically relevant	App content could potentially influence or guide a clinical decision	Epocrates
Book/published source	App that served as a digital accompaniment to an existing published textbook or medical journal	*Academic Emergency Medicine* journal app
Not English	App that does not contain English	Mobile medicine medical
Study tools/reference	App that contained useful medical information, but was not intended for clinical decision-making, such as board review questions and flashcard apps	PEERVII
Not clinically relevant	App that contained no medical information, such as games or medical apps not related to healthcare professionals	1800-Contacts App

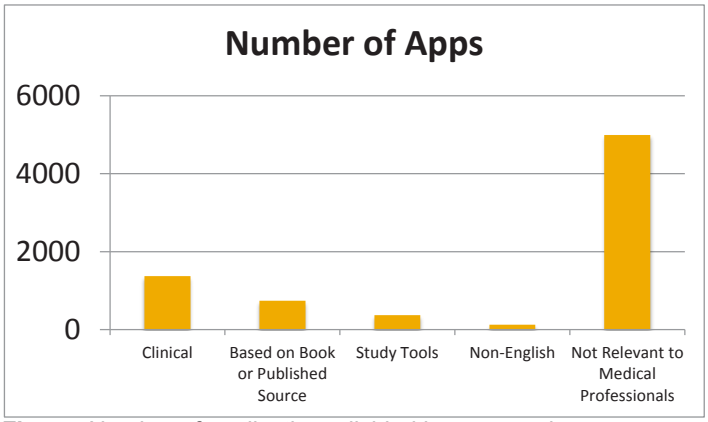

Figure. Number of applications divided into categories

providers will have difficulty in identifying clinically relevant material.

While guides and curated lists of "top apps" exist on the Internet, many of these resources cite the same content,[10-13] which raises the question: Are these the most relevant clinical applications or are they preferentially selected by reviewers without evaluating the full App Store content? If the latter statement is a more accurate reflection of these curated lists, it may propagate a situation where healthcare providers are not exposed to newer and potentially useful clinical apps.

These results also prompt a discussion about corporate collaboration with the medical profession and its responsibility in identifying healthcare-specific resources within their content collections. Both Apple, Inc and Google, Inc have engaged in collaborations with healthcare institutions[14-19] and as stated earlier, Apple has created its own curated list of Apps for Healthcare Professionals. Despite these efforts, our data suggest that there are opportunities for further collaboration, such as redefining the "Medical" categories to represent "true medical content" and create a broader "Health/Wellness" category for consumer use. Clinically relevant categorization of apps can happen without support from companies like Apple and Google; however, the process is labor intensive and their cooperation would likely yield higher and more consistent results.

Until there is a more useful "Medical" app category, there are several great resources that review medical Apps and provide recommendations, such as iMedicalApps.com. Some of the authors' most used and favorite Apps are listed in Table 2.

LIMITATIONS

New apps are being added all the time. Our study is cross-sectional and limited to what was published in the iTunes App Store at the time the terms were searched and app list collected. We attempted to control for this by using screen-captures of the search results, although at the time of publication, we recognize that the makeup of the "Medical" category will have changed.

The iTunes App Store catalog is proprietary information, so it is not possible to obtain a complete list and true denominator of all apps in the "Medical" category. As such, we were only able to find apps using our chosen search terms and ultimately only looked at 7699 of approximately 20,000 apps in the medical section of the app store. However, we assume that if the applications do not contain any of the search terms of interest then they are unlikely to be medically applicable.

Additionally, there is some subjectivity in categorization of the apps. Selecting non-relevant apps was generally clear-cut, while determining what was "clinical" vs. "study tools" was disagreed upon 0.7% of the time. Lastly, we only looked at descriptions and titles to categorize the apps. We did not download each app or attempt to measure the quality of the apps reviewed. Lastly, with the increase in Android and Windows devices, a similar analysis of these apps may be useful.

CONCLUSION

Given the increasing adoption of devices in healthcare, national EM associations should consider curating these resources for their members. Additionally, further studies evaluating the actual quality and evidence-based nature of useful medical apps is essential to the safe use of these apps in the clinical practice of EM, where rapid access to medical information is useful.

Table 2. Author-recommended applications.

Type	Apps
Comprehensive Emergency Medicine Apps	PEPID Emergency Medicine Suite, PalmEM, 5min EM Consult, WikiEM, palmEM, ERres
Calculators	MedCalc, NeuroToolKit
Pharmacy apps	Micromedex, Epocrates, EMRA Antibiotics Guide, EMRA Peds Meds, PressorDex
Pediatric apps	palmPEDi, Pedi Stat
Dermatology apps	VisualDx
Ultrasound	One Minute Ultrasound, SonoSupport, Pocket Atlas of Emergency Ultrasound
Toxicology apps	PEPID Elements, ACEP Toxicology Antidote App
Other apps	Eye Chart, Touch Surgery, UCSF Neuro Exam Tutor, UCSF MSK Exam Tutor

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Point-of-Care Ultrasound to Evaluate a Teenager with Presyncope

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A 16-year-old male presented with three months of palpitations at rest, fatigue, and episodic pre-syncope; his paternal grandfather died following presumed premature myocardial infarction at age 30. He was seen and discharged one week previously at an outside emergency department (ED). He followed up with his pediatrician and was promptly referred to our pediatric ED for evaluation given his risk factors. Pertinent vitals on arrival were pulse 110, blood pressure 129/66, and oxygen saturation 97% on room air. His exam was remarkable for a left upper sternal border 2/6 holosystolic murmur with radiation to apex. In addition, the patient had a chest radiograph (Figure), a nonspecific but abnormal EKG, and a point-of-care ultrasound (POCUS) of the heart performed.

POCUS (Video) suggested hypertrophic cardiomyopathy (HCM); this was confirmed by comprehensive echocardiogram that showed 4.7cm septal hypertrophy with intraventricular obstruction. Patient was admitted to the cardiac intensive care unit; during admission non-sustained runs of ventricular tachycardia were recorded. A pacemaker was placed before he was discharged on metoprolol and aspirin.

HCM has a prevalence of 1 in 500 and should be suspected with septal thickness ≥15mm or with other left ventricular or apical hypertrophy.[1,2] If performed, M-mode imaging may demonstrate systolic anterior mitral valve motion, which is specific for HCM. Our patient's diagnosis was not immediately apparent. Performance of POCUS helped confirm the diagnosis, risk-stratify the patient rapidly, and obtain timely consultation and disposition.

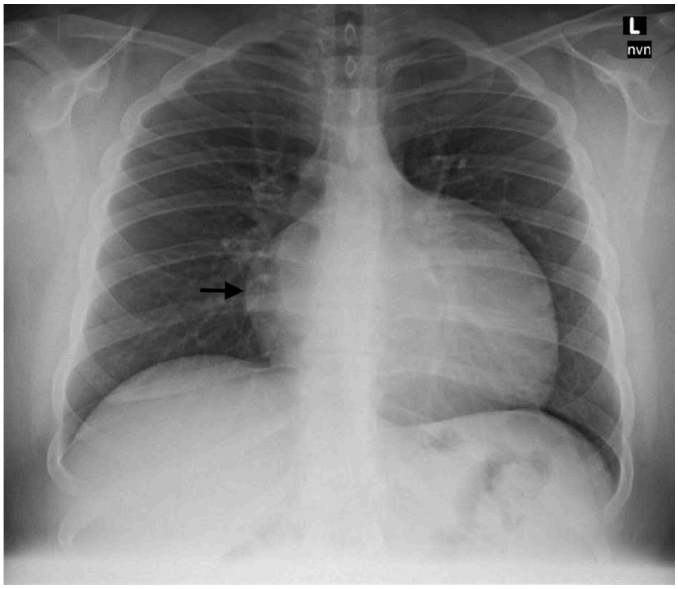

Figure. Chest radiograph showing enlarged cardiomediastinal silhouette with narrow vascular pedicle.

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Video. Point-of-care ultrasound, cardiac views.

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Retrospective Review of Ocular Point-of-Care Ultrasound for Detection of Retinal Detachment

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Introduction: Retinal detachment is an ocular emergency that commonly presents to the emergency department (ED). Ophthalmologists are able to accurately make this diagnosis with a dilated fundoscopic exam, scleral depression or ophthalmic ultrasound when a view to the retina is obstructed. Emergency physicians (EPs) are not trained to examine the peripheral retina, and thus ophthalmic ultrasound can be used to aid in diagnosis. We assessed the accuracy of ocular point-of-care ultrasound (POCUS) in diagnosing retinal detachment.

Methods: We retrospectively reviewed charts of ED patients with suspected retinal detachment who underwent ocular POCUS between July 2012 and May 2015. Charts were reviewed for patients presenting to the ED with ocular complaints and clinical concern for retinal detachment. We compared ocular POCUS performed by EPs against the criterion reference of the consulting ophthalmologist's diagnosis.

Results: We enrolled a total of 109 patients. Of the 34 patients diagnosed with retinal detachment by the ophthalmologists, 31 were correctly identified as having retinal detachment by the EP using ocular POCUS. Of the 75 patients who did not have retinal detachment, 72 were ruled out by ocular POCUS by the EP. This resulted in a POCUS sensitivity of 91% (95% CI [76-98]) and specificity of 96% (95% CI [89-99]).

Conclusion: This retrospective study suggests that ocular POCUS performed by EPs can aid in the diagnosis of retinal detachment in ED. [West J Emerg Med. 2016;17(2):196–200.]

INTRODUCTION

Ocular complaints represent between 2-3% of emergency departments (ED) visits. This includes many vision-threatening diagnoses such as retinal detachment, occurring in 3-4% of patients presenting with ocular complaints.[1-3] Retinal detachment is one of the few ophthalmologic emergencies commonly seen in the ED.[4] It requires immediate assessment, diagnosis and treatment to prevent permanent vision loss.[5]

Diagnosis of suspected retinal detachment often entails assessing visual acuity with the Snellen chart, confrontational visual field testing, slit lamp biomicroscopy and direct ophthalmoscopy after pharmacological dilation.[6] In a fast-paced ED setting, these tests can be time consuming and require proficiency with ophthalmological tools. Over the past decade, ophthalmology-specific courses and formal ophthalmology rotations have declined significantly across medical schools within the United States. This puts emergency physicians (EPs) and the patients they serve in a

compromising position to correctly diagnose and/or properly refer their patients.[7] Additionally, in rural settings, an on-call ophthalmologist may not be available. The use of bedside ocular point-of-care ultrasound (POCUS) has the potential to properly identify ocular emergencies in these settings.

Ophthalmic ultrasound has become useful in diagnosing various ocular pathologies. Originally, ocular ultrasound was used less frequently due to low-resolution ultrasound machines; however, newer machines have improved diagnostic capability.[8,9] A study by Blaivas' et al. found that ocular POCUS could be used in the diagnosis of various ocular pathologies including retinal detachment, central retinal artery occlusion, lens dislocation vitreous hemorrhage and vitreous detachment.[10] To date there have been two prospective studies that specifically look at the use of ocular POCUS to diagnose retinal detachments in the ED. Yoonessi et al prospectively studied 48 patients and found a sensitivity and specificity of 100% and 83% respectively.[11] Similarly Shinar et al prospectively studied 90 patients and found a sensitivity and specificity of 97% and 92% respectively.[12] These studies had various limitations including small sample sizes and large confidence intervals.

Our goal was to retrospectively investigate the outcomes of patients who had an ocular POCUS in the ED for suspected retinal detachment. We compared this diagnosis to the criterion reference diagnosis of the consulting ophthalmologist. We aimed to expand on previous research by studying a larger patient population.

METHODS

Study Design

After institutional review board approval, we conducted a retrospective chart review of patients who were billed for an ocular POCUS between the dates of July 2012 and May 2015. Medical record numbers were then used to identify patients who had both ocular POCUS and formal ophthalmologic consultation. Research personal recorded these data, using a systematic approach on a standardized data collection sheet.[13] Collected data included patient age, gender, basic demographics, POCUS diagnosis and ophthalmology diagnosis. Reviewers were blinded to patient ultrasound findings. A second reviewer confirmed all documented findings for agreement. We excluded patients if there was any concern for globe injury, or if they did not get a formal ophthalmologic consultation in the ED. The EP diagnosis, after performing the ocular POCUS, was compared to the ophthalmologist clinical diagnosis to determine the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of ocular POCUS. At our institution EPs perform ocular POCUS prior to evaluation by Ophthalmology. This ensured that EPs diagnosis was not influenced by an ophthalmology exam.

It should be noted that the emergency medicine (EM) ocular standard of care includes assessments of visual acuity, pupil size, and performance of direct ophthalmoscopy as well as slit lamp examinations. All were attempted prior to obtaining ocular POCUS.

Study Setting

The study took place at an urban university hospital ED that supports both EM and ophthalmology residency-training programs, as well as an emergency ultrasound fellowship. The annual ED census is approximately 48,000 patient visits, and 24-hour ophthalmologic consultation is available. A total of 26 different EPs evaluated patients presenting with symptoms concerning for retinal detachment. These physicians were a mixture of resident and attending physicians who have training in various applications in POCUS. This included a 30-minute lecture followed by supervised hands-on scanning of three volunteer models. The training introduced the physicians to ocular POCUS and highlighted the differences between normal retina, retinal detachment and vitreous hemorrhage (Figure 1). No additional training was provided to ED attending or resident physicians.

Study protocol

After the EP ocular physical examination described above, patients underwent ocular POCUS performed by the EP when the etiology could not be determined by physical exam. This consisted of using Sonosite M-Turbo ultrasound machine with a 7.5MHz, high frequency, linear probe (Sonosite, Botthell, WA). Both sagittal and transverse views of the affected eye were obtained. The posterior chamber on both sides of the optic nerve was examined for presence or absence of a detached retina. The results of the ocular POCUS were obtained from the electronic medical record. Ophthalmologic consultation was obtained following POCUS. The ophthalmologist's exam, performed by a combination of residents and attendings, included visual acuity, pupils, slit lamp exam, dilation, and indirect ophthalmoscopy with scleral depression. If the ophthalmologist had a poor posterior view and inconclusive diagnosis with the aforementioned examination skills, a B-scan ultrasound was performed.

Statistical Analysis

We calculated sensitivity, specificity, positive and NPVs with 95% confidence intervals for POCUS compared with formal ophthalmologic consulting physician's diagnosis. These parameters were calculated in the usual manner with confidence intervals by the efficient-score method with continuity correction.

RESULTS

A total of 142 patients who underwent ocular POCUS between July 2012 and May 2015 were identified. Of these patients, 109 received ophthalmology consultation following EP-administered ocular POCUS and were included in our study. These patients ranged in age from 8 to 84, with a mean of 49.3 years (+/-16.1). Thirty-five of these patients

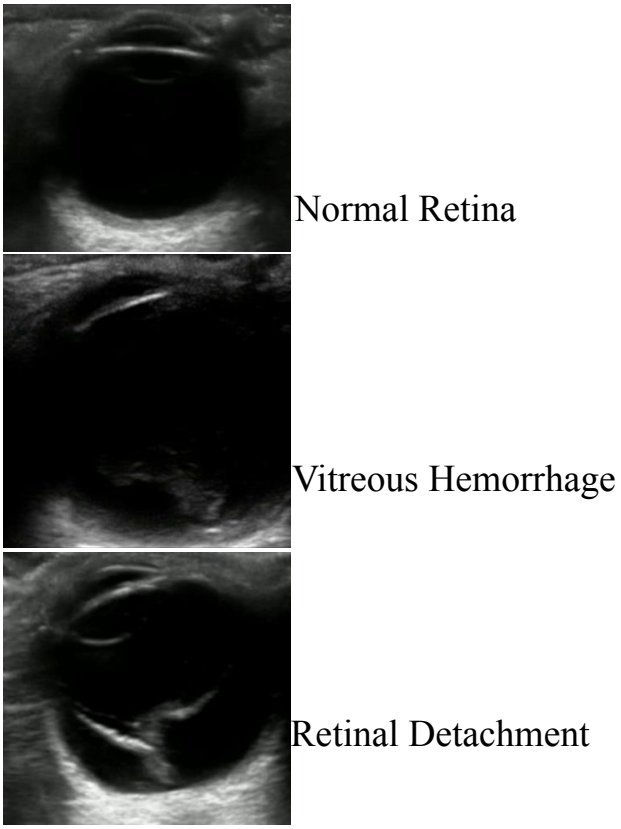

Figure 1. Ocular ultrasound representing normal retina, vitreous hemorrhage and retinal detachment.

presented with loss of vision (18 with progressive vision loss and 17 with sudden vision loss), 23 with floaters, flashes and/or spots, 10 with ocular irritation and 41 with blurry vision and/or decreased vision. There were 52 males and 57 females enrolled in the study. Twenty-six different EM attending physicians and 30 EM resident physicians used ocular POCUS in these 109 cases. Each attending physician accounted for between 1-30 enrolled patients, with a median of four scans.

A total of 34 patients (31%) were diagnosed with some form of retinal detachment by the ophthalmologic consulting physician (Figure 2). POCUS demonstrated the ability to detect 31 of these patients as having retinal detachment, resulting in a sensitivity of 91% (95% CI [76-98]). POCUS correctly ruled out retinal detachment in 72 of the 75 cases determined by ophthalmology to be negative for retinal detachment, resulting in a specificity of 96% (95% CI [89-99]). Thus, the PPV observed was 91% (95% CI [76-98]) while the NPV observed was 96% (95% CI [89-99], Table). Of the 75 negative cases, 19 were diagnosed with vitreous hemorrhage, six were diagnosed with vitreous detachment, 25 were determined to have no ocular pathology, two were diagnosed with retinal tear and 23 were diagnosed with other ocular pathologies (lens dislocation, increased intracranial pressure, pre-retinal heme, branch retinal vein occlusion etc.) (Figure 2).

