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Western Journal of Emergency Medicine:

Integrating Emergency Care with Population Health

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Integrating Emergency Care with Population Health

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

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Continuous Hemodynamic Monitoring in Acute Stroke: An Exploratory Analysis

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Introduction: Non-invasive, continuous hemodynamic monitoring is entering the clinical arena. The primary objective of this study was to test the feasibility of such monitoring in a pilot sample of Emergency Department (ED) stroke patients. Secondary objectives included analysis of hemodynamic variability and correlation of continuous blood pressure measurements with standard measurements.

Methods: This study was a secondary analysis of 7 stroke patients from a prospectively collected data set of patients that received 2 hours of hemodynamic monitoring in the ED. Stroke patients were included if hemorrhagic or ischemic stroke was confirmed by neuroimaging, and symptom onset was within 24 hours. They were excluded for the presence of a stroke mimic or transient ischemic attack. Monitoring was performed using the Nexfin device (Edwards Lifesciences, Irvine CA).

Results: The mean age of the cohort was 71 ± 17 years, 43% were male, and the mean National Institute of Health Stroke Scale (NIHSS) was 6.9 ± 5.5. Two patients had hemorrhagic stroke. We obtained 42,456 hemodynamic data points, including beat-to-beat blood pressure measurements with variability of 18 mmHg and cardiac indices ranging from 1.8 to 3.6 l/min/m2. The correlation coefficient between continuous blood pressure measurements with the Nexfin device and standard ED readings was 0.83.

Conclusion: This exploratory investigation revealed that continuous, noninvasive monitoring in the ED is feasible in acute stroke. Further research is currently underway to determine how such monitoring may impact outcomes in stroke or replace the need for invasive monitoring. [West J Emerg Med. 2014;15(4):345–350.]

INTRODUCTION

The management of acute stroke is increasingly relying on frequent measurements of blood pressure, particularly in hemorrhagic stroke and for thrombolytic candidates.[1,2] New technologies are making continuous hemodynamic measurements feasible in the emergency department (ED), including measurements of blood pressure and cardiac ouput.[3,4] This study explores the ED use of arterial waveform analysis for capturing continuous hemodynamic measurements in stroke.

Traditionally, blood pressure is measured using standard intermittent oscillometric devices, and monitoring

systemic hemodynamics and continuous blood pressure requires invasive technology. Non-invasive devices have been introduced that provide continuous monitoring using algorithms to estimate hemodynamic parameters from blood pressure waveform analysis. Our previous work indicates good correlation of the non-invasive blood pressure measurements using the Nexfin device (Edwards Lifesciences, Irvine, CA) with commonly used cuff measurements using the oscillometric technique.[4] Studies have indicated that cardiac output measured by the device closely correlates with pulmonary artery catheter measurements.[5,6]

This exploratory study assesses the utility of the Nexfin technology to capture blood pressure and systemic hemodynamics in acute stroke patients in the ED. Secondary objectives include assessing variability of beat-to-beat hemodynamic changes, and correlating continuous with standard blood pressure measurements.

Patients and Methods

Study Population

This was a secondary analysis of the subset of stroke patients enrolled in a previously published, observational study of hemodynamic monitoring in critically ill adults.[4] The original study prospectively enrolled adults (>18 years) who presented to a resuscitation room at an urban ED over a 4-month period in 2009 as a convenience sample, based on availability of a single trained research assistant. The hospital institutional review board approved the study, and informed consent was obtained prior to enrollment. In the event that patients were unable to give informed consent due to aphasia or mental status changes, consent was obtained from a legally authorized representative.

In this analysis, we included patients from the original study of 40 subjects if their hospital discharge diagnosis was acute stroke, based on confirmed ischemic or hemorrhagic stroke on neuroimaging with symptom onset occurring < 24 hours prior to ED presentation. Patients were excluded from analysis for the following: negative neuroimaging, transient ischemic attack, and presence of stroke mimic determined by treating neurology team.

The Nexfin monitoring is based on the concept of the pulsatile unloading of the finger arterial walls using an inflatable finger cuff with a built-in photoelectric plethysmograph.[7-9] While continuously measuring blood pressure, the monitor calculates the cardiac output by the pulse-contour method. The continuous finger pressure is transformed to a brachial artery waveform and the pulsatile systolic area is determined for each heartbeat. Using the arterial impedance, the device calculates cardiac output and stroke volume and determines index values using the patient's sex, height and weight. A proprietary heart reference system attaches to the patient's gown at the level of the brachial artery to ensure that the blood pressure values are measured at the same phlebostatic level even if the patient moves his/her hand. Hence, Nexfin readings will automatically correct for any hydrostatic pressure difference and not be falsely elevated or lowered by upward or downward movements of the patient's hand.

Table 1. Demographics of stroke patients.

Total patients	7
Male	3 (43%)
Female	4 (57%)
Age (mean ± SD)	71 ± 17 years
NIHSS (mean ± SD)	6.9 ± 5.5
Total hemodynamic data-points	42, 456
Hemodynamic data-points (mean ± SD)	6065 ± 1236
30-day mortality	0 %

NIHSS, National Institute of Health Stroke Scale; *SD*, standard deviation

For each patient, a sized finger cuff was placed on the second, third or fourth digit of an asymptomatic hand. Continuous beat-to-beat hemodynamic values from the Nexfin monitor were recorded, including: heart rate, systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), cardiac output, and systemic vascular resistance. The Nexfin device streams data in real-time to a display monitor. For this study, the treating physicians and nurses were blinded to the data. Usual ED cardiac and intermittent blood pressure monitoring continued at hourly intervals based on nursing protocol, and patients were managed as clinically indicated. All patients were contacted after 30 days to determine unexpected, unscheduled ED or healthcare provider visits or death.

Statistical Analysis

We captured and reviewed trends in hemodynamic profiles over a 2-hour period. We analyzed raw data and used moving averages technique to de-noise the beat-to-beat data to remove occasional, artifactual spikes in measurements. Descriptive statistical parameters of the mean and standard deviations of hemodynamic variables were assessed. We computed hemodynamic data over a 30-minute period along with standard deviations to represent variability. We calculated Pearson correlation coefficients to compare Nexfin blood pressure measurements to standard automated measurements and to compare Nexfin derived changes in SBP relative to changes in cardiac index and systemic vascular resistance. All statistical computation was done using SAS 9.2 (Cary, NC).

RESULTS

We initially monitored 7 patients with acute stroke using the Nexfin device, 5 with ischemic and 2 with hemorrhagic stroke. No patients received thrombolytics due to delayed presentation or hemorrhage, and there were no deaths or

Table 2. Hemodynamic measurements over 30-minute periods.