DISCUSSION

To date, this is the largest retrospective study performed investigating the use of ocular POCUS to diagnose retinal detachment. Our findings validate the findings of previous studies and demonstrate that EPs can use ocular POCUS to identify retinal detachments. Prompt and accurate diagnosis by an EP can lead to better communication with the ophthalmology consultant and improve quality of care.

An ophthalmologist has an advanced skill set, including a dilated fundoscopic exam with or without scleral depression and a specialized ophthalmic ultrasound machine to accurately differentiate retinal detachment from a retinal tear.[14] EPs trained in the performance and interpretation of ophthalmic ultrasound may be better able to transition care to an ophthalmologist. The use of ophthalmic ultrasound as a diagnostic modality is not meant to replace the role of the ophthalmologist, but rather serve as an adjunct to improve quality of eye care in the ED. This plays an especially important role in rural communities where an ophthalmologist may not be readily accessible.[15-18]

In a recent study done by Esparaz et al, medical students were evaluated on their preparedness in managing and diagnosing common ocular pathology and found that both second-year and fourth-year medical school students, on average, did not pass the ophthalmology proficiency quiz.[7,19] They discuss the decline in ophthalmologic clinical experience within medical schools and further suggest that residents may not have the appropriate training to properly manage ophthalmologic conditions.[7,19] With ultrasound being incorporated to a greater degree in medical education at all levels, POCUS becomes a more reasonable and readily available tool to be used in the ED, and can help bridge the growing gap in EP ophthalmologic examination skills.[20,21] However, ultrasound training is not uniform across medical schools, residency programs, or teaching hospitals across the country.[22] Davis, et al showed that sonologists with highest confidence in their POCUS skills had a much higher accuracy of emergency ultrasound diagnosis.[23] Thus, it is critical that those using POCUS in emergent situations are trained to a proper level to avoid making critical mistakes in diagnosis.[24,25]

At this time, it is unclear what degree of sonographic training is required for EPs to diagnose retinal detachment. Currently, no metric or level of training can be measured to satisfy a minimum level.[26] Blaivas et al show a sensitivity of 100% and specificity of 100% for EPs to diagnose retinal detachment using POCUS.[10] Given that ultrasound is operator dependent, this may not be uniform to all EPs. In our study, resident physicians in different years of training performed and interpreted ocular POCUS in the presence of an EM attending physician. Future studies will need to assess the number of ocular POCUS that a practitioner would need to perform to be deemed competent to independently diagnose

retinal detachment.

LIMITATIONS

There is currently no standardized protocol for diagnosing retinal detachments using ocular POCUS. Thus, results may have varied depending on ultrasound experience. A larger patient population is needed to confirm the accuracy of ocular POCUS in diagnosing retinal detachments. One attending physician accounted for nearly a third of enrolled patients. This may have introduced bias potentially inflating the value of POCUS for retinal detachment. Finally, since this was a retrospective study, EPs were not blinded to any past medical history and/or past surgical history, which may have influenced the ultrasound interpretation. Similarly, it was possible that ophthalmologists may have been able to access the ocular POCUS results prior to performing their own consultation. Our study results have shown that 31% of enrolled patients were diagnosed with retinal detachment. This may be due to the fact that our practitioners documented POCUS on patients with high clinical suspicion for retinal detachment. Despite these limitations, we feel that EP ocular POCUS is a viable option with test characteristics that may aid in the diagnosis and reduce the time to treatment for patients with retinal detachments in the ED setting.

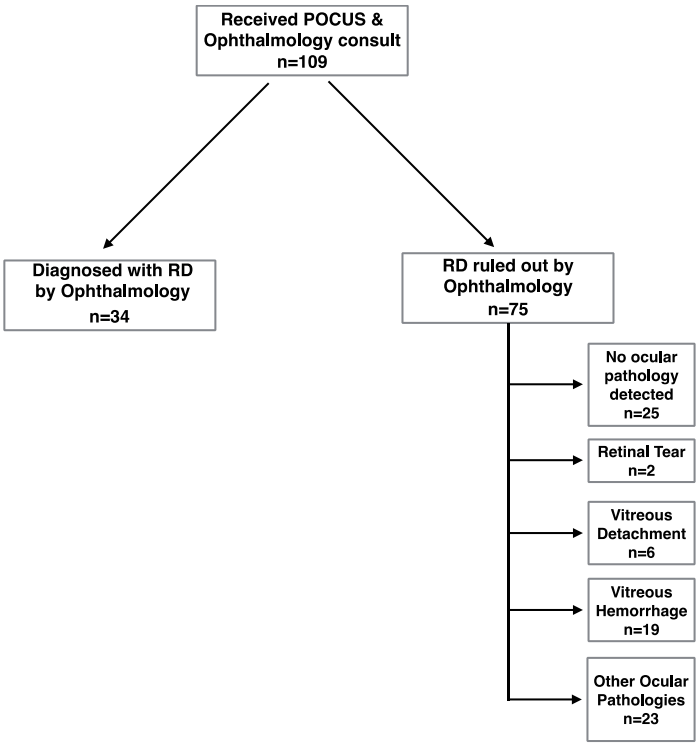

Figure 2. Algorithm for retinal detachment diagnosis using ultrasound.
POCUS, point of care ultrasound; *RD*, retinal detachment

Table. Point-of-care ultrasound (POCUS) findings compared with ophthalmology diagnosis.

	RD	No RD	Total
POCUS			
RD	31	3	34
No RD	3	72	75
Total	34	75	109
Sensitivity			91% (31/34); 95% CI [76-98]
Specificity			96% (72/75); 95% CI [89-99]
PPV			91% (31/34); 95% CI [76-98]
NPV			96% (72/75); 95% CI [89-99]

POCUS, point-of-care ultrasound; *RD,* retinal detachment; *PPV*, positive predictive value; *NPV*, negative predictive value

CONCLUSION

Ultimately, the use of ocular ultrasound to detect retinal detachment has important implications in the ED patient course. Our data support the findings of previous smaller-scale prospective and retrospective studies. Further large-scale prospective trials must be conducted to determine the training required for EPs to correctly diagnose retinal detachment via POCUS. With further validation, ocular POCUS has the potential to differentiate patients who need emergent ophthalmologic consultation from those who can follow up in the outpatient setting.

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Mistakes and Pitfalls Associated with Two-Point Compression Ultrasound for Deep Vein Thrombosis

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Introduction: Two-point compression ultrasound is purportedly a simple and accurate means to diagnose proximal lower extremity deep vein thrombosis (DVT), but the pitfalls of this technique have not been fully elucidated. The objective of this study is to determine the accuracy of emergency medicine resident-performed two-point compression ultrasound, and to determine what technical errors are commonly made by novice ultrasonographers using this technique.

Methods: This was a prospective diagnostic test assessment of a convenience sample of adult emergency department (ED) patients suspected of having a lower extremity DVT. After brief training on the technique, residents performed two-point compression ultrasounds on enrolled patients. Subsequently a radiology department ultrasound was performed and used as the gold standard. Residents were instructed to save videos of their ultrasounds for technical analysis.

Results: Overall, 288 two-point compression ultrasound studies were performed. There were 28 cases that were deemed to be positive for DVT by radiology ultrasound. Among these 28, 16 were identified by the residents with two-point compression. Among the 260 cases deemed to be negative for DVT by radiology ultrasound, 10 were thought to be positive by the residents using two-point compression. This led to a sensitivity of 57.1% (95% CI [38.8-75.5]) and a specificity of 96.1% (95% CI [93.8-98.5]) for resident-performed two-point compression ultrasound. This corresponds to a positive predictive value of 61.5% (95% CI [42.8-80.2]) and a negative predictive value of 95.4% (95% CI [92.9-98.0]). The positive likelihood ratio is 14.9 (95% CI [7.5-29.5]) and the negative likelihood ratio is 0.45 (95% CI [0.29-0.68]). Video analysis revealed that in four cases the resident did not identify a DVT because the thrombus was isolated to the superior femoral vein (SFV), which is not evaluated by two-point compression. Moreover, the video analysis revealed that the most common mistake made by the residents was inadequate visualization of the popliteal vein.

Conclusion: Two-point compression ultrasound does not identify isolated SFV thrombi, which reduces its sensitivity. Moreover, this technique may be more difficult than previously reported, in part because novice ultrasonographers have difficulty properly assessing the popliteal vein. [West J Emerg Med. 2016;17(2):201–208.]

INTRODUCTION

Deep vein thrombosis (DVT) is difficult to diagnose clinically,[1] and thus requires imaging for diagnosis. Although the ultimate gold standard for diagnosis is contrast venography,[2] ultrasound performed by a technologist and interpreted by a radiologist is the current test of choice

for diagnosis of DVT in the emergency department (ED).[3] With the potential to save both time[4] and money, emergency physician (EP)-performed DVT ultrasound offers an attractive alternative to reliance on radiology department-performed ultrasound imaging. Indeed, the American College of Emergency Physicians (ACEP) supports EP-performed DVT ultrasound training, as it now considers DVT ultrasound one of the core emergency ultrasound applications.[5]

At least 12 studies have evaluated EP-performed ultrasound studies to assess for DVT.[4,6-16] While some of these studies have found both the sensitivity and specificity for EP-performed DVT ultrasounds to be greater than 90%,[7,11,12,16] estimates of the sensitivity and specificity across these studies are inconsistent. Two systematic reviews[17,18] and meta-analysis[19] have evaluated EP-performed DVT ultrasonography, and have found the sensitivity and specificity to be in the mid to high 90s, but they lament the heterogeneity of the studies used in their analyses, and in some cases, the relatively few number of operators with a likely high degree of expertise.

Among the studies cited above that have evaluated EP-performed DVT ultrasounds, there is a great degree of variability in the technique used. Some studies have used a two-point compression technique,[4,6,8,9,11] in which only two locations are tested for compressibility – one in the groin to assess the common femoral vein and one in the popliteal fossa to test the popliteal vein. Other studies have used a three-point compression technique, which in addition to the common femoral and popliteal veins, assesses the superior femoral vein (SFV) at a single location for compressibility.[10,13,15] (Remember that despite its name, the SFV is a deep vein.) At least one study has evaluated EPs performing duplex ultrasounds of the entire leg,[16] and at least one study evaluated EPs performing compression ultrasound of the entire proximal leg,[7] excluding calf veins.

There are limited data comparing these various techniques, but one recent study found excellent results with the simplest of these techniques, the two-point compression technique. This study used 47 physicians, including emergency medicine (EM) attendings, EM residents, and residents rotating in the ED from other services. After only a 10-minute training session, they were able to use two-point compression ultrasound to achieve a sensitivity of 100% and a specificity of 99%.[11] Given the apparent ease by which this technique could be learned and the purported accuracy of this technique, if these results could be replicated, the two-point compression technique would clearly be the preferred technique in the ED. However, although data from radiology departments supports the use of a two-point compression technique,[20-22] to our knowledge no study using EPs as the operators has been able to replicate these results.

Our study was designed to attempt to replicate the results of the above-named study. We aimed to test the accuracy of the two-point compression technique for diagnosis of lower extremity proximal DVT as performed by EM residents with no prior formal training in this technique compared to the gold standard performed by ultrasound technologists and interpreted by radiologists. We also performed an analysis of our EM residents' ultrasound videos to determine if the ultrasound images were adequate and to assess for common errors that might be made when performing two-point compression ultrasound. Finally, we sought to characterize the potential impact on ED length of stay (LOS) if EPs were to make disposition decisions based on their bedside DVT ultrasound.

METHODS

Study Design

This was a prospective diagnostic test assessment of a convenience sample of ED patients suspected of having a lower extremity DVT. This study was approved by our hospital's institutional review board.

Study Setting and Population

This study was performed in the adult ED (annual census of approximately 83,300) of an academic, county, tertiary-care referral facility with a three-year EM residency.

Study Protocol

EM residents in our facility had no previous formal training in the two-point compression technique for diagnosing proximal lower extremity DVTs. All EM residents received approximately a two-hour training session that included a lecture on how to perform two-point compression ultrasound, practice on a human model, and a competency test with videos asking the residents to identify whether or not a DVT was present. As this study took place during two separate academic years, two separate training sessions were performed. The first trained and tested all EM residents in the program during the spring of 2013. The second session trained and tested the incoming intern class in July 2013. The format of the training sessions was identical.

Two-point compression ultrasound requires that the ultrasonographer identify the common femoral vein near the inguinal crease and the popliteal vein in the popliteal fossa. The a priori criteria for considering an ED ultrasound study positive were if either the vein would not compress completely from wall to wall or if an echogenic focus (representing a thrombus) was identified. EM residents were instructed to strictly follow the two-point compression method, and not to compress in other areas or use any supplemental methods for identifying DVT such as Doppler color flow or "augmentation." Augmentation is accomplished by squeezing the leg just distal to the site being examined with Doppler to help analyze flow through the vein. All ED scans were done with a standard 7.5 MHz linear probe on the Mindray M7.

Patients were eligible for inclusion in the study if they were at least 18 years old and suspected of having DVT with a radiology department-performed DVT ultrasound ordered.

We excluded patients if they had any of the following: a known DVT, a DVT within the previous six months, a DVT ultrasound within the last month, or a radiology department DVT ultrasound performed immediately prior to enrollment. We also excluded patients who were pregnant or in law enforcement custody.

Eligible patients were approached by research assistants or EM residents and shown a brief video explaining DVT and the purpose and process of the study. Written, informed consent was obtained, and then the ordering physician recorded basic patient demographics.

The subject underwent a two-point compression ultrasound by one of the EM residents; the resident determined whether or not the patient had a DVT and if so, which vein was involved. EM residents were instructed to save the videos of their scans, and to record their start and finish times on the data collection form. In some cases the ordering physician was also the resident who performed the two-point compression ultrasound. For the purposes of this research, orders for bilateral ultrasound constituted two separate studies. Subsequently, each subject underwent ultrasonography performed by a technologist from the radiology department, and interpretation was done by an attending radiologist. The radiology ultrasound technician and radiologist were blinded to the ED ultrasound results. Residents were prohibited from telling the patient whether the test was positive or negative, and no change in clinical care was permitted based on the resident's ultrasound study. The gold standard test was performed on all patients regardless of the EM resident ultrasound result.

The technique used by our ultrasound technologists involves a minimum of six points of compression: at the common femoral vein, just distal to the inguinal ligament, at three points along the SFV (proximal, middle, and distal), and at the popliteal vein and the posterior tibial vein. Any area that is noncompressible is considered positive for venous thrombosis. Any echogenic focus within the vein lumen is also considered a positive study. We grouped acute and chronic thrombi together in this study. Also, this study was concerned with identification of proximal lower extremity DVTs, so thrombi identified in the calf veins by the radiologists were considered negative studies. The technologists in our institution also perform Doppler examination at all six sites to look for flow, and they perform augmentation.

The study was conducted from May 10, 2013, to July 5, 2014. There are no EM residents in our department from 6 pm on Tuesdays until 2 pm on Wednesdays, so the study was temporarily suspended during those hours.

Outcome Measures

The primary outcome measure was the test performance characteristics for identification of a proximal lower extremity DVT by the two-point compression technique performed by EM residents as compared with a gold standard of radiology department ultrasounds. We also performed an analysis of the EM residents' ultrasound videos to assess them for adequacy, and to determine what errors the residents made when performing the compression ultrasounds. Finally, we sought to determine the EM resident-performed ultrasound's potential impact on ED LOS by comparing the time from ultrasound order placement to completion of the resident's ultrasound, compared to time of order placement to the official reading by the radiologist.

Data Analysis

We stored and analyzed data collected for this study in a Microsoft Excel (Version 14, Microsoft, Redmond, WA) spreadsheet. Based on the size of previous EP-performed DVT ultrasound studies,[4,6-16] all but one[16] of which have had fewer than 200 patients, we aimed to enroll 400 patients. This would make our study the largest study of EP-performed two-point compression ultrasound.

RESULTS

From May 10, 2013, through July 5, 2014, 32 EM residents performed compression ultrasound on 234 patients with a total of 288 ultrasounds performed. (Patient characteristics are shown in Table 1). In all cases, the gold standard test was performed. Flow of patients is shown in Figure.

Accuracy

The results of the ultrasounds performed for this study are shown in Table 2. Of the 288 ultrasounds performed, 28

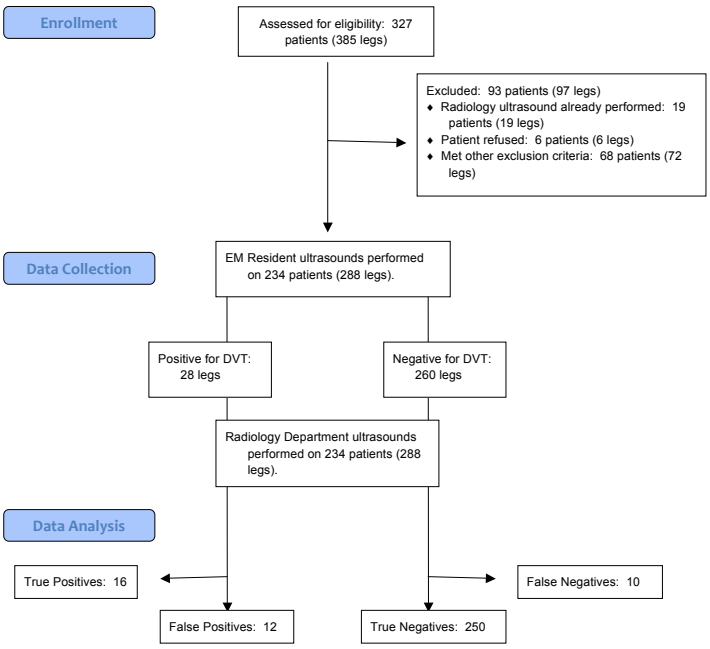

Figure. STARD flow diagram demostrating the flow of patients. *EM,* emergency medicine; *DVT,* deep vein thrombosis

Table 1. Baseline characteristics of patients.

Category	Value
Age	
Range 18-85 (median 48)	--
Gender	
Male	50.7%
Female	49.3%
Race	
African American	41.0%
Caucasian	34.7%
Hispanic	15.3%
Asian/Pacific Islander	4.2%
Other/Not documented	4.9%
Smoker?	
No	64.6%
Yes	30.6%
Not documented	4.9%

Table 2. Results of EM resident-performed 2-point compression ultrasounds and calculated test characteristics.

	Positive radiology ultrasound	Negative radiology ultrasound
Positive ED ultrasound	16	10
Negative ED ultrasound	12	250
Sensitivity, %	57.1 (95% CI [38.8-75.5])	--
Specificity, %	--	96.1 (95% CI [93.8-98.5])
Positive predictive value	61.5% (95% CI [42.8-80.2])	--
Negative predictive value	--	95.4% (95% CI [92.9-98.0])
Positive likelihood ratio	14.9 (95% CI [7.5 -29.5])	--
Negative likelihood ratio	--	0.45 (95% CI [0.29-0.68])

ED, emergency department

cases were deemed to be positive for DVT by the radiology ultrasound. Sixteen of the 28 were correctly identified by the residents with two-point compression as true positive DVTs. Among the 260 cases deemed to be negative for DVT by radiology ultrasound, 10 were falsely thought to be positive by the residents using two-point compression. Overall, the EM residents had a sensitivity of 57.1% (95% [CI 38.8-75.5]) and a specificity of 96.1% (95% CI [93.8-98.5]) for identification of proximal lower extremity DVT. This led to a test accuracy of 92.4% with a positive predictive value of 61.5% (95% CI [42.8-80.2]) and a negative predictive value of 95.4% (95% CI [92.9-98.0]). The positive likelihood ratio is 14.9 (95% CI [7.5-29.5]) and the negative likelihood ratio was 0.45 (95% CI [0.29-0.68]).

Thirty-two unique ultrasound operators contributed to this study. There was a large range in the number of studies performed by each resident. Three residents performed only one ultrasound, and one resident performed 51 ultrasounds. Eleven residents performed at least 10 ultrasounds. The results of the ultrasounds for each operator can be seen in the appendix.

Analysis of Resident Videos

The videos of the EM residents' ultrasounds in which the radiologist's interpretation differed from the resident's were reviewed. The total number of legs in which this was the case was 22 (10 false negatives and 12 false positives). Four of these videos could not be reviewed because they were not properly recorded and/or saved by the resident.

In two of the 22 discrepancies, the resident did not achieve adequate images of the common femoral vein. In one of these two, this appeared to be because the resident confused a lymph node with the common femoral vein.

In eight of the 22 cases, the resident's incorrect interpretation could be attributed to inadequate visualization of the popliteal vein. In the majority of those videos, the popliteal vein was not visible and it is not clear what structure the resident thought was the popliteal vein. However, in some of those cases, it appeared that a superficial vein was likely being confused with the popliteal vein. In one of those videos, the resident thought what was likely the tibial nerve was actually the popliteal vein with a hyperechoic thrombus.

In three of the 22 analyzed videos, the residents made other types of mistakes. In two, the residents obtained adequate visualization of the common femoral vein, but did not press hard enough to appropriately test for compressibility. In the third, the resident obtained adequate visualization of the common femoral vein, and upon review of the video, it appeared that part of the vein was not compressible. The resident, however, incorrectly interpreted the images and determined that there was no thrombus.

Finally, five of the 22 videos appeared to have adequate images of both the common femoral and popliteal veins despite being interpreted as having a DVT by the radiologist. In four of those cases, there was an isolated thrombus in the SFV, so there was no mistake on the resident ultrasonographer's part since evaluation of the SFV is not part of the two-point compression technique. In the other case, there appeared to be adequate compression of both the common femoral and popliteal veins upon our review of the videos, but the radiologist's report read "suspicious for small partial thrombus," as he or she felt there was a very small part of the vessel that was not collapsible.

Speed

The median (and interquartile range [IQR]) time for EM residents to complete a two-point compression ultrasound was four minutes (IQR two to eight minutes, minimum less than one minute, maximum 24 minutes). The ED ultrasounds were completed in a median of 84 minutes (IQR 62 to 119 minutes, minimum 15 minutes, maximum 756 minutes) before the radiology ultrasound report was made available to the EPs.

DISCUSSION

The sensitivity for two-point compression ultrasound in this study was significantly lower than in some of the previous studies of EP-performed DVT ultrasound,[7,11,12,16] including the study upon which we modeled this study.[11] There are several possible reasons for this.

First, the operators in our study may have been less experienced or less skilled at ultrasound. Several of the previous studies used operators who were highly trained attendings,[6] had "extensive experience,"[8] or who had a 30-hour training course.[16] However, the study by Crisp, et al.[11] had 47 operators with varying experience, many of whom had no prior experience, similar to the operators in our study. Thus, our results contradict those of the Crisp study in that it does not appear that one can become competent at two-point compression ultrasound after a brief training session. Indeed, our ultrasound video analysis demonstrated that at least 13 of the 22 discrepancies between the radiologist's and EM residents' ultrasounds could be attributed to an EM ultrasonographer error that might have been avoided with more intensive training, expanded training on how to avoid the pitfalls found in this study, or more experience. If these 13 cases had been evaluated by a more experienced ultrasonographer we would have achieved sensitivity and specificity that would more closely resemble those of some previous studies of EP-performed DVT ultrasound.

Another reason that the sensitivity in our study may have been lower than in previous EP-performed DVT ultrasound studies is that the two-point compression technique may be inferior to other DVT ultrasound techniques. The previous studies showing the highest sensitivities and specificities for EP-performed DVT ultrasounds used more thorough techniques,[7,12,16] such as complete proximal leg ultrasound[7] or whole leg ultrasound (including calf veins).[16] The exception to this was the study by Crisp, et al.,[11] which used a two-point compression technique and found a sensitivity of 100% and a specificity of 99%. At this point, that study appears to be an outlier. Indeed, our results were similar to those from a recent study of two-point compression performed by inexperienced operators on intensive care unit (ICU) patients (sensitivity 63%, specificity 97%).[23]

Logically, it would make sense that an ultrasound that does not specifically evaluate the SFV would have low sensitivity for identifying DVTs in it, but several studies from the 1990s suggest that a two-point compression technique is adequate,[21,22,24-26] and the study by Crisp, et al.[11] seems to provide EM-specific support for this. The idea behind this technique is that isolated SFV thrombi are rare.

However, more recent data suggest isolated SFV thromboses occur with some regularity, which would make the two-point compression technique undesirable. Indeed, a recent study found that 5.5% of proximal lower extremity DVTs were isolated to the SFV,[27] suggesting that a two-point compression technique should theoretically not achieve a sensitivity greater than the mid-90s, even with perfect ultrasound technique. Additionally, a study of two-point compression on ICU and intermediate care patients found six isolated SFV thromboses out of 12 patients who had DVTs.[23]

ACEP's Emergency Ultrasound Imaging Criteria Compendium supports two-point compression ultrasound, stating that the evaluation of the SFV "is not a primary focus of the standard lower extremity EUS [emergency ultrasound studies] evaluation."[28] Based on the results of our study and other recent data discussed above, we do not support this statement. We suggest using a protocol that routinely evaluates the SFV.

We admit that the sensitivity and specificity reported in this paper do not represent the greatest sensitivity and specificity that could be achieved using the two-point compression technique with more experienced operators. This begs the question: how many ultrasounds does one have to perform to achieve proficiency in compression ultrasound?

In one prior study of EP-performed compression ultrasounds, sensitivity was initially mediocre but became 100% after having performed ultrasounds on three patients.[10] We, however, doubt that proficiency can be attained so easily. In our study, reanalyzing the data only for residents who had already performed three compression ultrasounds for our study did not produce a statistically significant improvement in sensitivity or specificity. The recalculated sensitivity was 66.7% (95% CI [47.8-85.5]) and the specificity was 95.5% (95% CI [92.4-98.5]). Thus, while there is likely a learning curve for performing compression ultrasound, our study did not amass enough data to determine when an operator becomes proficient at performing this test; performing three ultrasounds does not appear to be sufficient.

Compared to some previous studies, one aspect that made our study unique was that we had the EM residents record videos of their ultrasounds, so that we could assess the images on which they based their interpretations. We are unaware of any previous study that has specifically analyzed EP-performed DVT ultrasounds for the purpose of finding common mistakes that might be made by novice ultrasonographers. This analysis produced several interesting findings.

First, the most common error made by EM resident ultrasonographers was inadequate visualization of the popliteal vein. Given the high frequency at which errors appear to occur at the popliteal vein, ultrasound educators should take heed of this to specifically target avoiding this

error. ACEP's Emergency Ultrasound Criteria Compendium does not list this as a potential pitfall of DVT ultrasound[28], when in fact our data suggest it is the most common error.

Second, our analysis of the EM residents' ultrasounds suggests that DVT ultrasound training should emphasize how to distinguish lymph nodes, nerves, and DVTs. Training should also emphasize how to determine how much pressure to apply when compressing the veins. Although the training session we provided did include some information about these topics, it may have been insufficient.

Finally, the four cases in which the EM residents missed an isolated SFV thrombus bring us back to the point that two-point compression ultrasound may not be sufficient for diagnosis of lower extremity DVT.

Lastly, this study confirmed the findings of other studies[4,15] that have found that EP-performed compression ultrasound is rapid (generally less than five minutes based upon our results) and has the potential to reduce the patient's time to disposition and time to treatment significantly. This makes further research in this field imperative to determine an ultrasound protocol to evaluate for DVT that has better test characteristics and is still rapid.

LIMITATIONS

This study had several limitations that are important to consider when interpreting the results. First, we used a convenience sampling of patients and that may have resulted in some patients who would have been more difficult to ultrasound (for example, because of obesity) not getting enrolled.

This was a single-center study, which limits the generalizability, but we had 32 operators, which is more than all but two of the previous EP-performed DVT ultrasound studies.[10,11] The fact that the ultrasonographers were all novices also limits the generalizability of the results in some ways, but the study was designed in this fashion for two main reasons. First, the study by Crisp, et al.[11] found excellent results with a heterogeneous group of ultrasonographers, including many who had only received a10-minute training session. While our training was more extensive than in that study, we otherwise copied the design of that study. Second, the use of novice ultrasonographers allowed us to perform an analysis of common mistakes made by the resident ultrasongraphers for educational purposes. The majority of EPs currently practicing did not learn DVT ultrasound during their residencies; therefore, the majority of EPs are novices at DVT ultrasound, and in this sense, it makes our study more generalizable than some of the previous studies.

In our study, one resident performed 51 of the 288 DVT ultrasounds (about 18% of all the ultrasounds). This resident was also an investigator on the study, and so was particularly motivated. Allowing one resident to perform this many ultrasounds could have resulted in inflated sensitivity, and capping the number of ultrasounds allowed by a given resident may have been preferable.

Another limitation to consider was that our study was undersized because of under-enrollment. A large contributing factor in this regard was that our ED implemented a new electronic medical record (EMR) system approximately six months into the data collection period. We relied heavily on research assistants to identify patients for possible enrollment, but the new EMR restricted the access of the research assistants and made it more difficult for them to identify patients for enrollment. The study was ended prior to reaching our enrollment goal because the rate of enrollment dropped dramatically after the implementation of the new EMR system. Nonetheless, 288 ultrasounds were included, which makes this, to the best of our knowledge, the largest study of EP-performed two-point compression DVT ultrasound to date. The additional 112 ultrasounds would have been primarily helpful to assess for the number of ultrasounds it takes for one to become competent at two-point compression ultrasound.

There were some instances in which the residents did not completely follow study protocol. This resulted in some ultrasound videos not being available for our review. Moreover, some residents only recorded their overall start and finish times instead of the time it took to complete each individual leg. In these cases, the time for each leg was recorded as the total time for both legs, when the time actually would be about half that length. This means the overall time to complete a two-point compression ultrasound is likely shorter than seven minutes.

Finally, we recognize that radiology department ultrasounds represent a false gold standard, since as mentioned above, contrast venography actually represents the gold standard test for DVTs. However, given the rarity by which contrast venography is ordered, radiology ultrasound is functionally the gold standard in the ED, and this study would not have been feasible if we chose contrast venography as our gold standard.

CONCLUSION

Although, compression ultrasound shows promise as a means for EPs to rapidly diagnose proximal lower extremity DVT, the two-point compression method does not identify thrombi isolated to the SFV, which detracts from the method's sensitivity. Although more experienced operators may be able to achieve higher sensitivities and specificities with two-point compression ultrasound than what we achieved, after video analysis of the ultrasounds performed in this study, it is clear that isolated SFV thrombi may occur and be missed even by a perfectly performed two-point compression technique. Future DVT ultrasound studies should focus on techniques that include an evaluation of the SFV.

Our findings suggest that it is more difficult to become

competent at compression ultrasound than previously thought. Emergency ultrasound educators should be aware of this and of the difficulties that novice ultrasonographers have in properly assessing the popliteal vein for DVT.

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Computerized Diagnostic Assistant for the Automatic Detection of Pneumothorax on Ultrasound: A Pilot Study

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Introduction: Bedside thoracic ultrasound (US) can rapidly diagnose pneumothorax (PTX) with improved accuracy over the physical examination and without the need for chest radiography (CXR); however, US is highly operator dependent. A computerized diagnostic assistant was developed by the United States Army Institute of Surgical Research to detect PTX on standard thoracic US images. This computer algorithm is designed to automatically detect sonographic signs of PTX by systematically analyzing B-mode US video clips for pleural sliding and M-mode still images for the seashore sign. This was a pilot study to estimate the diagnostic accuracy of the PTX detection computer algorithm when compared to an expert panel of US trained physicians.

Methods: This was a retrospective study using archived thoracic US obtained on adult patients presenting to the emergency department (ED) between 5/23/2011 and 8/6/2014. Emergency medicine residents, fellows, attending physicians, physician assistants, and medical students performed the US examinations and stored the images in the picture archive and communications system (PACS). The PACS was queried for all ED bedside US examinations with reported positive PTX during the study period along with a random sample of negatives. The computer algorithm then interpreted the images, and we compared the results to an independent, blinded expert panel of three physicians, each with experience reviewing over 10,000 US examinations.

Results: Query of the PACS system revealed 146 bedside thoracic US examinations for analysis. Thirteen examinations were indeterminate and were excluded. There were 79 true negatives, 33 true positives, 9 false negatives, and 12 false positives. The test characteristics of the algorithm when compared to the expert panel were sensitivity 79% (95 % CI [63-89]) and specificity 87% (95% CI [77-93]). For the 20 images scored as highest quality by the expert panel, the algorithm demonstrated 100% sensitivity (95% CI [56-100]) and 92% specificity (95% CI [62-100]).

Conclusion: This novel computer algorithm has potential to aid clinicians with the identification of the sonographic signs of PTX in the absence of expert physician sonographers. Further refinement and training of the algorithm is still needed, along with prospective validation, before it can be utilized in clinical practice. [West J Emerg Med. 2016;17(2):209–215.]

INTRODUCTION

In the hands of appropriately trained clinicians, bedside thoracic ultrasound (US) can rapidly diagnose pneumothorax (PTX) with improved accuracy over the physical examination and without the need for chest radiography (CXR). In a recent meta-analysis, the pooled sensitivity and specificity of bedside thoracic US to detect PTX was 90.9% and 98.2%, respectively.[1] However, the major hurdle in realizing the full potential of bedside thoracic US is the implementation of an effective training program that ensures the competency of the sonographer, and at least one prior study demonstrated that operator skill is highly correlated with diagnostic accuracy.[2] To aid the US novice in the absence of expert clinical sonographers, such as in austere environments or community settings, a computerized diagnostic assistant was created by biomedical software engineers at the United States Army Institute of Surgical Research (USAISR). This computer algorithm systematically analyzes B-mode US video clips for pleural sliding as well as M-mode still images for the seashore sign, which are indicators of normal aerated lung.[1]

Computer programs that assist clinicians in the interpretation of diagnostic studies are not a novel concept.[3-18] For example, electrocardiogram (EKG)-reading software is in widespread use today and can assist non-cardiologists in achieving more uniform and consistent interpretations.[18] To our knowledge, there has been only one publication examining the potential of an automated thoracic US interpretation system.[19] In this study, a computer algorithm to diagnose acute pulmonary edema on thoracic US was described. Although our concept is similar to the aforementioned study, we believe that there is no published research specifically evaluating the potential for an automated system to detect PTX.

The primary objective was to obtain a baseline estimate of the diagnostic accuracy of our computerized diagnostic assistant to detect sonographic signs of PTX. The secondary objectives were to analyze its performance after stratifying the examinations by image quality, mode of imaging, and transducer selection in order to guide future prototype development.

METHODS

Study Design

We conducted a retrospective pilot study using bedside thoracic US images obtained on adult emergency department (ED) patients between May 23, 2011, and August 6,2014. We sampled images from the Picture Archive and Communications System (PACS) through query of our US quality assurance database (Filemaker Pro, Santa Clara, CA). The computerized diagnostic assistant analyzed images and reported the result as positive, negative, or indeterminate for PTX. A blinded, independent expert panel of three physician sonographers then reviewed the same images and recorded their interpretations on a standardized data collection sheet. For the primary outcome, we compared the algorithm's interpretation to the consensus decision of the expert panel. The study was approved by the institutional review board with a waiver of informed consent.