Patient (NIHSS)	1 (4)	2 (3)	3 (5)	4 (7)	5 (11)	6 (1)	7 (17)
SBP, mean (SD)							
0-30 minutes	172 (13)	133 (23)	170 (10)	166 (19)	177 (22)	170 (28)	201 (15)
30-60	159 (20)	144 (22)	170 (17)	165 (19)	168 (20)	191 (22)	204 (12)
60-90	154 (12)	142 (25)	189 (24)	177 (12)	173 (19)	168 (13)	209 (18)
90-120	153 (13)	153 (25)	194 (22)	177 (16)	178 (16)	154 (11)	197 (17)
DBP, mean (SD)							
0-30 minutes	109 (6)	72 (12)	72 (4)	70 (14)	94 (11)	81 (19)	111 (8)
30-60	102 (12)	76 (10)	73 (7)	70 (9)	88 (10)	83 (11)	109 (8)
60-90	98 (7)	78 (13)	81 (10)	70 (7)	87 (11)	72 (6)	114 (12)
90-120	96 (8)	79 (15)	83 (9)	100 (9)	83 (12)	66 (5)	109 (16)
MAP, mean (SD)							
0-30 minutes	136 (9)	92 (14)	106 (6)	107 (14)	124 (14)	114 (19)	146 (11)
30-60	125 (14)	98 (12)	106 (10)	105 (11)	116 (13)	123 (15)	145 (10)
60-90	120 (9)	99 (16)	119 (15)	109 (11)	117 (13)	106 (10)	141 (12)
90-120	118 (10)	103 (14)	123 (12)	72 (9)	114 (12)	96 (8)	128 (19)
CI, mean (SD)							
0-30 minutes	2.7 (0.2)	2.5 (0.9)	1.8 (0.1)	3.1 (0.4)	3.6 (1.3)	2.6 (0.8)	3.0 (0.3)
30-60	2.7 (0.7)	2.6 (1)	1.8 (0.2)	3.0 (0.6)	3.4 (1.3)	2.8 (0.6)	3.1 (0.3)
60-90	2.6 (0.2)	2.5 (1.3)	1.8 (0.4)	3.2 (0.3)	3.3 (1.4)	2.7 (0.4)	2.9 (0.4)
90-120	2.7 (0.4)	2.4 (1.4)	1.8 (0.5)	3.1 (0.5)	3.6 (1.2)	2.8 (0.1)	2.6 (0.7)
SVRI, mean (SD)							
0-30 minutes	4070 (1342)	3865 (6772)	4738 (790)	3082 (4899)	3312 (2474)	4420 (5692)	3913 (1158)
30-60	4088 (4895)	4063 (5039)	4910 (1220)	3475 (8893)	3207 (1777)	3863 (4433)	3864 (1662)
60-90	3789 (1194)	4887 (7603)	5428 (2807)	2782 (1497)	3507 (2371)	3225 (2941)	3671 (1893)
90-120	4474 (2085)	4945 (9521)	5572 (4079)	2980 (2287)	3682 (1746)	2715 (3150)	3447 (1921)
HR, mean (SD)							
0-30 minutes	70 (3)	98 (20)	54 (4)	70 (7)	110 (27)	66 (16)	77 (7)
30-60	73 (12)	105 (20)	53 (7)	70 (10)	104 (27)	66 (11)	74 (5)
60-90	69 (5)	106 (27)	56 (10)	69 (4)	92 (23)	61 (7)	72 (12)
90-120	72 (12)	96 (34)	60 (17)	70 (7)	97 (19)	60 (3)	68 (11)

SBP, systolic blood pressure; *SD*, standard deviation; *MAP*, mean arterial pressure; *DBP*, diastolic blood pressure; *HR*, heart rate; *CI*, cardiac index; *SVRI,* systemic vascular resistance index

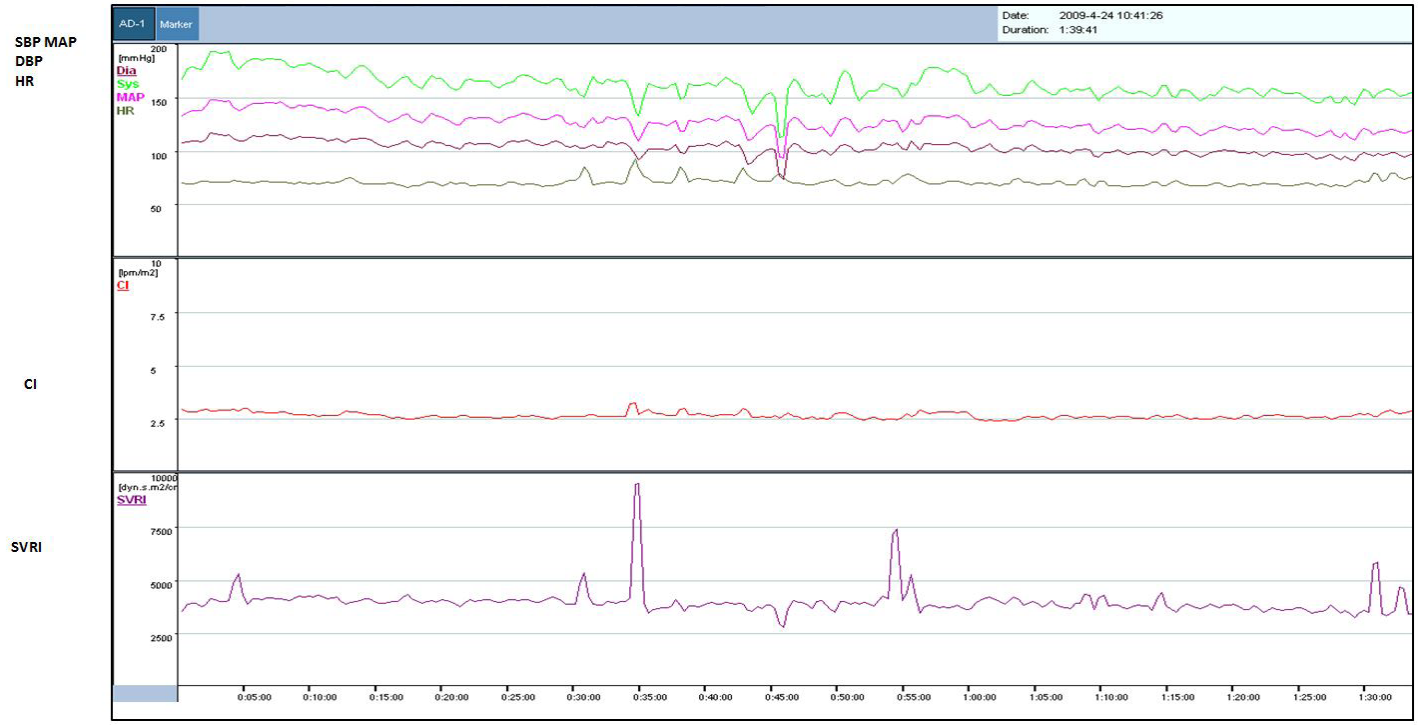
unscheduled healthcare-related visits in the cohort within 30 days. The mean age of the cohort was 71 ± 17 years and all were African-American; 43% of the cohort was male and the presenting mean National Institute of Health Stroke Scale (NIHSS) was 6.9 ± 5.5 (see Table 1).