Study Setting

The study setting was an academic level I trauma center ED with an annual census of 77,000 patients. All US images were acquired with the Sonosite M-turbo or S-FAST system (Bothell, WA), based on clinician preference. At our institution, we support a robust training and quality assurance (QA) program for ED US and perform approximately 7,000 bedside examinations per year. Our QA process entails a weekly review of 100% of archived ED bedside US examinations. During these QA sessions, faculty input a report for each study into a Filemaker Pro (Santa Clara, CA) computer database (Figure 1). This report contains the study type and date, the sonographer, the study result, and a unique 8-digit accession number that links to the images in PACS.

Study Protocol

We queried the Filemaker Pro (Santa Clara, CA) database for all positive bedside thoracic US examinations reported during the study period on ED patients aged 18-89 years. We then inputted the accession numbers into the PACS and exported the images to a compact disc (CD). After the positives were collected, we queried the database for a random sample of negative thoracic US examinations obtained during the same study period. For convenience, we chose to sample a 2:1 ratio of negative examinations to positives to maximize efficiency. A 1:1 ratio would require over 1,000 negative studies. In order to collect the negatives, we used http://www.randomization.com to generate a single column of random two-digit integers, and we performed a database search for US studies with accession numbers ending in these two digits. We continued searching the database with each generated two-digit number down the column until we had achieved a 2:1 ratio. The negative PTX images were then exported from the PACS in the same fashion as the positives. Finally, all of the positive and negative images were de-identified and placed in random order on four identical CDs, one for each expert panel member and one for the computer algorithm.

Measurements

The Computerized Diagnostic Assistant

Biomedical software engineers at the USAISR, in consultation with emergency medicine US fellowship-trained physicians, developed the PTX computerized diagnostic assistant as the first phase of the intelligent focused assessment with sonography for trauma (iFAST) project.[20] The patent application for this project was published on April 2, 2015.[20] The PTX algorithm was initially trained on a de-identified set of 80 positive and 80 negative thoracic US images used by the fellowship for teaching purposes.

For thoracic B-mode images, the iFAST is designed to detect the presence of the sliding lung sign, which is indicative of normal apposition of the visceral and parietal surfaces.[21] It is also capable of identifying common reverberation artifacts that can assist with the identification of PTX in standard B-mode imaging.[22] In the first step of the B-mode algorithm, two discrete ribs with posterior acoustic shadowing assist the device in locating the intercostal space on the US image (Figure 2). The iFAST identifies the pleural line by searching for a hyper-echoic linear and contiguous line that runs immediately beneath the ribs in the intercostal space. While focusing on the pleural line, it dynamically scans each frame of the respiratory cycle, searching for horizontal pixel movements to and fro in a coordinated fashion as well as reverberation artifacts. If the algorithm identifies pixel movement back and forth along the pleural line or pleural line reverberations, it will report negative for PTX. If pixel movement cannot be detected and there are no reverberation artifacts extending below, then it will report positive for PTX. If it cannot identify the pleural line at all, it will report as indeterminate.

The iFAST was also trained to analyze M-mode US images of the thorax. In normal M-mode imaging, horizontal movement along the pleural line will cause granular or speckled artifacts to appear below the pleural line resembling a sandy beach, also known as the seashore sign.[21] With PTX, absence of motion due to interposed air will create a barcode pattern with linear artifacts below the pleural line, known as the stratosphere sign.[21] The M-mode algorithm first identifies the pleural line as the most hyper-echoic contiguous line on the screen, and then it analyzes below for granularity or barcode pattern.

The Expert Panel

The primary outcome was the consensus decision of an independent expert panel of physician sonographers. This panel consisted of one board-certified radiologist (JR), one board-certified pulmonary/critical care physician with Registered Diagnostic Medical Sonographer certification (KG), and one US fellowship-trained emergency physician (JK), each with experience reviewing over 10,000 US examinations. The expert panel members were blinded to all clinical data as well as to the iFAST interpretation. No expert panel member was involved in the iFAST project or patenting of the computer algorithm.

Each panel member received a CD along with a separate standardized data collection instrument. The panel members individually reviewed the images and recorded an interpretation along with an image quality score. The scoring system used was a five-point Likert scale (Table 1) recommended for US quality assurance by the 2011 American College of Emergency Physicians Ultrasound Standard Reporting Guidelines.[23] By convention, images with a score of three or greater yielded diagnostic information, whereas scores of one or two were deemed indeterminate.

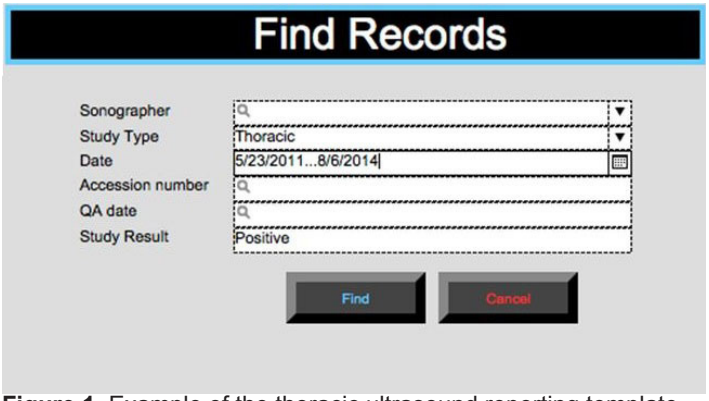

Figure 1. Example of the thoracic ultrasound reporting template in the emergency department quality assurance database (Filemaker Pro, Santa Clara, CA).

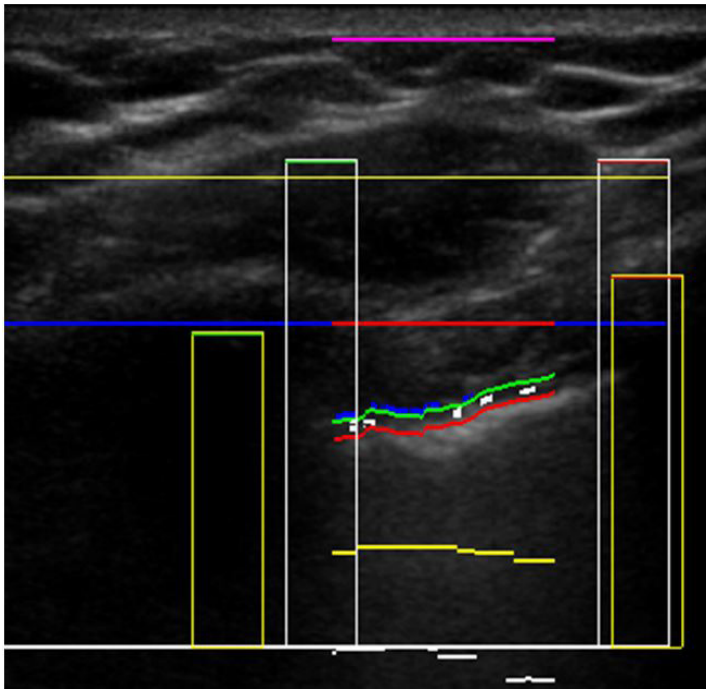

Figure 2. In this B-mode image, the intelligent focused assessment with sonography for trauma (iFAST) has correctly identified the pleural line in order to examine for sliding lung sign. The purple line denotes the skin surface. The first horizontal yellow line is the pectoralis muscle. To find the pleural line, the iFAST first locates the rib shadows (yellow rectangles). The red break in the blue horizontal line between the ribs defines the intercostal space. The pleural line appears like a road with paired green and red horizontal lines in the intercostal space. The small white rectangles on the "road" denote pixel movements back and forth along the pleural line, indicating normal sliding lung.

After the expert panel members completed their independent review of the US images, we examined their interpretations for concordance. If all panel members unanimously agreed on the study result, then the US images were included in the study. For the studies in which there

Table 1. American College of Emergency Physiciancs (ACEP) emergency ultrasound standard reporting guidelines.

	1	2	3	4	5
Grading scale definitions	No recognizable structures, no objective data can be gathered	Minimally recognizable structures but insufficient for diagnosis	Minimal criteria met for diagnosis, recognizable structures but with some technical or other flaws	Minimal criteria met for diagnosis, all structures imaged well and diagnosis easily supported	Minimal criteria met for diagnosis, all structures imaged with excellent image quality and diagnosis completely supported

was initial disagreement, the expert panel had a plenary discussion to determine consensus. If the panel could not reach a consensus, then the study was excluded. Thirteen scans were excluded, resulting in analysis of 133 scans. Indeterminate scans with scores below three on the American College of Emergency Physiciancs (ACEP) image quality scale were excluded from study. This scale is shown in Table 1.

ANALYSIS

For the primary analysis, we compared the iFAST interpretation to the expert panel consensus decision to determine test characteristics along with the corresponding 95% confidence intervals. Cohen's Kappa was calculated to determine initial agreement between the three expert panel members. A Kappa from 0.40 to 0.75 indicated fair to good agreement. A Kappa >0.75 indicated excellent agreement.

For the secondary analysis, we stratified the US examinations by image quality scores and analyzed the performance of the algorithm in these subgroups. In order to hypothesize about proper mode and transducer selection for future prospective studies, we created contingency tables for the test performance for both B-mode versus M-mode images as well as linear versus phased array probes.

RESULTS

Query of the Filemaker Pro (Santa Clara, CA) QA database revealed 49 bedside thoracic US examinations reported as positive for PTX along with 98 randomly sampled negative examinations. The examinations were performed by sonographers from all post-graduate year (PGY) training levels (Figure 3) with a wide range of prior US experience (Figure 4). After excluding one study for patient age, 146 images were exported from the PACS and copied onto a CD for review by the expert panel and the iFAST. Thirteen of these images were reported as indeterminate and were excluded from final data analysis, leaving 133 scans for analysis. When the iFAST interpretation was compared to the expert panel as the gold standard, there were 79 true negatives, 33 true positives, 9 false negatives, and 12 false positives. For the primary outcome, the overall test characteristics of the algorithm were as follows: sensitivity 79% (95 % CI [63-89]), specificity 87% (95% CI [77-93]).

Our results demonstrated excellent agreement for the expert panel. After the first independent blinded review, there was unanimous agreement between the three expert panel members for 90% of US examinations. Consensus decision on the final result was reached for all of the remaining studies during the plenary discussion. Initial agreement between the first expert panel reviewer (KG) and the second reviewer (JK) was Kappa 0.84 (95% CI [0.75-0.93]), between the first (KG) and third reviewer (JR) was Kappa 0.86 (95% CI [0.78-0.95]), and between the second (JK) and third (JR) was Kappa 0.83 (0.74-0.92).

For the secondary analysis, the range of image quality scores was from 2 to 5, (mean 3.8, median 4; interquartile range 3 to 4). The iFAST performed well when interpreting US examinations with an image quality score of 5, although the sample size was too small to draw definite conclusions (Table 2). Table 3 reports the test characteristics of the iFAST when grouped by mode of imaging and transducer selection. The iFAST appeared to perform with higher sensitivity for B-mode images and with the phased array transducer, although there were no statistically significant differences.

DISCUSSION

The iFAST algorithm was initially developed by the USAISR as a potential diagnostic tool to assist combat medics in austere environments. Thoracic US in the prehospital setting may alter management for injured patients, such as the evacuation destination, the evacuation platform, or the need for tube thoracostomy.[24] However, in one study of thoracic US performed by aeromedical transport teams, the sensitivity for detection of PTX was only 18.7%.[25] Furthermore, training prehospital providers across a wide variety of systems presents significant logistical challenges such as ensuring skill retention and providing quality assurance. The iFAST was designed to mitigate these challenges by providing novice sonographers with a reliable computerized diagnostic assistant capable of recognizing common sonographic signs of PTX. The iFAST could be useful in a prehospital or aeromedical environment where conditions are not optimal and novice sonographers may be present, but further refinement and study of the algorithm is required for these settings. The purpose of this pilot study was to estimate the diagnostic accuracy of the algorithm, provide proof of concept, and determine needs for future prototype development.

In our pilot study, the iFAST was 79% sensitive and 87% specific, which we believe supports proof of concept and is encouraging considering the non-standardized way in which the images were recorded. For the images with quality scores of five, the iFAST performed well, which suggests that the

Table 2. Overall test characteristics of the intelligent focused assessment with sonography for trauma (iFAST) when compared to the expert panel interpretation with results stratified by image quality score.

Test characteristics	Overall N=133 (95% CI)	Image quality 3 N=45 (95% CI)	Image quality 4 N=68 (95% CI)	Image quality 5 N=20 (95% CI)
Sensitivity, %	79 (63-89)	73 (39-93)	75 (53-89)	100 (65-100)
Specificity, %	87 (78-93)	88 (72-96)	84 (69-93)	92 (62-100)
PPV, %	73 (58-85)	67 (35-88)	72 (50-87)	88 (47-99)
NPV, %	90 (81-95)	91 (75-98)	86 (71-94)	100 (70-100)

PPV, positive predictive value; *NPV,* negative predictive value

Table 3. Test characteristics of the intelligent focused assessment with sonography for trauma (iFAST) when stratified by mode of imaging and transducer selection.

Test characteristics	B-mode N=107 (95% CI)	M-mode N=26 (95% CI)	Linear array N=80 (95% CI)	Phased array N=53 (95% CI)
Sensitivity, %	87 (68-96)	58 (29-84)	76 (57-88)	89 (51-99)
Specificity, %	86 (75-92)	93 (64-100)	87 (74-95)	86 (72-94)
PPV, %	65 (56-74)	88 (47-99)	81 (62-92)	57 (30-81)
NPV, %	94 (85-98)	72 (46-89)	84 (70-92)	97 (85-100)

PPV, positive predictive value; *NPV,* negative predictive value

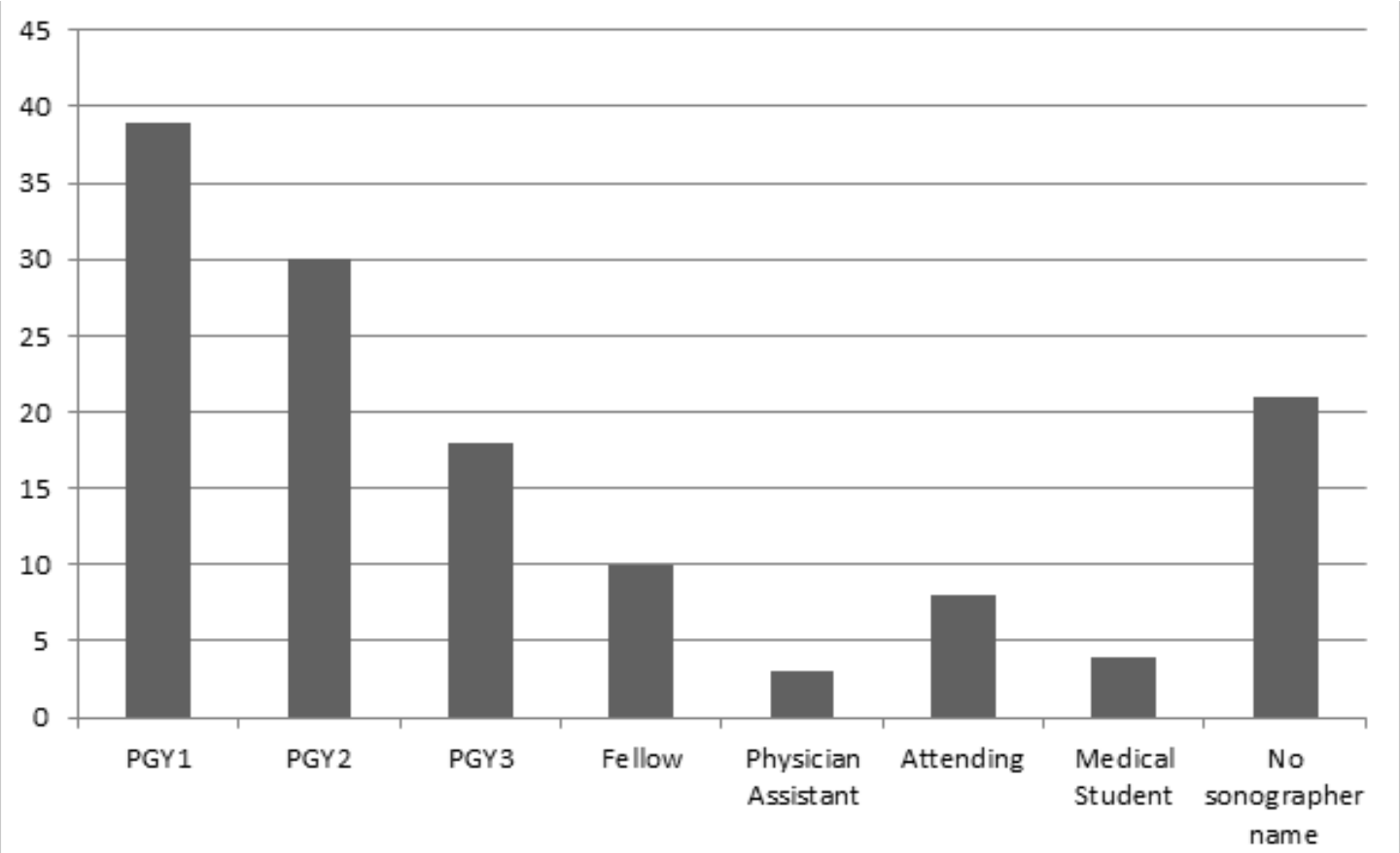

Figure 3. Post-graduate year (PGY) level of the sonographers who performed the bedside thoracic ultrasound (US) examinations. Twenty-one sonographers failed to input their name on the US study at the time of imaging; thus, their PGY level could not be ascertained.

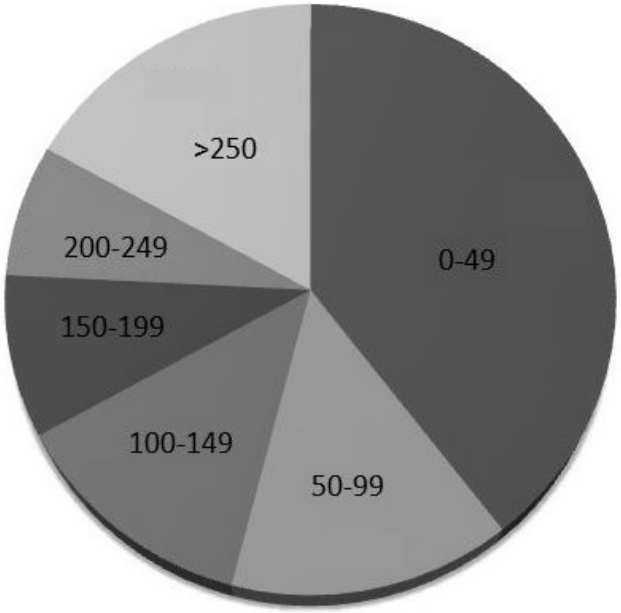

Figure 4. Prior ultrasound experience of the sonographers who performed the bedside thoracic ultrasound examinations.

actual computer algorithm can work if it "sees" a good image. However, our overall results were far from optimal and cannot be used to support the current clinical use of the iFAST over the experience of US-trained personnel.

To improve image interpretation capabilities, we plan to train the iFAST with a larger sample of known positive and negative thoracic US images. However, the bigger challenge will be to standardize the image acquisition process in such a way that the iFAST can be given the best chance to render an accurate interpretation. Much like with EKG computerized programs where a reliable reading depends on the correct location of electrodes, an accurate algorithm in clinical practice will require correct placement of the transducer.[18] Because of retrospective design, we do not know if controlling the methods in which the images were obtained would have improved the diagnostic accuracy. However, based on the performance of the algorithm with image quality scores of five, we believe that our primary focus for future prototype development should be standardizing image acquisition rather than aggressive retraining of the computer software. Because our device will ultimately be intended for novices, the guidelines for image acquisition should be relatively straightforward and easily employed. The logical next step to assess the iFAST should be a prospective evaluation of US novices using the algorithm in a blinded, predefined fashion and comparing the results to computed tomography (CT).

LIMITATIONS

This was a small retrospective study at a single center with a robust US training program; thus, our results may not be generalizable. The retrospective nature of this study precluded controlling certain parameters such as depth, frequency, and mode, and there may have been image quality degradations when exporting US video secondary to data compression. Also, sonographers may have chosen not to archive examinations if there was technical difficulty, leading to potential selection bias. Using a convenience sample of negatives may also have caused selection bias; however, we did randomly select the negatives to improve our chances of achieving a representative sample. By using a 2:1 ratio for negative to positive findings, investigators controlled prevalence, thus affecting the positive and negative predictive values. Using a 2:1 ratio is indeed a limitation.

Another major limitation of our study was the choice of the expert panel as the gold standard rather than CT. We chose these methods in order to hypothesize whether the predominant source of iFAST diagnostic error was due to image quality, transducer placement, or an inherent flaw in the software's interpretation of the images. For example, if the algorithm missed the sonographic signs of PTX when compared to experts, especially with a high-quality image, this would suggest a flaw in the interpretation algorithm and would require retraining. If the iFAST correctly interpreted the presence of sliding lung, multiple US experts agreed that the image was negative, but the CT was positive, this could suggest that the transducer was not placed in the correct intercostal space to "see" the PTX. The latter problem, while still important, would not necessarily mandate retraining of the computer. Rather, it would require solutions to assist the novice operator obtain reliable images for the software to interpret. Ultimately, controlling image acquisition and ensuring reliable software interpretation will be critical for successful deployment of the iFAST to novices in a clinical setting; however, each requires a different focus for future prototype development.

CONCLUSION

In the absence of expert physician sonographers, the iFAST computerized diagnostic assistant has potential to aid clinicians with the identification of the sonographic signs of PTX. This algorithm has additional potential in settings in which conditions are not optimal for US use and novice sonographers are present. However, in its current form, the iFAST is not sufficiently sensitive or specific for lower quality US images when compared with expert physician interpretation. The optimal image acquisition process to ensure reliable readings must be further defined, standardized, and validated in future prospective studies before it can be deployed in clinical practice.

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Ultrasound-Guided Cannulation: Time to Bring Subclavian Central Lines Back

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Despite multiple advantages, subclavian vein (SCV) cannulation via the traditional landmark approach has become less used in comparison to ultrasound (US) guided internal jugular catheterization due to a higher rate of mechanical complications. A growing body of evidence indicates that SCV catheterization with real-time US guidance can be accomplished safely and efficiently. While several cannulation approaches with real-time US guidance have been described, available literature suggests that the infraclavicular, longitudinal "in-plane" technique may be preferred. This approach allows for direct visualization of needle advancement, which reduces risk of complications and improves successful placement. Infraclavicular SCV cannulation requires simultaneous use of US during needle advancement, but for an inexperienced operator, it is more easily learned compared to the traditional landmark approach. In this article, we review the evidence supporting the use of US guidance for SCV catheterization and discuss technical aspects of the procedure itself. [West J Emerg Med. 2016;17(2):216–221.]

INTRODUCTION

Since its original description over 60 years ago by Aubaniac, the subclavian vein (SCV) has been an important vessel for central venous cannulation.[1] The SCV cannulation offers several advantages when compared to the common alternative sites for central venous access. These advantages may include fewer cases of thrombosis, infectious complications, better patient comfort, and increased ability to remain patent in hypovolemic states.[2-8] Unfortunately, cannulation of the SCV is not without complications such as catheter malposition, arterial puncture, hematoma, pneumothorax, hemothorax, and nerve injury. The rate of clinically relevant mechanical complications has been shown to be as high as 18.8%, likely due to the traditional landmark (LM)-guided or "blind" approach, and also dependent on user experience.[4,6] As a result, alternative approaches to SCV cannulation, including ultrasound (US)-guided techniques, have been explored and determined to have improved safety and reduced complications particularly when using real-time US in the longitudinal or "in-plane" method.[9,10] In this article, we review the evidence supporting the use of US guidance for SCV catheterization, and discuss technical aspects of several approaches.

ULTRASOUND GUIDANCE

Wide availability and improved technology have made bedside US a valuable tool for establishing vascular access. It allows for direct visualization of and evaluation for the vessel of choice in addition to precise needle positioning during cannulation.[11,12] Multiple studies have compared US-guided central vein catheterization to LM techniques and found US superior with a 12% reduction of unsuccessful line placement, 1.19 fewer attempts, and a 71% reduction in overall catheter-related complications for internal jugular vein (IJV) placement.[9,13] As a result, multiple national and international organizations, including The American College of Emergency Physicians (ACEP), National Institute for Clinical Excellence (NICE), and the Agency for Healthcare

Research Quality (AHRQ), recommend the use of US in central vein cannulation.[14,15]

At first glance, the SCV seems difficult to visualize on US because it travels beneath the highly reflective clavicle bone. This, along with the higher complication rate of the LM-guided approach, has resulted in the SCV falling out of favor for elective central vein cannulation in many modern clinical settings. To explore this notion, recent studies have compared the use of US to the LM approach in SCV cannulation (Table) and results suggest a significant impact of US on the safety and feasibility of SCV cannulation. In a prospective randomized control trial by Fragou et al comparing real-time US guidance with the LM technique, US guidance was found to improve success rates, 100% vs. 87.5% and reduce the rate of mechanical complications, including arterial puncture and hematoma formation.[10] Additionally, there was a reduction in the rate of pneumothorax (4.9%) using US, likely secondary to the ability to visualize the needle and prevent posterior vessel wall penetration.[10,16] Two recent meta-analyses also showed a significant reduction in arterial puncture and hematoma formation, as well as improved rate of successful cannulation when using real-time US with a longitudinal "in-plane" infraclavicular approach.[9,17] Similarly, Randolph et al demonstrated the use of US was associated with a reduced risk of catheter placement failure (relative risk 0.32; 95% confidence interval 0.18 to 0.55), lower overall complication rates (relative risk 0.22; 95% confidence interval 0.10 to 0.45), and a reduced number of needle sticks before successful placement (relative risk 0.60; 95% confidence interval 0.45 to 0.79), for both SCV and IJV cannulation.[11] Gualtieri et al demonstrated that the use of US improved the SVC cannulation success rate in less-experienced operators (92% vs 44%).[16] The benefits of US guidance make the SCV an excellent option for central venous cannulation.

ULTRASOUND TECHNIQUES: LONGITUDINAL VS. SHORT AXIS VIEW

Positioning the long footprint of the US probe perpendicular to the course of the vessel gives rise to a short axis view (Figure 1a). This view allows for visualization of the target vessel and surrounding structures, and offers the operator a good midline orientation. This view allows for an "out-of-plane" needle-guided approach, which does not offer the optimal ability to visually control the needle tip during the cannulation process. This is because the needle artifact on the screen only shows a cross section of the needle. This may be the needle tip, but it could also be any part of the needle shaft – they look identical on US. Alternatively, the longitudinal, or long axis view, is obtained with the transducer and vessel axes in parallel (Figure 1b). This view identifies the target vessel along its length. Using this view for obtaining vascular access allows one to insert the needle using an "in-plane" needle tip approach which allows for direct and full visualization of both the needle tip and needle shaft during catheterization. The needle is easily witnessed entering the target vessel and, importantly, the guidewire's direction of travel can be verified. The challenge with the "in-plane" technique requires the operator to have the dexterity needed to line up the one millimeter thickness of sound beam with the one millimeter thickness of needle, all within the midline axis of the vessel's longitudinal plane. Another potential limitation of the long axis approach is not being able to simultaneously see both

Table. Studies evaluating direct ultrasound-guided subclavian vein cannulation in comparison to landmark approach.

Authors/ publication	Type of study	Participants	Enrollment	Operators	Outcomes
Fragou et al.[10]	Prospective randomized single center	Mechanically ventilated and sedated patients in the medical ICU	LM group: N=201, US group: N=200	Multiple, with more than 6 years of experience in placement of central venous catheters	Increased success rate for experienced operators (100% vs 87.5%) Significantly decreased mechanical complication rate
Alic, Y et al.[28]	Prospective randomized single center	ICU patients (type of ICU not specified)	LM group: N=35, US group: N=35	One physician experienced in both techniques	No significant difference between success at 1st attempt, overall success, or complication rate between LM and US group.
Palepu et al.[29]	Prospective randomized single center	Combined medical and surgical ICU Patients	LM group: N=28, US group: N=17	Multiple operators with varying levels of experience	No significant difference between overall success (p=0.52), number of attempts (p=0.23) or complication rate (p>0.99)
Gualtieri et al.[30]	Prospective randomized single center	Combined trauma, surgical and medical ICU Patients	LM group: N=27, US group: N=25	More than one operator with varying levels of experience	Increased success rate for inexperienced operators (92% vs 44%) using direct US guidance Reduced minor complications (4% vs 41%)

ICU, intensive care unit; LM, landmark; US, ultrasound

artery and vein on the screen as in the short axis approach. After identification of the vein in the long axis, it is possible that due to necessary coupling gel, that the operator's hand could slide a few millimeters and be visualizing the artery. In the long axis veins and arteries can appear similar, particularly when they are in an area that is not conducive to compression.

A single-center randomized crossover control trial including 57 emergency medicine residents and attending physicians of varying US experience compared the short axis versus long axis approach for axillary vein cannulation using a torso phantom model.[18] The long axis approach was superior for successful placement on initial attempt with fewer needle redirections and reduced complications. When surveyed, the long axis approach was also the preferred approach of the examined operators. In another prospective study comparing emergency medicine trainees' skills in obtaining an adequate view for catheterization using a human torso model, the long axis SCV view led to quicker access time, reduced redirections, and significantly fewer posterior wall penetrations compared to the short axis probe orientation.[16]

SUPRACLAVICULAR SUBCLAVIAN VEIN CANNULATION UNDER ULTRASOUND GUIDANCE

Multiple studies have demonstrated the advantages of a supraclavicular approach to SCV cannulation, but results have been dependent on operator experience.[19,21] The approach has a well-defined insertion LM - the clavisternomastoid angle, with insertion from above the clavicle.[21] This approach offers a shorter, more direct course to the SCV, traversing only fascial planes, whereas with an infraclavicular approach, it must traverse the pectoralis major muscle, which may lead to increased catheter malpositioning.[22,23] In a randomized prospective comparative study of infraclavicular vs. supraclavicular approaches using a LM technique, there was a 9% incidence of catheter malpositioning in the infraclavicular group compared to 0.5% in the supraclavicular group.[22] In another prospective comparative study evaluating 144 patients requiring central venous catheterization, a supraclavicular approach had a statistically significant higher success rate in comparison to an infraclavicular approach.[20]

There are limited published data comparing supraclaviclar to infraclavicular approaches with real-time US guidance. In one prospective anatomical study of normovolemic patients, Stachura et al demonstrated that identifying the SCV in the supraclavicular region using US is technically easier compared to the infraclavicular region.[8] The use of real-time US for supraclavicular SCV cannulation is limited by a lack of space in the supraclavicular area for both the US probe and the needle used for cannulation.[22] Understanding this limitation, Mallin et al described a supraclavicular approach using an endocavitary probe with a smaller footprint, creating adequate space for real-time US-guided cannulation.[24] As most US systems are not routinely equipped with endocavitary probes, it is not surprising that currently available literature favors the infraclavicular approach as the preferred approach for SCV cannulation. Future studies focused on smaller US vascular probes may lead to better understanding of the value of the supraclavicular approach.

INFRACLAVICULAR SUBCLAVIAN CANNULATION UNDER ULTRASOUND GUIDANCE

The axillary vein courses medially and becomes the SCV at the lateral border of the first rib. It continues its path under the clavicle, arching upward across the superior surface of the first rib and then inclines medially, downwards and across the insertion of the anterior scalene muscle. At this point, it enters the thorax as it unites with the IJV behind the sterno-clavicular joint.[10,21,25] SCV visualization via US is possible in the clavipectoral triangle, 2-3cm distal to the point where the SCV crosses below the clavicle. As a result, US-guided SCV cannulation using an infraclavicular approach is positioned near the border of the axillary vein, which is noticeably lateral to the LM approach.[26,27]

The procedure begins with the patient placed in a supine position, prepared and draped in a sterile fashion. The subclavian and axillary veins are visualized by placing a high frequency linear transducer in the infraclavicular fossa (Figure 2a), in order to obtain a short axis view of the vein and artery (Figure 2b). After identification of the target vessel, the vein is positioned centrally on the screen and the transducer is rotated (Figure 2c), maintaining visualization of the vein, until a longitudinal view is obtained. This view enables visualization of axillary vein and distal SCV, as well as the pleural lining below the vessel (Figure 2d). Tilting the transducer cephalad enables visualization of the subclavian artery, and is used to identify and differentiate the vein from the artery. Vessel compressibility and venous pattern on pulse-wave Doppler are generally recommended for confirmation of the appropriate vessel (Figure 2e and 2f). In the longitudinal orientation, the needle is inserted in the midpoint of the small footprint of the transducer (Figure 3a), enabling an in-plane view. The inserting needle should be advanced slowly and visualized throughout the entire procedure while maintaining a view of the vessel and adjacent anatomical structures (Figure 3b-d). If needle visualization is lost, it is essential to avoid complications by ceasing to advance the needle, withdrawing slightly and then relocating the needle tip and shaft before proceeding. Once within the lumen of the vessel the guidewire is inserted with the J-tip pointing caudad and the direction of travel visualized in real time. The anticipated length of line insertion is, in general, 1-2cm longer in comparison to the length anticipated with subclavicular LM approach due to the more lateral approach described above.

This longitudinal, real-time, US-guided infraclavicular SCV cannulation approach offers several advantages to the LM technique. Using this approach, the operator can control the advancement of the needle, identify adjacent anatomical structures, including the pleura and posterior wall of the vessel.