We obtained 42,456 total hemodynamic data points for the 7 patients in the cohort. These data points consist of beat-to-beat measurements of 120 minutes of SBP, DBP, cardiac output, stroke volume, and systemic vascular resistance. A graphical sample of continuous non-invasive monitoring of various hemodynamic parameters of 1 of the 7 patients is shown in Figure 1, including de-noised parameters using the moving averages filter for this patient. After averaging data over 30-minute periods, the cohort's hemodynamic trends over 2-hours of monitoring are shown in Figure 2. Full hemodynamic statistics for the cohort is listed in Table 2. Variability for the hemodynamic data is represented by the standard deviation. A comparison of all standard automated systolic blood pressure readings and Nexfin values showed a Pearson Correlation Coefficient of 0.83 ($p < 0.005$).

The average variability of SBP, DBP and MAP for the cohort was 18.1 mmHg, 9.9 mmHg and 12.2 mmHg respectively. The variability in SBP for each patient over 30-minute increments is represented by the standard deviation lines shown in Figure 3. The cohort's range of cardiac indices was 1.8 to 3.6 l/min/m^2, and the range for the systemic vascular resistance indices was 2715 to 5572 dynes·sec/cm^5/m^2. Changes in blood pressure correlated poorly with changes in systemic vascular resistance and cardiac output. The correlation coefficients were -0.21 (-0.46 to 0.07, 95% CI) and 0.24 (-0.04 to 0.48, 95% CI) respectively.

DISCUSSION

This analysis reveals the feasibility of non-invasive, continuous blood pressure and hemodynamic monitoring in acute stroke. Due to the invasive nature of prior methods for determining hemodynamic measurements, there is little data on hemodynamic changes in stroke and their relationship to outcomes. Nevertheless, identification of high-risk hemodynamic profiles in stroke could lead to better risk stratification and potential interventions to improve clinical outcomes. Our group is currently investigating the relationship



SBP, systolic blood pressure; *MAP*, mean arterial pressure; *DBP*, diastolic blood pressure; *HR*, heart rate; *CI*, cardiac index; *SVRI*, systemic vascular resistance index

Figure 1. Single-subject 2-hour trend curve of hemodynamic data using moving averages as measured by Nexfin device.

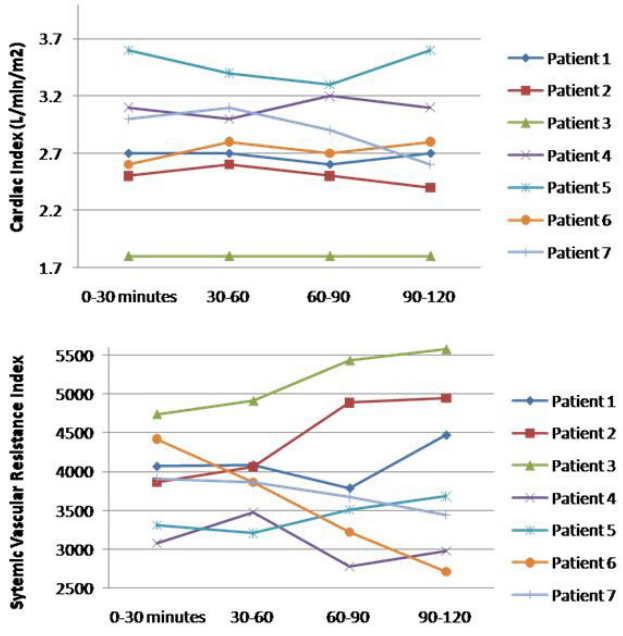


Figure 2. Hemodynamic trends of cardiac index and systemic vascular resistance index as measured by Nexfin device.

between hemodynamic profiles in stroke, anatomic location and alterations in cerebral blood flow.[10]

Continuous monitoring may be particularly of interest in hemorrhagic stroke, as recent literature indicates a role for more aggressive blood pressure lowering.[1] The continuous measurements by the Nexfin are displayed on a portable screen to the treating clinician equivalent to arterial line monitoring. Although we used minute-averaging techniques to smooth the data trends for data analysis, a clinician can readily use the real-time measurements to make management decisions in lieu of arterial-line or oscillometric measurements. Such monitoring may also be of interest in managing patients that are thrombolytic candidates. These patients have a short time to reach goal blood pressure (< 185/110 mmHg) prior to thrombolytic administration, and if they receive thrombolytics, guidelines recommend vigilant maintenance of SBP < 180 mmHg.[2]

Finally, the ability to detect variability in blood pressure may have prognostic significance in stroke. Fluctuations early in the course of ischemic stroke are associated with poor 90-day survival.[11] A study done within 72-hours of stroke onset, which obtained 10-minute continuous recordings, found that high arterial pressure variability was associated with a poor outcome, defined as death or dependency.[12] Our data