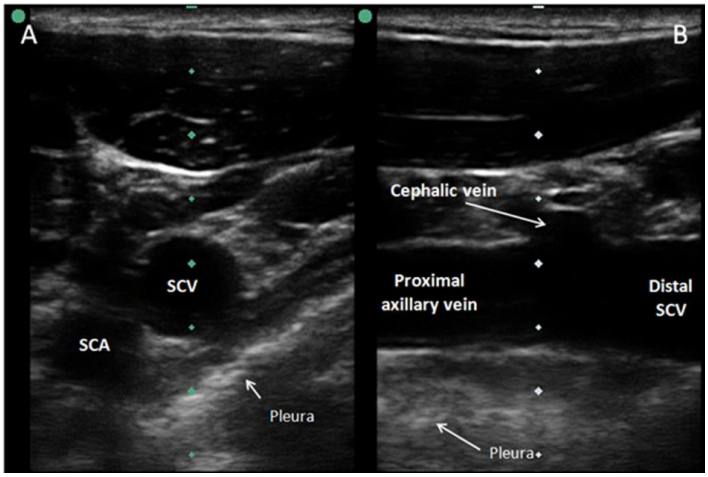

Figure 1. A) Short axis view of subclavian vein using ultrasound vascular probe. B) Long axis view of subclavian vein using ultrasound vascular probe.
SCV, subclavian vein; *SCA*, subclavian artery

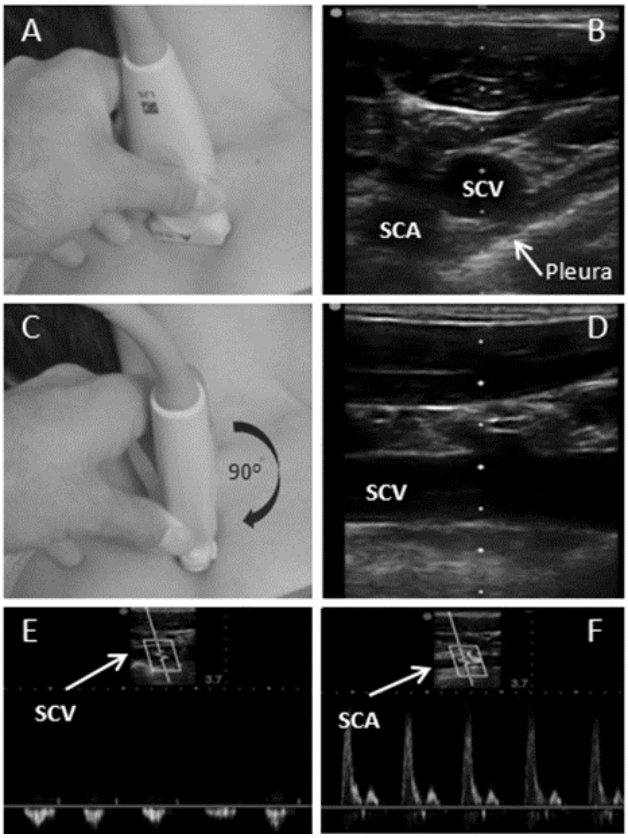

Figure 2. A) Linear transducer is placed perpendicularly and inferior to clavicle. B) Identified anatomical structures include the transverse (short axis) view of subclavian vein (SCV), subclavian artery (SCA) and pleura. C) With SCV centrally positioned, the transducer is rotated 90° clockwise until D) longitudinal view of subclavian vein is obtained. E) Pulse-wave Doppler view of the SCV confirms non-pulsatile flow and identifies the vessel. F) Tilting the transducer cephalad enables the visualization and identification of SCA with pulse-wave Doppler ultrasound for better anatomic orientation.

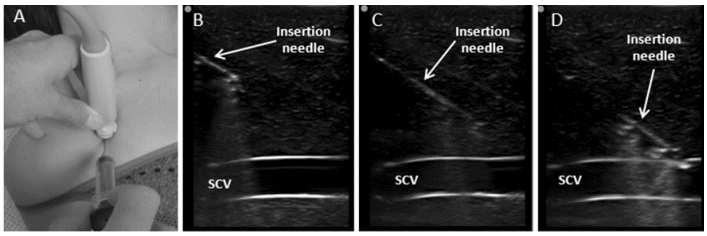

Figure 3. A) After identification and in-plane alignment of subclavian vein (SCV) on ultrasound, the insertion needle enters the skin at midpoint of the transducer's small footprint and is advanced within the plane of ultrasound penetration. B), C) and D) The transducer remains in steady position enabling continuous longitudinal view of SCV, and the needle is carefully and slowly introduced with maintenance of needle visualization until the anterior wall of SCV is punctured.

This in turn allows for a decreased risk of posterior vessel wall puncture, lowering the subsequent risk of pneumothorax.[16] Additionally, the approach has been demonstrated to decrease the rate of arterial puncture and hematoma formation.[9,17] Additionally, real-time longitudinal views lead to a significantly increased overall success rate, with fewer attempts, redirections, or malpositioned catheters.[10,16,25] In a prospective study by Fragou et al., 401 sedated and mechanically ventilated patients were randomized to either real-time US guidance (n=201) or LM technique (n=200) for placement of subclavian catheters by experienced operators.[10] This study found the time to obtain vascular access and number of attempts were significantly lower using real-time US guidance ($p<0.05$). It is, however, possible that with an inexperienced operator or due to US preparation time, US-guided line placement may be slightly longer in duration in comparison to LM approach.[25] Lastly, SCV cannulation can be learned on simulation models more rapidly with US guidance compared to the LM technique. In a study by Tokumine et al., 20 medical trainees received instruction on both LM and US-guided SCV cannulation using the longitudinal axis.[23] Sufficient skill to place an US-guided SCV catheter was achieved with three attempts compared to nine for the LM technique.

CONCLUSION

The SCV offers multiple advantages as a target for central venous access in the appropriately selected patient. The use of real-time US guidance for infraclavicular placement of SCV catheters allows for direct visualization of needle insertion and adjacent anatomical structures, as well as guidewire location and directionality, all of which can lead to decreased mechanical complications and improved cannulation success, compared to a LM technique. Although more research is needed, in our opinion the current literature supports the use of the infraclavicular longitudinal US-guided SCV catheterization as the preferred technique for cannulation of SCV when compared to LM approach and a solid alternative to cannulation of IJVs.

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Effects of Intraosseous Tibial vs. Intravenous Vasopressin in a Hypovolemic Cardiac Arrest Model

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Introduction: This study compared the effects of vasopressin via tibial intraosseous (IO) and intravenous (IV) routes on maximum plasma concentration (Cmax), the time to maximum concentration (Tmax), return of spontaneous circulation (ROSC), and time to ROSC in a hypovolemic cardiac arrest model.

Methods: This study was a randomized prospective, between-subjects experimental design. A computer program randomly assigned 28 Yorkshire swine to one of four groups: IV (n=7), IO tibia (n=7), cardiopulmonary resuscitation (CPR) + defibrillation (n=7), and a control group that received just CPR (n=7). Ventricular fibrillation was induced, and subjects remained in arrest for two minutes. CPR was initiated and 40 units of vasopressin were administered via IO or IV routes. Blood samples were collected at 0.5, 1, 1.5, 2, 2.5, 3, and 4 minutes. CPR and defibrillation were initiated for 20 minutes or until ROSC was achieved. We measured vasopressin concentrations using high-performance liquid chromatography.

Results: There was no significant difference between the IO and IV groups relative to achieving ROSC (p=1.0) but a significant difference between the IV compared to the CPR+ defibrillation group (p=0.031) and IV compared to the CPR-only group (p=0.001). There was a significant difference between the IO group compared to the CPR+ defibrillation group (p=0.031) and IO compared to the CPR-only group (p=0.001). There was no significant difference between the CPR + defibrillation group and the CPR group (p=0.127). There was no significant difference in Cmax between the IO and IV groups (p=0.079). The mean ± standard deviation of Cmax of the IO group was 58,709±25,463pg/mL compared to the IV group, which was 106,198±62,135pg/mL. There was no significant difference in mean Tmax between the groups (p=0.084). There were no significant differences in odds of ROSC between the tibial IO and IV groups.

Conclusion: Prompt access to the vascular system using the IO route can circumvent the interruption in treatment observed with attempting conventional IV access. The IO route is an effective modality for the treatment of hypovolemic cardiac arrest and may be considered first line for rapid vascular access. [West J Emerg Med. 2016;17(2):222–228.]

INTRODUCTION

Each year in the United States more than 326,000 out-of-hospital cardiac arrests occur.[1] In fact, cardiac arrest remains the leading cause of morbidity and mortality with

more than 900 occurrences daily in the U.S.[1,2,4] Hemorrhage with subsequent cardiac arrest is the leading cause of death on the military battlefield as well as in civilian trauma.[2] When a patient is in cardiac arrest, it is essential to establish rapid and reliable vascular access. Research has shown that survival rate depends on a rapid sequence of therapeutic interventions including vascular access.[3-7] The chances of survival is worsened for every minute that drugs are delayed.[5,8,9] In a cardiac arrest scenario particularly from hypovolemic shock, the patient's veins have collapsed preventing vascular access. This makes the procedure not only difficult but time consuming, which could delay administration of life-saving drugs. In emergent conditions, trained providers take significantly longer and more attempts to establish vascular access via conventional peripheral intravenous (IV) insertion than the intraosseous (IO) approach.[6] In current military operations, in pre-hospital emergencies, and mass casualties, there are many additional environmental and tactical obstacles to overcome while attempting to establish vascular access.

The IO route provides access to a rapidly obtained, non-collapsible, venous plexus.[8] The American Heart Association (AHA), the European Resuscitation Council (ERC), the American College of Emergency Physicians (ACEP), the American Academy of Pediatrics (AAP), the American College of Surgeons (ACS), the U.S. National Association for Emergency Medical Service Physicians (NAEMSP), and the U.S. Army Committee on Tactical Combat Casualty Care (TCCC) recommend the use of IO access if IV access is not readily available.[3,10-16] The recommendation is based on limited evidence that the route is effective for drug administration during a cardiac arrest. Two variables relative to IO drug administration have the potential to alter the pharmacokinetics and subsequent return of spontaneous circulation (ROSC): vascular distribution to the bone marrow and flow to the bone. Bone marrow changes structure and composition with age. At birth, bone contains primarily red marrow, which is highly vascularized. After five years of age, the red marrow is replaced by yellow marrow, which is significantly less vascular. By adulthood, red marrow is found primarily in the sternum, proximal femur, humerus and skull. IO site selection may be important given the variability of blood flow to these different types of marrow.[17] Also, when a patient is in hypovolemic shock, endogenous catecholamines and subsequent vasoconstriction to the bone may lead to less flow from the bone. We speculated that the when a patient is in cardiac arrest, tibial IO compared to IV administration of vasopressin would result in lower concentrations, lower maximum plasma concentrations (Cmax), and the time it takes to reach maximum concentration in plasma (Tmax). We also speculated that hypovolemia would alter drug distribution and affect the concentration, Cmax, and Tmax reducing the chances of ROSC. Furthermore, we reasoned the time to achieve ROSC would be more for IO compared to IV administration.

No research studies have evaluated the pharmacokinetics of vasopressin-administered IO compared to IV in a hypovolemic model. Furthermore, no study has addressed ROSC using tibial IO vasopressin in the hypovolemic model in a cardiac arrest model. The purposes of this study were to compare ROSC, time to ROSC, serum concentration of vasopressin, Cmax, Tmax, and odds of survival relative to administration by IV and IO tibia routes compared with control groups that received cardiopulmonary resuscitation (CPR) and defibrillation and one that received just CPR.

Specifically, the following research questions guided the study:

1. Are there statistically significant differences in ROSC and time to reach ROSC between the groups?
2. Are there statistically significant differences in Cmax and Tmax of serum vasopressin when administered via tibial IO and IV routes?
3. Are there statistically significant differences in mean concentration of vasopressin over four minutes between the tibial IO and IV routes?
4. What are the comparative odds of su0rvival by group?

METHODS

Design and Sample

The study was a prospective, between-subjects, experimental design. The Institutional Animal Care and Use Committee (IACUC) approved the research protocol, and the animals received care in compliance with the Animal Welfare Act. Twenty-eight Yorkshire swine were randomly assigned by a computer generated random number program to one of four groups: IV + defibrillation (n=7), IO tibia + defibrillation (n=7), CPR + defibrillation (n=7), and a control group that received just CPR (n=7). Two additional swine were added in the each of the IV and IO groups for model development. These two swine meet the criteria for inclusion in the study, and no changes were necessary in the protocol. Therefore, the pigs were included in both groups to make a total of eight in both the tibial IO and IV groups. However, one pig in the IO group was ill and was deleted from the study making a total of seven in that group.

Swine were selected because the cardiovascular system and bone are comparable to humans. In addition, their blood volume is the same as humans: 70ml per kg of body weight.[18,19] To avoid any variability in subjects, we purchased the swine from the same vendor and acquired pigs that were approximately the same size. Male swine were used to avoid any potential hormonal effects. Subjects weighing between 60 to 80kg were used as this range represents the average weight of an adult, male human.[20] They were observed for three days to ensure they were in a good state of health. All subjects received no food after midnight the evening before the study but were allowed fluids as desired until the experiment

Procedures

Each subject received pre-emptive analgesia with Telazol (4-8mg/kg). They were then sedated, anesthetized, intubated, and placed on mechanical ventilation. A standard Narkomed® anesthesia machine (Dräger, Telford, PA) was used to deliver isoflurane at a maintenance dose (0.5–2%) and ventilation at 8-10mL/kg at 10-14 breaths per minute. A peripheral IV was started on all subjects using an 18- or 20-gauge catheter in the auricular vein. The peripheral auricular vein was chosen because it is most comparable to the antecubital vein in humans.[21] Hemodynamics were evaluated continuously that included the following: electrocardiogram, arterial blood pressure via a left carotid artery catheter, mean arterial pressure, oxygen saturation, end-tidal carbon dioxide, and temperature. A forced-air warming blanket was used to sustain rectal temperature greater than 36 degrees Celsius. A Vigileo™ (Edwards Lifesciences, Irvine, CA) was used to obtain cardiac output and stroke volume measurements via the arterial line. The femoral artery was cannulated for the collection of blood samples and for the achievement of controlled hemorrhage.

For swine in the tibial IO group, we inserted an EZ-IO® device (Vidacare, San Antonio, TX) in the proximal, medial tibia. Placement was confirmed by aspiration of blood and easy irrigation with 10mL of 0.9% normal saline (NS). Patency was maintained by administering Lactated Ringer's solution with a pressure bag at 300mmHg. Subjects were allowed to stabilize for 15 minutes; we then exsanguinated 31% of their blood volume from the femoral artery catheter into a canister. This represented a Class III hemorrhage. Hemorrhage was accomplished by allowing blood to drain by gravity over approximately 15 minutes. To ensure the amount exsanguinated was correct, the investigators used a scale that was accurate and precise within 0.5%.

In response to hypovolemic shock in accordance with Tactical Combat Casualty Care guidelines, we administered 500mL of 5% albumin to all subjects over 10 minutes.[22] Five minutes after the administration of albumin, the investigators placed the pigs in cardiac arrest, defined as a nonperfusing arrhythmia. Specifically, after we visualized the heart on transthoracic ultrasound, one spinal needle was placed superior and one placed inferior to the heart. The needles were attached to alligator clamps. The clamps were attached to three 9-volt batteries that were connected in a series to deliver an electrical current, thereby inducing nonperfusing ventricular fibrillation. We were able to establish ventricular fibrillation usually within 10 seconds. In some cases, we had to reposition the needles resulting in 100% being placed into ventricular fibrillation.

The pigs were allowed to remain in arrest for two minutes. Then CPR was initiated by use of the Michigan Automated Thumper™ (Michigan Instruments, Grand Rapids, MI) to automatically compress the sternum to a predetermined depth of 1½ inches at a rate of 100 compressions per minute as per guidelines of the AHA.[3] The device ensured consistency and reproducibility of quality chest compressions across all subjects. CPR continued for two minutes with ventilations delivered at 10 breaths per minute.

Vasopressin was then administered at a dose of 40 units to the IV and IO subjects. The drug was rapidly injected IV or IO push followed by 20mL of NS flush. Blood samples (10mL) were collected from the femoral artery catheter every 30 seconds for three minutes and again at four minutes after vasopressin injection. Before each sample was collected, 10mL of blood was collected and discarded to avoid sample contamination. The catheter was then flushed with 10mL of NS to maintain patency. A baseline sample was not necessary because the drug contains arginine while endogenous vasopressin in swine exclusively contains the lysine isoform.

After the samples were collected, we defibrillated the swine starting at 200 joules. If a nonperfusing rhythm persisted, the pigs were defibrillated with 360 joules. CPR continued on all subjects, and pigs that remained in ventricular fibrillation were defibrillated at 360 joules every two minutes. CPR was continued for 20 minutes or until ROSC. The investigators defined ROSC as the presence of a sustained perfusing heart rhythm, palpable femerol pulse, and systolic blood pressure (SBP) of ≥60mmHg. Defibrillation was not initiated earlier because any pigs that achieved ROSC before all samples were collected would confound the analyses of drug pharmacokinetics. Subjects that achieved ROSC were monitored for an additional 30 minutes. For all groups, arterial blood gases (ABG) were obtained every five minutes to determine the effectiveness of the treatment modalities. The same procedures for the CPR + defibrillation group were used as above, but vasopressin was not administered and no samples were collected. For the CPR only group, these subjects did not receive vasopressin or defibrillation. To determine mean concentration and Cmax, the investigators used a liquid chromatography with mass spectrometry (HPLC-MS/MS). The HPLC method is considered to be the gold standard in pharmacokinetic research.[23] One trained person, who was blinded to group assignment, performed all of the HPLC analyses, specifically the mean concentration and Cmax. For the purposes of this study, Cmax was defined as the peak or highest concentration of serum vasopressin. The mean concentration of was defined as the arithmetic average of each time a sample was collected.

Statistical Analyses

The investigators used data from similar, previous studies and calculated a large effect size of 0.6.[24-26] Using an α of 0.05, an effect size of 0.6, and a power of 0.80, the investigators determined a sample size of 28 (n=7 per group) was needed. We performed power analysis using G*Power 3.1 for Windows (Heinrich Heine University, Dusseldorf, Germany).

IBM® SPSS® Statistics v.17 software (Chicago, IL) was used for data analysis. We calculated means, standard

deviations, and standard error of the mean for the IO and IV groups. A chi-square was used to determine if there were differences in ROSC between groups. We used a multivariate analyses of variance (ANOVA) to determine if there were significant differences between the groups relative to the pretest data, the time to ROSC, Cmax, and Tmax. A repeated measures ANOVA (RANOVA) was used to determine if there were statistical differences between groups (measured at 30 second intervals) regarding the mean concentrations over four minutes. We calculated and compared the odds of ROSC by each group.

RESULTS

There was no significant difference in pretest data by group (weight, amount of hemorrhage, cardiac output, stroke volume, systolic blood pressure, diastolic blood pressure, mean arterial blood pressure, temperature, and pulse) indicating the groups were equivalent on those variables ($p>0.05$). There was no significant difference between the IO and IV groups relative to achieving ROSC ($p=1.0$) but a significant difference between the IV compared to the CPR + defibrillation group ($p=0.031$) and IV compared to the CPR-only group ($p=0.001$). There was a significant difference between the IO group compared to the CPR + defibrillation group ($p=0.031$) and IO compared to the CPR-only group ($p=0.001$). There was no significant difference between the CPR + defibrillation group and the CPR group ($p=0.127$). The number of subjects achieving ROSC (See Table 1), and the odds of survival were compared by group (See Table 2).

There was no significant difference in Cmax between the IO and IV groups ($p=0.079$). The mean ± standard deviation of Cmax of the IO group was 58,709 ± 25,46 pg/mL compared to the IV group, which was 106,198 ± 62,135pg/mL (Figure 1).

There was no significant difference in mean Tmax between the groups ($p=0.084$). The times are in seconds ± standard deviations for the IO and IV groups respectively and were as follows: 158 ± 78.8 and 86 ± 70. There was also no significant difference in time to ROSC by group. (See Table 3 for a summary.) The overall mean concentration of vasopressin over four minutes between the IO and IV groups was not significant ($p=0.365$). However, a pairwise comparison indicated a significant difference at 60 seconds ($p=0.021$) between IO and IV groups (mean ± standard error 23,595 ± 14,856pg/mL vs. 76,787 ± 1,896pg/mL respectively (Figure 2).

Table 1. Subjects achieving return of spontaneous circulation (ROSC).

Group	Number achieving ROSC	Number not achieving ROSC
IV (N=8)	7(87.5%)	1(12.5%)
CPR + defibrillation (N=7)	2(28.6%)	5(71.4%)
IO (N=7)	6(85.7%)	1(14.3%)
CPR only (N=7)	0(0%)	7(100%)

IV, intravenous; *CPR*, cardiopulmonary resuscitation; *IO*, intraosseous

Table 2. Comparison of odds of ROSC by group.

Group comparison	Odds of ROSC	Confidence interval	P value
IV vs. CPR + defibrillation	17.5	1.2232 to 250.3694	0.03*
IV vs. CPR only	75	2.6133 to 2152.4792	0.01*
IV vs IO	1.6	0.0593 to 22.9378	0.10
IO vs. CPR + defibrillation	15	1.0306 to 218.3109	0.04*
IO vs. CPR only	65	2.2384 to 1887.4682	0.01*
CPR + defibrillation vs. CPR only	33	1.3059 to 833.9222	0.03*

ROSC, return of spontaeous circulation; *IV*, intravenous; *CPR*, cardiopulmonary resuscitation; *IO*, intraosseous
*Significant at the 0.05 level.

Table 3. Comparison of time to ROSC by group.

Comparisons	Mean ± standard deviations in seconds	P value
IV vs. IO	559±231	0.619
IO vs. CPR + defibrillation	493±226	0.069
CPR + defibrillation vs. IV	863±181	0.127

ROSC, return of spontaeous circulation; *IV*, intravenous; *IO*, intraosseous; *CPR*, cardiopulmonary resuscitation

DISCUSSION

The purposes of this study were to compare ROSC, time to ROSC, serum concentration of vasopressin, Cmax, Tmax, and odds of survival relative to administration by IV and IO tibia routes compared with control groups that received CPR + defibrillation and one that received just CPR in a hypovolemic swine model. The results are consistent with the findings of Von Hoff, et al. who found there were no statistically significant differences between the Cmax or Tmax after IO (iliac crest) and IV administration of morphine sulfate in humans. However, these authors caution that there may be differences between IO and IV resuscitation drugs and other IO sites.[27] The results of our study support the findings of Johnson, et al. who compared the humerus IO and IV administration of epinephrine and found no statistically significant difference in Cmax, Tmax, ROSC, or time to ROSC. However, Johnson et al. found that at 30 seconds, the mean concentration of epinephrine was higher in the humerus IO group compared to the IV group.[28] Conversely, in the current study, we found that

the mean concentration of vasopressin was consistently higher in the IV compared to the IO group. Our results are consistent with the findings of Burgert et al., Hoskins et al., and Wenzel et al. who found that IV was higher than tibial IO administration of drugs.[5,25,29] Specifically, Wenzel et al. found vasopressin administration in a swine model of pediatric cardiac arrest resulted in a comparable rate of ROSC compared to IV vasopressin.[29] Voelckel et al. found that blood flow decreased significantly during hemorrhagic shock, which they speculated would impair absorption of drugs administered by the IO route in a pediatric model.[30] We did find that the concentration and Cmax was lower the tibial IO compared to IV but these findings may be because of the yellow marrow and distance from the heart. The current study adds to the body of knowledge in that we investigated not only the pharmacokinetics but also ROSC and time to ROSC in a hypovolemic, adult cardiac arrest model. We consistently found the mean concentration and the Cmax to be lower, and the Tmax to be longer in the IO group compared to the IV group. However, these findings did not affect ROSC. Specifically, we found there were no significant differences in the IO and IV groups relative to ROSC or time to ROSC.

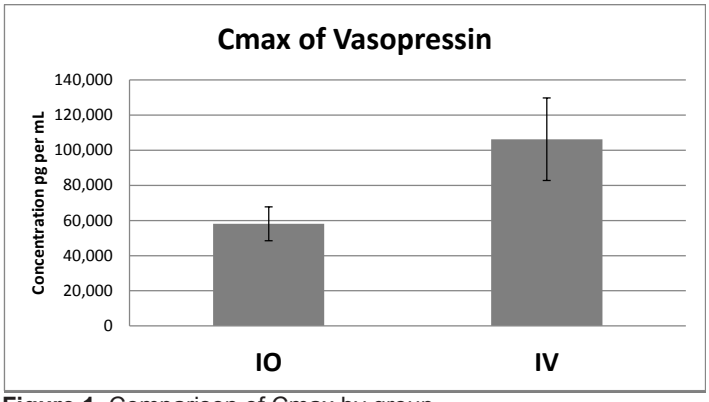

Figure 1. Comparison of Cmax by group.
IO, intraosseous; *IV*, intravenous

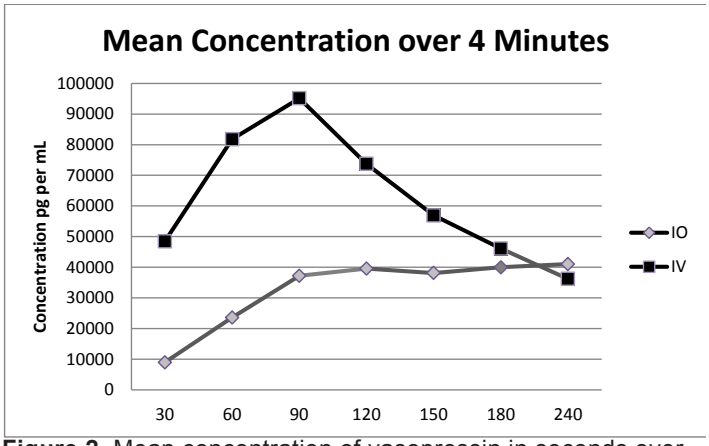

Figure 2. Mean concentration of vasopressin in seconds over four minutes.
IO, intraosseous; *IV*, intravenous

LIMITATIONS

The primary limitation was that experimenters were not blinded to group assignment, but the protocol was followed with the same rigor regardless of group assignment. Another limitation was that the results of the study may not be not generalizable to humans; however, the bone and cardiovascular system are comparable to humans.[18,19] The study used a small sample size and the reader should be cautioned that only two in the CPR + defibrillation group had ROSC. In addition, there was no statistically significant difference in Cmax between the IV and IO groups, but the IO group had 55% of the concentration compared to the IV group. This suggests that the study was underpowered relative to this variable. With a larger sample size, we probably would have found a statistically significant difference. However, further studies are warranted to use a larger sample size. In addition other IO sites need to be used to determine and compare pharmacokinetics and the effectiveness of those sites. We also acknowledge that the study did not have strict adherence to advanced cardiovascular life support (ACLS) guideline relative to defibrillation. We did not want the swine to have ROSC before all of the samples were collected. CPR and a beating heart may have yielded different findings relative to the kinetics and not because of routes of administration. If ACLS guidelines had been followed, we reasoned that ROSC in both the IV and IO groups may have been shorter, but the current study strongly suggest that both routes of administration are effective.

CONCLUSION

This study illustrates that prompt access to the vascular system using IO insertion can circumvent the interruption in treatment observed with attempting conventional IV access. Time is of the essence when treating cardiac arrest. The time to acquire IV access would certainly take longer even with a skilled provider than the 10 seconds it took us to insert the IO device. Studies show that the time to establish IV access in a variety of settings ranges from 2-49 minutes.[31-33] Administration of vasopressin by IO and IV achieved excellent survival rates indicating both are effective methods of access. Based upon these findings, the IO route might be considered the first choice for rapid vascular access with vasopressin administration for a hypovolemic patient in cardiac arrest.

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Physician Quality Reporting System Program Updates and the Impact on Emergency Medicine Practice

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In 2007, the Centers for Medicaid and Medicare Services (CMS) created a novel payment program to create incentives for physician's to focus on quality of care measures and report quality performance for the first time. Initially termed "The Physician Voluntary Reporting Program," various Congressional actions, including the Tax Relief and Health Care Act of 2006 (TRHCA) and Medicare Improvements for Patients and Providers Act of 2008 (MIPPA) further strengthened and ensconced this program, eventually leading to the quality program termed today as the Physician Quality Reporting System (PQRS). As a result of passage of the Affordable Care Act of 2010, the PQRS program has expanded to include both the "traditional PQRS" reporting program and the newer "Value Modifier" program (VM). For the first time, these programs were designed to include pay-for-performance incentives for all physicians providing care to Medicare beneficiaries and to measure the cost of care. The recent passage of the Medicare Access and Children's Health Insurance Program (CHIP) Reauthorization Act in March of 2015 includes changes to these payment programs that will have an even more profound impact on emergency care providers. We describe the implications of these important federal policy changes for emergency physicians. [West J Emerg Med. 2016;17(2):229–237.]

INTRODUCTION

In 2001 the Institute of Medicine published a landmark review which noted that there were significant gaps in the quality of healthcare being delivered in the United States.[1] Research over the past two decades has also shown substantial variations in, and relationship between, the cost of care delivered to Medicare beneficiaries and quality outcomes.[2] These patterns emerged amidst a growing national concern that federal healthcare spending was increasing at an unsustainable pace, which threatens national bankruptcy.[3] As such, the Centers for Medicaid and Medicare Services (CMS), the nation's largest insurer, chose to launch a novel payment program named the Physician Voluntary Reporting Program (PVRP) designed to incent physicians to focus on quality of care measures. The goal of the PVRP program was to financially reward providers for successfully reporting a set of quality measures to CMS. The program required that a physician report their performance to CMS via administrative claims, or billing data, on a limited number of quality measures. From the initial implementation of the PVRP, emergency medicine was one of the medical specialties with the highest proportion of program participants.[4] Over the last decade the program has been modified and expanded many times, eventually evolving into the current permanent CMS provider quality payment program termed the Physician Quality Reporting System (PQRS).[5,6] Today the expanded PQRS program includes both the "traditional PQRS" reporting program, in addition to the newer "Value Modifier" program (VM). Described by CMS as

"a reporting program that uses a combination of incentive payments and payment adjustments to promote reporting of quality information by eligible professionals (EPs)," this program includes evaluations of EP quality and cost measure performance and tiers providers based on this performance.[7] Eligible professions are defined by CMS as physicians: doctor of medicine, doctor of osteopathy, doctor of podiatric medicine, doctor of optometry, doctor of dental surgery, doctor of dental medicine, doctor of chiropractic; practitioners: physician assistant, nurse practitioner, clinical nurse specialist, certified registered nurse anesthetist, certified nurse midwife, clinical social worker, clinical psychologist, registered dietician, nutrition professional, audiologist or therapist, physical therapist, occupational therapist, and qualified speech-language therapist. Importantly, the definition of EPs includes all part-timers, moonlighters, and other episodic providers who were registered in Medicare's Provider Enrollment, Chain, and Ownership System (PECOSs) as of October 15, 2015.[8] The Accountable Care Act requires that CMS officially transition the VM program to a penalty program in 2015.

PQRS Updates

On October 31, 2014, the CMS released its 2015 Medicare Physician Fee Schedule Final Rule, which detailed changes to the federal quality reporting requirements for payment of physician services.[9] Beginning in 2015 the penalties for non-participation in the PQRS programs (both the "traditional PQRS" and VM program) become more significant and compounded. Physician groups of 10 or more EPs that choose not to participate in any of the PQRS programs are subject to a maximum penalty of 6% of Medicare payments (Table 1). This represents a potential 2% withheld for not successfully reporting via the "traditional PQRS" program and an additional 4% automatic penalty under the VM program (2% for individual physicians and those in groups of less than 10 eligible providers). The definition of a "group" is defined by use of the same tax identification number (TIN) by EPs. CMS also announced that it intends to publicly report physician performance rates for all PQRS measures collected in 2016 (based on 2015 performance) on the "Physician Compare" website.

The American Board of Emergency Medicine (ABEM) promoted an additional 0.5% incentive for Medicare fee for service work by attesting to participation in the 2014 PQRS program. There is no ABEM incentive currently in place for performance year 2015 or beyond.

Traditional PQRS Program (2005-2015)

To avoid the 2% penalty, EPs must participate in the traditional PQRS program and report performance on established quality measures. To date, there are currently five ways to report performance for participation in the PQRS programs for emergency physicians (Table 2a and 2b). These include direct submission (i) via an electronic health record (EHR) product of certified health information technology vendor, (ii) via the CMS Group Practice Reporting Option (GPRO) web interface, (iii) a CMS "qualified" registry, (iv) a qualified clinical data registry (QCDR), or (v) claims (billing) data. The first two options do not tend to be viable for most small single specialty independent emergency physician practices. Submission by an EHR is not often practical because as a hospital-based specialty, the EHR vendor administration is typically not managed by the emergency medicine physician group but rather the hospital. The GRPO reporting process is a viable option for hospital-employed or larger multispecialty groups, which according to CMS was used by roughly 5,500 EM providers in 2014.[10] New in 2015 is the requirement that groups choosing to report via GPRO must administer and report patient experience survey data (Consumer Assessment of Healthcare Providers and Systems, CAPHS) at the groups' expense. Option (iii), qualified registries are those that have been reviewed and approved by CMS. Very few exist specific to only EM.[11] The option to report via a QCDR is currently limited to a single large group practice on the west coast, which has the only fully functional private EM-specific QCDR today. This option, however, will be more available after the American College of Emergency Physicians implements their version.[12] Until then, as of today most emergency

Table 1. Summary of physician quality reporting system program impact on 2015 reporting and 2017 payments.*

	2014	2015
PQRS		
Bonus for traditional PQRS+	+0.5% payment in 2015	No incentives
Bonus for PQRS maintenance of certification+	+0.5% payment in 2015	
Penalty for failure to satisfy PQRS	-2.0% in 2016	-2.0% in 2017
Value modifier		
Additional penalty for failure to satisfy PQRS	-2.0% in 2016	Up to -4.0% in 2017
Total potential maximum penalties	-4.0% in 2016	-6.0% in 2017

*Increasing impact of physician quality reporting system (PQRS) participation.

Table 2a. 2015 Physician quality reporting system (PQRS) reporting options.*

Reporting mechanism	Measure type	Reporting criteria	Applicability to emergency medicine
Claims	Individual measures	• Report at least 9 measures covering at least 3 National Quality Strategy (NQS) domains, including 1 cross-cutting measure, and report each measure for at least 50% of the Medicare Part B fee for service (FFS) patients seen during the reporting period to which the measure applies. • If less than 9 measures apply, report 1-8 measures covering 1-3 NQS domains, but subject to Measures Applicability Validation Process (MAV). • Measures with a 0 performance rate will not be counted.	• Viable option. • Only option for cross cutting measure applicable to emergency medicine (EM) is #317 – Screening for high blood pressure and follow up documented.
Qualified registry	Individual measures	• Report at least 9 measures covering at least 3 NQS domains • OR, if less than 9 measures covering at least 3 NQS domains apply, report 1-8 measures covering 1-3 NQS domains, AND report each measure for at least 50% of the Medicare Part B FFS patients seen during the reporting period to which the measure applies. • If less than 9 measures apply, report 1-8 measures covering 1-3 NQS domains, but subject to MAV. • Measures with a 0 performance rate will not be counted.	• Viable option.
Qualified registry	Measures groups	• Report at least 1 measures group, and report each measures group for at least 20 patients, the majority (11 patients) of which must be Medicare Part B FFS patients. • Measures groups containing a measure with a 0 percent performance rate will not be counted.	• Not viable option. • Measure group specifications for minimum participation do not allow most individuals to successfully report based on low volumes.
Direct electronic health record (EHR) product or EHR data submission vendor	Individual measures	• Report 9 measures covering at least 3 of the NQS domains. • If an eligible professional's (EP's) EHR product/vendor does not contain patient data for at least 9 measures covering at least 3 domains, then the EP would be required to report all of the measures for which there is Medicare patient data. • EPs are required to report on at least 1 measure for which there is Medicare patient data.	• Typically not viable.
Qualified Clinical Data Registry (QCDR)	Individual PQRS and/or non-PQRS measures	• Report at least 9 measures available for reporting under a QCDR covering at least 3 of the NQS domains, and report each measure for at least 50% of all applicable patients (both Medicare and non-Medicare). • Of these measures, at least 2 must be outcome measures, or, if 2 outcomes measures are not available, at least 1 outcome measure and at least 1 resource use, patient experience of care, efficiency/appropriate use, or patient safety measure.	• Will be viable in 2016.