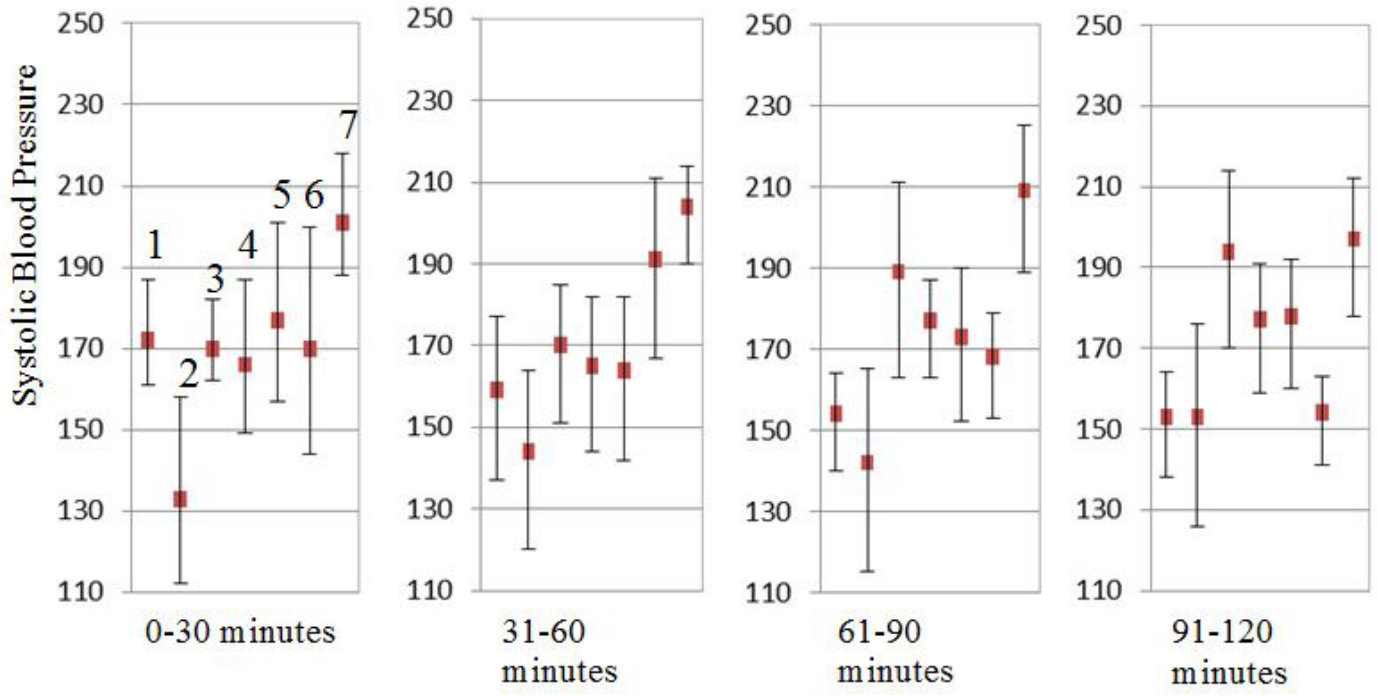


Figure 3. Variability in systolic blood pressure measured by Nexfin device. Vertical lines around each mean value represent standard deviation and show variability in systolic blood pressure for each study patient.

show similar variability of blood pressure in acute stroke in the initial hours of presentation, although this analysis is underpowered to assess outcomes. The wide standard deviation values for SBP, DBP and MAP point to this significant intra- and inter-individual variability (Table 2 and Figure 3).

LIMITATIONS

Limitations of our study include the small sample size, exploratory analysis, mixed stroke etiologies and convenience sampling methods. The sample size is too small to make any meaningful patient-centered conclusions. Additional methodological limitations were the inclusion of stroke patients with varying times of symptom onset within a 24-hour period and the fact that stroke anatomic location was not recorded. Finally, the Nexfin derived hemodynamic measurements have been validated against thermodilution techniques but are not the gold standard measurements.

CONCLUSION

This exploratory investigation reveals that continuous, non-invasive monitoring of blood pressure and cardiac hemodynamic variables is feasible in acute stroke. As non-invasive monitoring technology advances, there may be a role for improved monitoring, prognostication and interventions based on robust hemodynamic data in a previously data-poor area of critical illness.

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Arm Weakness and Deformity

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A healthy 58-year-old man presented to the emergency department with right arm weakness first noticed while playing hockey that day. He could not recall the onset of injury, but endorsed several weeks of antecedent intermittent right shoulder discomfort. Examination revealed a deformity of the right biceps brachii with distal bunching of the muscle (Figure). Tenderness existed along the proximal humerus near the long head of the biceps. The patient had full range of motion with decreased elbow flexion strength on the right. He was diagnosed clinically with an acute biceps brachii tendon rupture.

Acute biceps tendon rupture most commonly occurs at the proximal end of the long head of the biceps brachii and is usually associated with trauma. Acute biceps tendon rupture frequently occurs in patients with underlying overuse injuries and tendinopathies—thus the actual moment of rupture may go unnoticed.[1-4] While the diagnosis can generally be made by history and physical examination, ultrasound and magnetic resonance imaging can aid in diagnosis.[1-4] Most injuries are managed conservatively and the typical post-injury reductions in strength are mild to moderate and well tolerated.[2-5] Surgical management may lessen loss of elbow flexion and supination strength and may be considered in the management of highly active patients.[3,5]

This patient underwent surgical open subpectoral biceps tenodesis with successful resolution of his biceps contour and restoration of full strength and mobility.

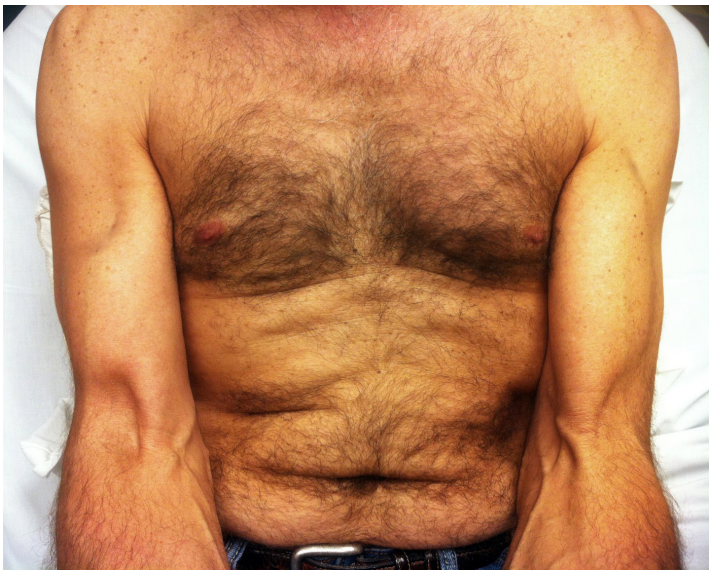

Figure. Appearance of the patient's affected right arm and normal left arm.

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Man with Altered Mentation after Trauma

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A 37 year-old male presented after an altercation in which he was dragged by a vehicle. The patient was intoxicated and asking repetitive questions. He demonstrated significant facial trauma—including frank bloody discharge from both ears and dental trauma. His vitals signs were as follows: Temperature 36.8 C; Blood pressure: 125/88; Heart rate: 90; Respiratory rate: 24; O_2 sat: 100% room air. His portable chest x-ray can be seen below (Figure 1).

Secondary to his mechanism, intoxication, and chest radiograph results, he was sent for computed tomography (CT) imaging. Immediately post CT, his imaging was reviewed (Figure 2). Shortly thereafter, the patient's altered mentation worsened and he acutely decompensated.

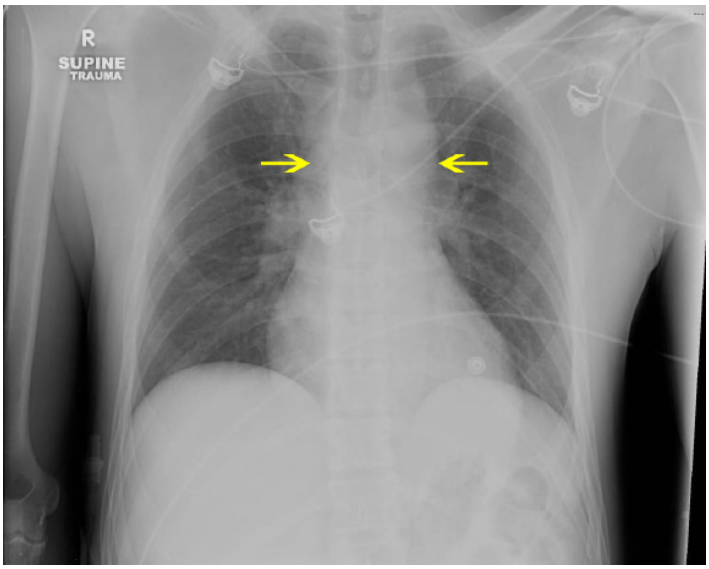

Figure 1. Chest radiograph demonstrating a widened upper mediastinum.

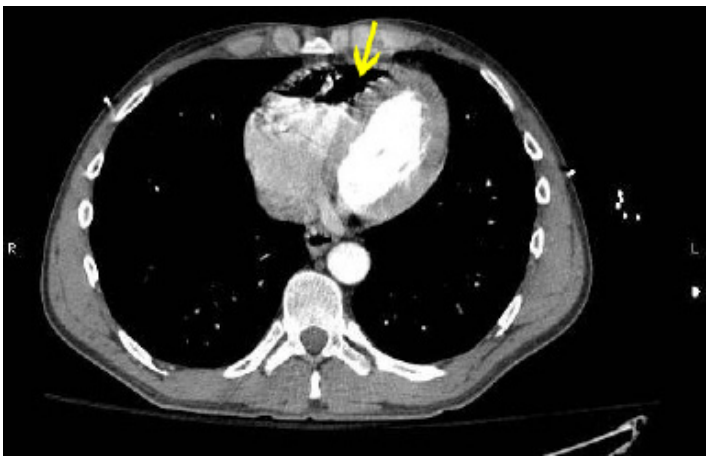

Figure 2. Computed tomography of the thorax with intravenous contrast demonstrates a large right ventricular air embolus.

DIAGNOSIS

Iatrogenic air embolism. Iatrogenic air embolism is a rare side-effect of invasive and surgical procedures. While rare, retrospective studies demonstrate mortality up to 23% and recent prospective literature demonstrates a 1-year mortality of 21%. Morbidity is higher.[1-5] Iatrogenic air emboli can be either arterial or venous. Arterial gas emboli (AGE) can manifest as chest pain, transient ischemic attack, stroke, or shock.[3,5-7] While most are asymptomatic, venous gas emboli (VGE) more commonly present as shortness of breath.[5, 6]

It is important, though, to recognize that VGE can readily convert to AGE via right-to-left shunting mechanisms such as pulmonary arterial-venous malformations and patent foramen ovale (PFO). A PFO is present in approximately 26-39% of the general population.[8-11] Additionally, it is important to remember that iatrogenic air emboli can occur secondary to procedures that we often consider routine in the emergency department, i.e., central line placement or—like our patient—CT with intravenous contrast.

In our case the patient acutely decompensated, was intubated, and received hyperbaric oxygen therapy. After

hyperbarics, the patient's status improved and he was extubated in the intensive care unit and later discharged without complications.

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Man with Abdominal Distension

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CASE

A 63-year-old man presented with abdominal distension and shortness of breath for two days. He reported flatus and denied chest pain, anorexia, vomiting, or abdominal pain. Surgical history was notable for left hepatectomy, cholecystectomy and choledochojejunostomy with a Roux-en-Y. He was afebrile with a pulse in the 100s, blood pressure of 130/60, respiratory rate of 34, and oxygen saturation of 92% on room air. Breath sounds were decreased in the lower lung fields and bowel sounds were noted in the chest. Abdominal exam was notable for distension, tympany and normoactive bowel sounds, but no tenderness, rigidity or fluid wave.

Complete cell count, chemistry panel and lipase were normal. Bedside echocardiography was obscured by air. A computed tomography (CT) was obtained. What is the diagnosis?

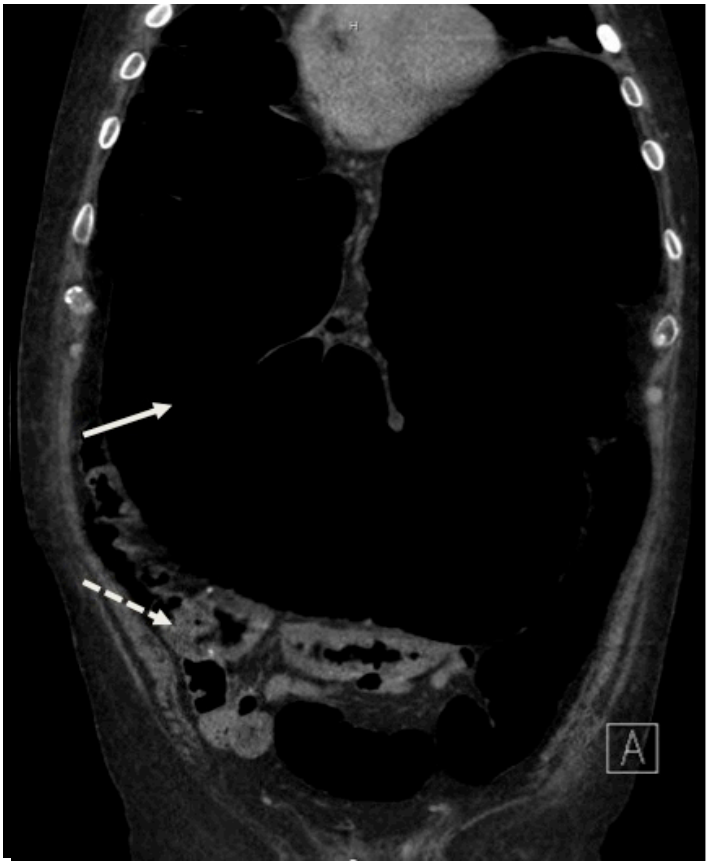

Figure 1. Dilated bowel (solid arrow) compressing the left atrium and lungs. Dilated colon contains stool and gas (dashed arrow).