*Option for individual physicians.

physicians report via claims data.

One aspect of the PQRS program is the notable lag between the performance and payment periods. Specifically, dollars paid (or penalties) in 2015 for physician services are based on a two-year "look back." Meaning that in 2015, payment for services to Medicare beneficiaries is based on how a provider on quality measures in 2013. This is also true for the VM Program. Therefore, the reported data are unlikely to be actionable for quality improvement nor allow patient consumers timely assessments to make care utilization decisions. The 0.5% bonus offered for participation in the PQRS Maintenance of Certification program (as that offered by ABEM) expired after 2014, and performance of these quality improvement activities in not set to be publically reported.

In 2015, CMS retired 50 quality measures including four of the five that were previously commonly reported by EM providers as part of the 2014 "emergency care cluster." These include PQRS #28: Aspirin for AMI, #55: 12-Lead Electrocardiogram for syncope, #56: Pneumonia (community-acquired pneumonia): Vital Signs, and #59: Pneumonia (CAP): Empiric Antibiotic. The list of remaining measures potentially applicable to EM is limited (Table 3). Claim submissions are denoted by the addition of PQRS codes, which are abstracted by an EP's coding and billing company and then placed in the claim submission

Table 2b. 2015 Physician quality reporting system (PQRS) reporting options.*

Group practice specifications	Measure type	Reporting mechanism	Reporting criteria
2-99 Eligible professionals (EPs)	Individual measures	Qualified registry	• Report at least 9 measures covering at least 3 National Quality Strategy (NQS) domains, including 1 cross-cutting measure, and report each measure for at least 50% of the Medicare Part B fee for service (FFS) patients seen during the reporting period to which the measure applies. • If less than 9 measures apply, report 1-8 measures covering 1-3 NQS domains, but subject to Measures Applicability Validation Process (MAV). • Measures with a 0 performance rate will not be counted.
	Individual measures and CAHPS for PQRS	Direct EHR product or EHR data submission vendor product and use of Centers for Medicare & Medicaid Services (CMS) certified survey vendor	• The group practice must have all Consumer Assessment of Healthcare Providers and Systems (CAHPS) for PQRS survey measures reported on its behalf via a CMS-certified survey vendor, and report at least 6 additional measures, outside of CAHPS for PQRS, covering at least 2 of the NQS domains using the direct EHR product or electronic health record (EHR) data submission vendor product. • If less than 6 measures apply to the group practice, the group practice must report up to 5 measures. • Of the additional 6 measures that must be reported in conjunction with reporting the CAHPS for PQRS survey measures, a group practice would be required to report on at least 1 measure for which there is Medicare patient data.
25-99 Eligible professionals	Individual group practice reporting option (GPRO) measures in GPRO web interface	GPRO web interface	• Report on all measures included in the web interface; and populate data fields for the first 248 consecutively ranked and assigned beneficiaries in the order in which they appear in the group's sample for each module or preventive care measure. • If the pool of eligible assigned beneficiaries is less than 248, then group practice must report on 100% of assigned beneficiaries. • Must report on at least 1 measure for which there is Medicare patient data.
25-99 EPs, OR ≥100 EPs	Individual GPRO measures in the GPRO web interface and CAHPS for PQRS	GPRO web interface and use of CMS certified survey vendor	• Requires CAHPS be completed for PQRS survey measures reported on its behalf via a CMS-certified survey vendor. • Report on all measures included in the GPRO Web Interface (as above).
	Individual measures and CAHPS for PQRS	Qualified registry and use of CMS certified survey vendor	• The group practice must have all CAHPS for PQRS survey measures reported on its behalf via a CMS-certified survey vendor, and report at least 6 additional measures, outside of CAHPS for PQRS, covering at least 2 of the NQS domains using the qualified registry. If less than 6 measures apply to the group practice, the group practice must report up to 5 measures. Of the additional measures that must be reported in conjunction with reporting the CAHPS for PQRS survey measures, the group practice must report on at least 1 measure in the cross-cutting measure set.

*Group reporting options.

form. To avoid the payment adjustment, in 2015 individuals must report nine measures across three National Quality Strategy (NQS) domains with at least one "cross-cutting" measure. This new list of cross-cutting measures represents a core set where CMS believes that there are significant performance gaps across specialties. The only measure that applies to typical emergency care, albeit not easily, is PQRS #317 "Preventive Care and Screening: Screening for High Blood Pressure and Follow Up Documented" (NQS Community-Population Health Domain). The measure specifications state that this is to apply to all Medicare patients who have a documented emergency department (ED) systolic blood pressure greater than 120 or diastolic greater than 80.[13]

Groups are required to report on nine measures across three domains. A performance score of zero does not satisfy the requirements. Given these requirements and the available measures pertinent to EM, it is unlikely that the typical individual emergency physician practice will be able to satisfy the reporting requirements. As such, most

will be subject to the Measure Applicability Validation (MAV) process. Through this process CMS groups PQRS measures into measure clusters. CMS expects that if a provider reports on one measure in a cluster that the provider could report on additional measures within the same cluster. CMS reviews the provider's claims to see if the provider could have reported on additional measures within the cluster. If CMS finds that the provider could have reported additional measures within the cluster but did not, the provider will be deemed as failing the MAV process and a PQRS payment adjustment may apply. If CMS does not find additional measures within the cluster that the provider could have reported on, the provider will be deemed as passing the MAV. CMS established an alternative option for satisfying reporting for emergency physicians by defining an "emergency medicine cluster" (Table 4). It is recommended that the typical EM provider should select this reporting option.

Qualified clinical data registries (QCDRs) are an alternative PQRS reporting option. QCDRs are certified registries of quality metrics that allow providers to report on a different set of measures than those in PQRS. The measures in QCDRs must be approved by CMS, but they do not require National Quality Forum (NQF) approval, streamlining the measure development process. Although not an option for EM in the past, in 2015 CMS approved two QCDRs for EM reporting.[14] QCDRs may submit information on both PQRS and up to 30 non-PQRS specialty-specific measures. This methodology does not require reporting of a cross-cutting measure or measure endorsement by the National Quality Forum (NQF) process nor does it require participation in the CAHPS program. It does require data collection and submission for all payers and allows for a more comprehensive view of a specialists practice and collection of measures of rare events and diagnosis as the sample size is not limited to Medicare patients. In addition, first-year QCDR measures are not considered in the calculation of the VM quality component given the lack of historical benchmark data. The measures for the EM American College of Emergency Physicians (ACEP) QCDR have not been finalized, but a potential set of measures have been developed (Table 5). There is a plan to have potential measures released for public comment later this summer.

Value Modifier Program

Section 3007 of the Affordable Care Act (ACA) mandates that CMS begin applying a VM payment adjustment, based on cost and quality metrics, to physician payments starting in 2015.[15] It also requires that the modifier be added in a budget-neutral manner. This means that within the national performance pool there must be winners and losers in the program. Ranking will be done with primary designated specialties, so emergency providers will compete against themselves. A similar but distinct VM program has been in existence for hospital (facility) performance since 2013. The VM program is based on performance in two main categories: quality and cost. Quality tiering is based on six defined quality of care domains (clinical care, patient experience, population/community health, patient safety, care coordination, and efficiency measures). Cost tiering is based on performance on five per capita cost measures; total per capita costs (Parts A and B) and total per capita costs for beneficiaries with four chronic diseases (diabetes, cornary artery disease, chronic obstructuve pulmonary disease, and heart failure). These cost measures are separated into two per capita domains: total overall costs measure and total costs for beneficiaries with specific conditions (four measures). Payment for the VM is based on overall quality and cost performance, as compared to a benchmark, and depends on the practice size an EP is associated with (Table 6a and 6b).

The benchmarks for 2015 VM performance are based on 2014 performance. A national mean is calculated by including all physician groups with 100 or more EPs. Quality measures that are new in the performance period are not benchmarked in the quality composite calculation during the following one year. Medicare Spending Per Beneficiary (MSPB) costs are the sum from three days before to 30 days after index admission. Attribution is given to those who charged the most Medicare Part B (provider) charges during the index inpatient stay. The EM codes (99281-99285) are exempt from attribution.

Participation in the VM program is similar to those for PQRS (GPRO, traditional registry, EHR or claims submissions). Physician VM payments for 2015 excluded physicians who provide services in rural health clinics, federally qualified health centers, critical access hospitals (CAHs), and groups physicians participate in Medicare Shared Savings Program Accountable Care Organizations (ACOs), pioneer ACOs, and Comprehensive Primary Care Initiatives. However, these groups are included in 2015 performance for 2017 VM payments. During this same performance period nurse practitioners, physician assistants and clinical nurse specialists' costs will be attributed to their associated TIN. The VM program requires participation in the traditional PQRS program (described above). Failure to participate in the PQRS program will affect both traditional PQRS payments (-2%), in addition to VM payments (-4%) for a maximum of a -6% penalty for groups with 10 or more.

Patient attribution for EP performance is based on a retrospective assignment based on claims. The methodology is the same as Medicare Shared Savings Program assignment to an Accountable Care Organization.[16] Patient assignment is to a group or individual TIN based on following cascading prioritization: (i) plurality of evaluation and management (E&M) primary care visits, then (ii) plurality of E&M specialty care if no primary care. Emergency medicine billing codes (CPT 99281-99285)

Table 3. Potential physician quality reporting system (PQRS) reporting measures for emergency care.

PQRS#	NQS domain	Quality measure title	Reporting mechanism	MAV cluster
#54	Clinical effectiveness	EM:12-lead ECG performed for non-traumatic chest pain	Claims Registry	Claims: cluster 4 Registry: none
#76	Patient safety	Prevention of CRBSI: central venous catheter insertion protocol	Claims Registry	Claims: cluster 12 Registry: cluster 24 *can report alone
#91	Clinical effectiveness	Acute otitis externa (AOE): topical therapy	Claims Registry	Claims: cluster 7 Registry: cluster 12
#93	Efficiency	AOE: systemic antimicrobial therapy – avoidance of inappropriate use	Claims Registry	Claims: cluster 7 Registry: cluster 12
#187	Clinical effectiveness	Stroke & stroke rehabilitation: thrombolytic therapy (tPA)*	Registry	Registry: cluster 21
#254	Clinical effectiveness	Ultrasound determination of pregnancy location for pregnant patients with abdominal pain	Claims Registry	Claims: cluster 4 Registry: none
#255	Clinical effectiveness	Rh immunoglobulin (Rhogam) for Rh-negative pregnant women at risk of fetal blood exposure	Claims Registry	Claims: cluster 4 Registry: none
#317	Community-population health	Preventative care and screening: screening for high blood pressure and follow up documented	Claims Registry	Claims: cross cutting Registry: cross cutting
#326	Clinical effectiveness	Atrial fibrillation and atrial flutter: chronic anticoagulation therapy†	Claims Registry	Claims: none Registry: none

NQS, national quality strategy; *MAV,* measures applicability validation process; *EM,* emergency medicine; *ECG,* electroencephalogram; *CRBSI,* catheter-related bloodstream infection
*Also known as hospital STK-4.
†Also known as STK-3.

Table 4. 2015 Emergency medicine cluster.

Title	PQRS #	Domain	Description
Cluster 4			
Emergency care	54	Effective clinical care	Emergency medicine: 12-lead electrocardiogram (ECG) performed for non-traumatic chest pain
	254	Effective clinical care	Ultrasound determination of pregnancy location for pregnant patients with abdominal pain
	255	Effective clinical care	Rh immunoglobulin (Rhogam) for Rh-negative pregnant women at risk of fetal blood exposure
Cross-cutting	317	Population & community health	Preventative care and screening: screening for high blood pressure and follow-up documented

Note: Cross-cutting measures represents a core set where Centers for Medicaid and Medicare Services (CMS) believes that there are significant performance gaps across specialties. Measure #317 is the only measure that applies to emergency care patients as defined by the measure specifications. Because most emergency physicians will be subject to the Measure Applicability Validation (MAV) because of a limited number of attributable quality measures, CMS created a Emergency Medicine cluster. If eligible professionals use this cluster they will pass the MAV process.

are exempt from attribution methodology, but urgent care codes are not. This assignment to a provider is invisible to patients and there are no patient penalties for behaviors that drive costs.

WHAT DOES THE FUTURE OF FEDERAL PROVIDER MEASUREMENT PROGRAMS HOLD FOR EMERGENCY MEDICINE?

In April 2015 the Medicare Access and Children's Health Insurance Program (CHIP) Reauthorization Act (MACRA) was passed by Congress.[17] This bill not only repealed the Sustainable Growth Rate (SGR) (which was used to calculate physician fee for service payments), it also directs that the current PQRS programs (i.e. VM and traditional PQRS) programs will continue through 2018. However, starting in 2019 a new program titled the Merit-Based Incentive Payment System (MIPS) will be initiated. This novel program increases at-risk Medicare provider payments to up to 9% (plus or minus) by 2022. Assessment categories dictated by law are in the stated categories of quality, resource use, EHR meaningful use, and clinical practice improvement activities. Those who participate in, and receive a significant share of their revenues

Table 5. Potential qualified clinical data registries (QCDR) physician quality reporting system (PQRS) quality measures.

PQRS#	Measure title	NQS domain
#54	12-lead electroencephalogram (ECG) performed for non-traumatic chest pain	Clinical effectiveness
#76	Prevention of catheter-related bloodstream infections (CRBSI): central venous catheter insertion protocol	Patient safety
#91	Acute otitis externa (AOE): topical therapy	Clinical effectiveness
#93	Acute otitis externa (AOE): systemic antimicrobial therapy–avoidance of inappropriate use	Clinical effectiveness
#187	Stroke and stroke rehabilitation: thrombolytic therapy (tPA); also known as hospital STK-4	Clinical effectiveness
#254	Ultrasound determination of pregnancy location for pregnant patients with abdominal pain	Clinical effectiveness
#1	ED utilization of CT for minor blunt head trauma for patients aged 18 years and older	Efficiency & cost reduction
#2	ED utilization of CT for minor blunt head trauma for patients aged 2 through 17 years	Efficiency & cost reduction
#3	Coagulation studies in patients presenting with chest pain with no coagulopathy or bleeding	Efficiency & cost reduction
#4	Appropriate ED utilization of CT for pulmonary embolism	Efficiency & cost reduction
#5	ED LOS for discharged ED patients–overall rate	Patient experience of care
#6	ED LOS for discharged ED patients–general rate=(overall rate – psych patients – transfer patients)	Patient experience of care
#7	ED LOS for discharged ED patients–psych mental health patients	Efficiency & cost reduction
#8	ED LOS for discharged ED patients–transfer patients	Efficiency & cost reduction
#9	Door to diagnostic evaluation by a qualified medical personnel	Patient safety
#10	Anti-coagulation for acute pulmonary embolism patients	Patient safety
#11	Pregnancy test for female abdominal pain patients	Patient safety
#12	Three-day return rate for ED visits	Communication & care coordination
#13	Three-day return rate for UC visits	Communication & care coordination
#14	Tobacco screening and cessation intervention for asthma and COPD patients	Effective clinical care
#15	tPA considered	Community-population health
#16	Adult sinusitis: antibiotic prescribed for acute sinusitis	Efficiency & cost reduction
#17	Adult sinusitis: appropriate choice of antibiotic	Efficiency & cost reduction
#18	Avoidance of antibiotic treatment in adults with acute bronchitis	Efficiency & cost reduction

NQS, National Quality Strategy; *ED,* emergency department; *CT,* computed tomography; *LOS*, length of stay; *UC,* urgent care

Table 6a. Calculation of the 2017 value modifier using the quality-tiering approach.†

Cost/quality	Low quality	Average quality	High quality
Low cost	0.0%	+2.0x*	+4.0x*
Average cost	-2.0%	0.0%	+2.0x*
High cost	-4.0%	-2.0%	0.0%

†Groups with >10 eligible professionals.

*Groups eligible for an additional +1.0% (if average beneficiary risk score in the top 25% of all beneficiary risk scores where "x" represents the upward payment adjustment factor. The upward payment adjustment factor will be determined after the performance period has ended based on the aggregate amount of downward payment adjustments).

through "alternative payment models," will be exempt from the MIPS program.

Alternative payment programs (APM) have yet to be fully specified. Until the regulations are written, it is unclear exactly what the impact will be on EM. However, it is critical that EM begins to develop model programs that may be a way to generate innovative payment models which describe the value of high quality emergency care services. Recent work facilitated by the Brookings Institute that described the need for payment innovation for acute care services is an important

Table 6b. Calculation of the 2017 value modifier using the quality-tiering approach.†

Cost/quality	Low quality	Average quality	High quality
Low cost	0.0%	+1.0x*	+2.0x*
Average cost	0.0%	0.0%	+1.0x*
High cost	0.0%	0.0%	0.0%

†Groups with 2-9 eligible professionals and solo practitioners.
*Groups eligible for an additional +1.0% (if average beneficiary risk score in the top 25% of all beneficiary risk scores where "x" represents the upward payment adjustment factor. The upward payment adjustment factor will be determined after the performance period has ended based on the aggregate amount of downward payment adjustments).

first step in this development.[18] QCDR measures should align with this APM model.

Hospitals have a growing number of required quality reporting programs that are similar to, but distinctly different from, the provider-based PQRS program. These include measures described within the Outpatient Quality Reporting, Inpatient Quality Reporting, Value-Based Payment, and Core Measure. CMS has been clear that it intends to increase the amount of money at risk for provider performance. Now MACRA defines that at least 20% of physician's Medicare payments will be at risk in the next decade. Continuing to research to evaluate the opportunities for emergency medicine to show economic value to the system are critical for our specialty.

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