DIAGNOSIS

Acute intestinal pseudo-obstruction (AIPO). Also known as Ogilvie's Syndrome, AIPO is a rare diagnosis seen in patients with history of trauma, recent surgery, neurologic disorder, infection or electrolyte abnormalities.[1] Patients present with painless abdominal distension and have normal bowel sounds.[2] Plain films show distended bowel without fluid levels. Abdominal CT is typically obtained to exclude mechanical obstruction, perforation or toxic megacolon.[1] Most patients improve with fluids, bowel rest and nasogastric decompression. Neostigmine is also a safe and effective treatment.[3-5] Surgery is only indicated if conservative therapy fails.[1] If cardiac compression or tamponade is present, emergent decompression with percutaneous transabdominal catheterization can be performed.[6] Mortality from AIPO is as high as 50%, and is mainly due to ischemic necrosis, perforation and other complications.[1]

Our patient's vital signs normalized and his distension improved with fluid resuscitation and nasogastric decompression.

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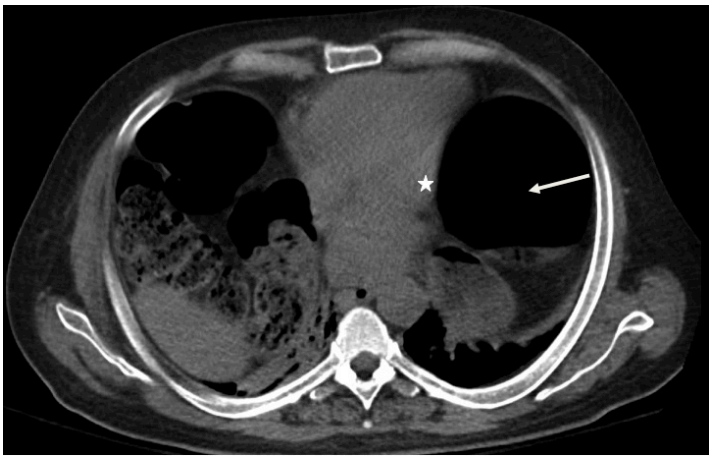

Figure 2. Dilated bowel (solid arrow) compressing the left atrium (star) and lungs.

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Giant Hydronephrosis

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CASE

A 83-year-old man with a history of urinary stone disease presented to the emergency department with abdominal and right-sided flank pain. Examination demonstrated distended abdomen and right costovertebral angle tenderness. Vital signs were unremarkable, and laboratory evaluation showed a blood urea nitrogen level of 34.5 mg/dL and creatinine of 1.45 mg/dL. Urinalysis showed red blood cell count: 37/high power field (HPF); white blood cell count: 4/HPF; yeast cells: 4/HPF. Abdominal ultrasonography revealed a large cystic mass localized in the right side of the abdomen. Subsequent computed tomography (CT) of the abdomen and pelvis were also obtained (Figure).

DIAGNOSIS

Subsequent CT showed giant right-sided giant hydronephrosis and hydroureter with thinning of renal parenchyma due to obstruction by a ureteral stone. Patient consulted with department of urology and a percutaneous nephrostomy tube was placed. Approximately 4000 mL of urine was drained.

Symptomatic nephrolithiasis and hydronephrosis are frequently presenting clinical conditions, but giant hydronephrosis is an uncommon entity and a rare cause of urological emergencies. Giant hydronephrosis is defined as the presence of over 1000 mL of fluid within the adult renal collecting system. The most common cause of giant hydronephrosis is ureteropelvic junction obstruction, although stone disease, trauma, renal ectopy, and ureteral tumor have also been reported.[1] Emergency physicians should be aware of this clinical presentation, especially in patients with urinary stone disease. A high index of suspicion and prompt management should avoid adverse outcomes.

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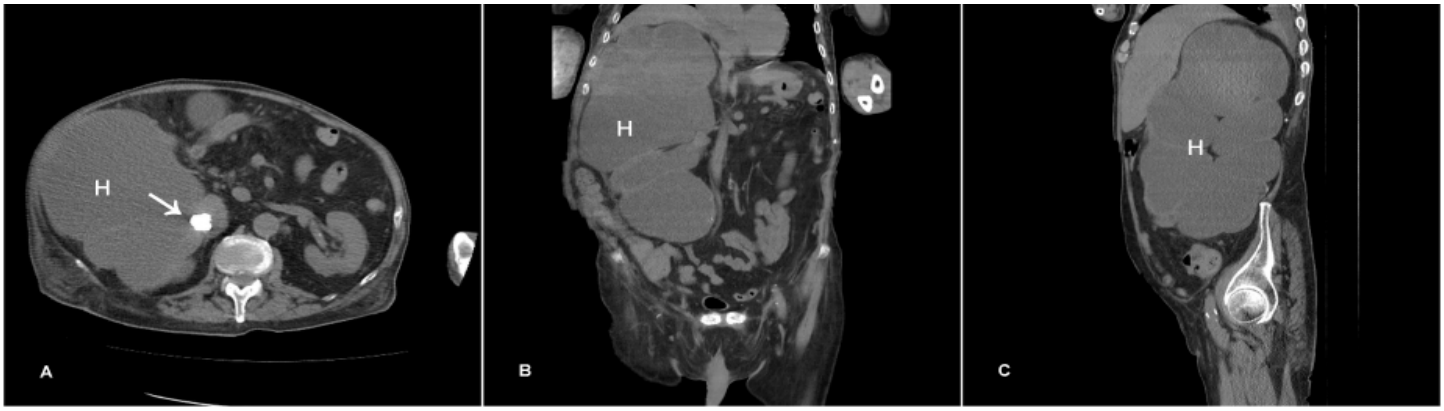

Figure. Computed tomography of abdomen showed right ureteral stone (white arrow) in a axial view (A), right giant hydronephrosis in a coronal (B) and sagittal (C) views. Abbreviation: H, hydronephrosis

Chemosis from Trauma

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PATIENT PRESENTATION

A 51-year-old male with a history of chronic obstructive pulmonary disease and obstructive sleep apnea presents to the emergency department complaining of 48 hours of progressive right eye pain and swelling after he ran into his dresser while sleep-walking. He does not know which surface of the dresser contacted his eye. He denies changes in visual acuity, flashes, or floaters. He has no other complaints and denies recent illness, fever, chills, nausea, vomiting, diarrhea, chest pain, or shortness of breath. Physical exam reveals inability of the patient to close his eyelids on the right. His cranial nerves are intact. His vision exam is unremarkable.

DISCUSSION

The patient has impressive conjunctival chemosis, which is edema of the conjunctiva (Figure). This constitutes one half of the reactions that make-up conjunctivitis. It is an inflammatory reaction mediated by the release of histamine, serotonin, and bradykinin. Polymorphonuclear cells also migrate into the reaction site.[1]

Chemosis is nonspecific finding and is secondary to direct conjunctival endothelial insult. It can result from allergic reaction, bacterial or viral infection, angioedema, or trauma.[2] When it is disproportionate to other signs of injury after a traumatic mechanism it can indicate scleral rupture, an ophthalmologic emergency. Chemosis is usually generalized; however, in the setting of scleral rupture it may be confined to only one or two quadrants.[3] If there is chronic chemosis following a traumatic mechanism the physician must include lymphatic obstruction most likely secondary to obstructing mass on the differential.[4]

Globe rupture was not detected in this patient. He could not close his right eyelid, which can lead to ocular damage. A tarsorrhaphy (partially sewing together the eyelids) was performed to protect the eye. At follow-up the patient's sutures were removed and he was given a pressure patch. By one month this had resolved.

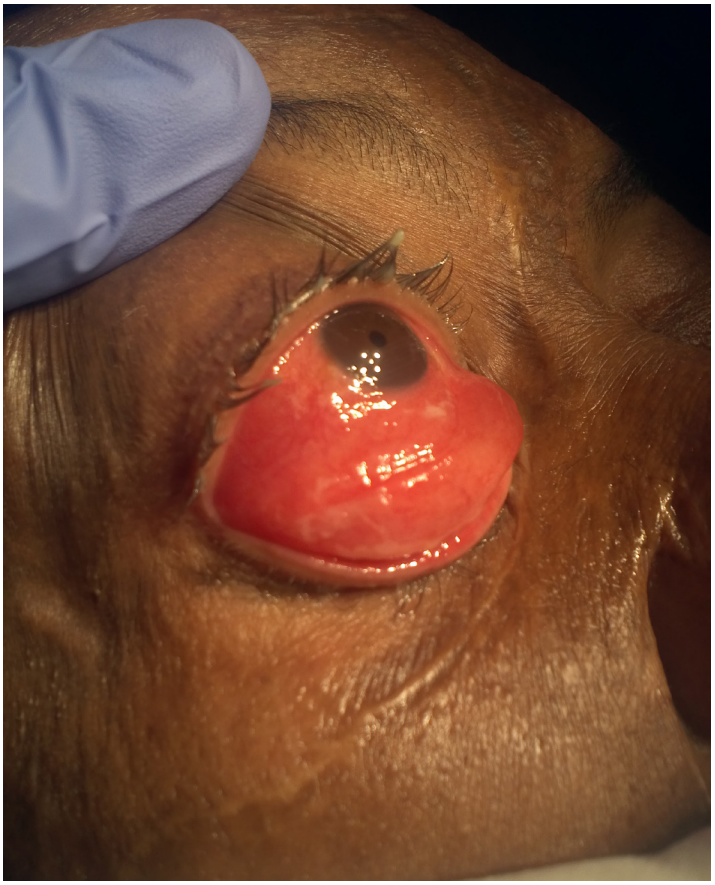

Figure. Chemosis of right eye.

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"Whirl Sign" of Primary Small Bowel Volvulus

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A 59-year-old man had been admitted to our hospital three times with tarry stool, hematemesis, and abdominal discomfort. His medical history included no abdominal operation. Repeated upper endoscopy, colonoscopy, and computed tomography (CT) had been negative. Gastrointestinal bleeding scintigraphy and Meckel scintigraphy had been also negative. In the last admission, he presented abrupt and sharp abdominal pain. An abdominal radiograph showed dilations and air-fluid levels of small intestine and colon. An abdominal CT revealed dilation of small intestine with the lack of contrasts, mesenteric and bowel wall edema, and "clockwise" rotation of the mesentery around the mesenteric vessels (whirl sign) (Figure, arrow). The exploratory laparotomy showed a volvulus of the small intestine at the base of the mesentery, and an edematous mesentery (Figure). The cause of the mesenteric rotation was not identified, such as congenital malrotation, bands, and postoperative adhesion. Primary small bowel volvulus (PSBV) was diagnosed, and the affected bowel was untwisted. Postoperative course was uneventful, and he was discharged home 14 days after surgery.

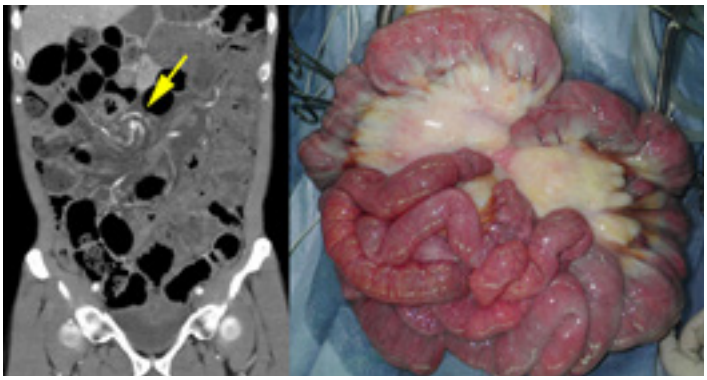

Figure. Abdominal computed tomography revealed dilation of small intestine with the lack of contrasts, mesenteric and bowel wall edema, and "clockwise" rotation of the mesentery around the mesenteric vessels (whirl sign) (arrow).

PSBV is defined as torsion of large segment small intestine at the basis of the mesentery without any associated underlying cause, such as congenital malrotations, bands, postoperative adhesions, tumors, and diverticular disease. The preoperative diagnosis of PSBV is rather difficult because of limited value of physical examination and radiograph films. However, several authors have reported the usefulness of preoperative abdominal CT for the diagnosis of PSBV.[1-3] A tightly twisted mesentery around the point of torsion (whirl sign) was described as a typical sign of volvulus of the small intestine. In conclusion, we emphasize PSBV is an important emergency disease demanding prompt surgical intervention,and whirl sign in CT is the key for its diagnosis.

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Incidental Finding in a Headache Patient: Intracranial Lipoma

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A 60 year old female, with a history of atrial fibrillation who was on warfarin therapy, presented to our emergency department with chief complaint of the most severe headache that she ever had. Her vital signs, systemic and neurological examinations were normal. She had emergency computed tomography (CT) of the brain with suspicion of intracranial hemorrhage that revealed a lesion in fat dansity in the lateral ventricle and interhemispheric fissure (Figure a). Her international normalized ratio was 3,2. She underwent cranial magnetic resonance imaging (MRI) that revealed a hyperintense lesion in T1 and T2 sequances in the lateral ventricles, pericallosal area and interhemispheric fissure that did not show contrast enhancement (Figure b and c). After the symptomatic relief by analgesics she was discharged from the emergency department for out-patient follow-up.

Intracranial lipomas are rare and benign congenital malformations accounting for 0,1% to 0,46% of all intracranial tumors.[1] Since half of all cases are asymptomatic, they are usually an incidental finding during neuroimaging studies. Headache is the most common symptom in adults if it becomes symptomatic.[2]

The deep interhemispheric fissure, especially the corpus callosum, is the most common localization of intracranial lipomas.[1] Intracranial lipomas are often associated with other malformations of the central nervous system, such as callosal agenesis or hypogenesis, spina bifida or a cranium bifidum.[1,3]

Noncontrast cranial CT and brain MRI allow definitive diagnosis. The appearance of the corpus callosum lipoma on the cranial CT scan is quite typical, with the low attenuation seen only in adipose tissue, which ranges from -40 to -100 hounsfield units.[4,5] In the brain MRI the lesion presents characteristics of fatty tissue, with a hyperintense signal in both T1 and T2-weighted studies.[6]

Most lipomas are treated conservatively and rarely requires neurosurgical treatment because of their benign nature.[1] Our patient did not have any accompanying lesion and was discharged to follow-up as an out-patient.

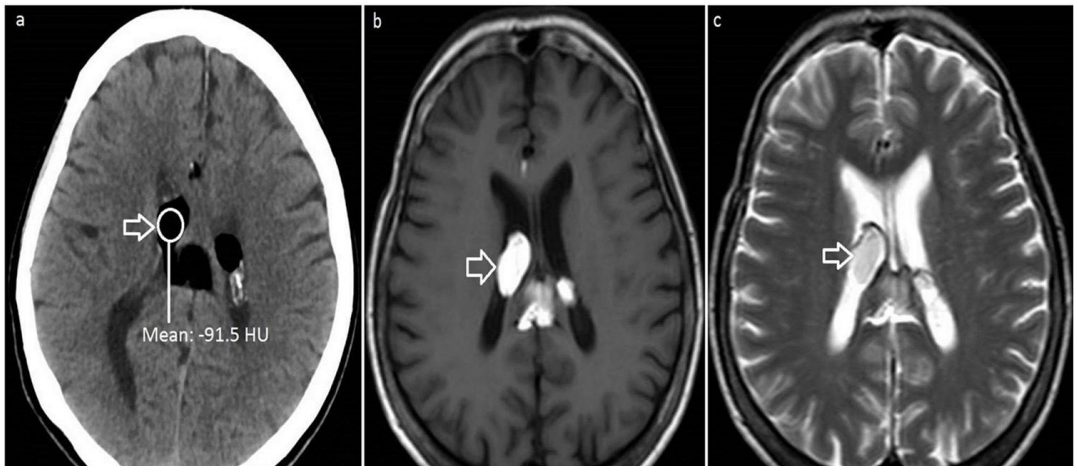

Figure. Image (a) shows cranial computed tomography. There is a homogenously hypodense lesion measuring 33 mm x 30 mm in the lateral and third ventricles with about -101 to -110 Hounsefield unit. Image (b) and (c) show magnetic resonance imaging with hyperintense mass lesion in lateral ventricle (T1-weighted and T2-weighted images, respectively).

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Ear Drainage After Trauma

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A restrained 20 year old male driver presents after a rollover motor vehicle collision. He is repetitive after sustaining a loss of consciousness, but is a Glasco Coma Scale of 15 on arrival. He is complaining of left ear and shoulder pain. He has no focal findings other than a ruptured left tympanic membrane (Figure).

A "halo" or "ring" sign, occurs when cerebrospinal fluid (CSF) mixes with blood on an absorbent surface. The blood forms a spot in the center and a lightly stained ring forms a halo around it. The halo sign is reliable for detecting CSF but not exclusive.[2] Saline and water, can also form a halo sign when mixed with blood. In the setting of trauma, the halo sign may represent a basilar skull fracture. An aspirate of the fluid can be analyzed for CSF confirmation. Glucose is the usual screening test for CSF detection; however, false positives are common in diabetic patients.[3] Beta-2-tranferrin, a protein found only in CSF, perilymph and aqueous humor[4] is a more reliable biomarker for CSF leakage. It is detectable outside the body for up to 7 days regardless of storage at room temperature or exposure to nasal mucosa.[3]

Our patient's computerized tomography scan head and c-spine were negative for injury. The persistent fluid from his ear was positive for B-2-transferrin - confirming a CSF leak. He was admitted and observed without any further intervention.

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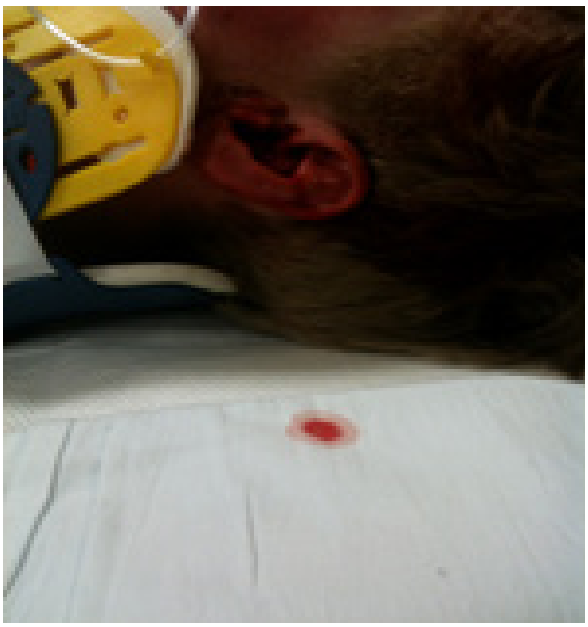

Figure. Classic halo sign in patient with diagnosis of cerebrospinal fluid leak.

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Thoracic Outlet Syndrome with Secondary Paget Schröetter Syndrome: A Rare Case of Effort-Induced Thrombosis of the Upper Extremity

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CASE

A 19-year-old man presented to the emergency department complaining of two days of right arm pain and swelling. The pain started while lifting weights. He did not experience a pop or pulling sensation. He stated his arm felt a little cold but otherwise denied numbness or tingling. He denied chest pain, neck pain or shortness of breath.

Examination demonstrated a diffusely edematous right upper extremity. Distal pulses were strong and regular. His fingers had a dusky appearance and the entire arm was cool to touch. Range of motion, motor and sensory exam were normal. Heart and lung exam were normal. A computed tomography (CT) angiogram of the chest and upper extremity were performed. The chest CT revealed an axillo-subclavian thrombosis (Figure).

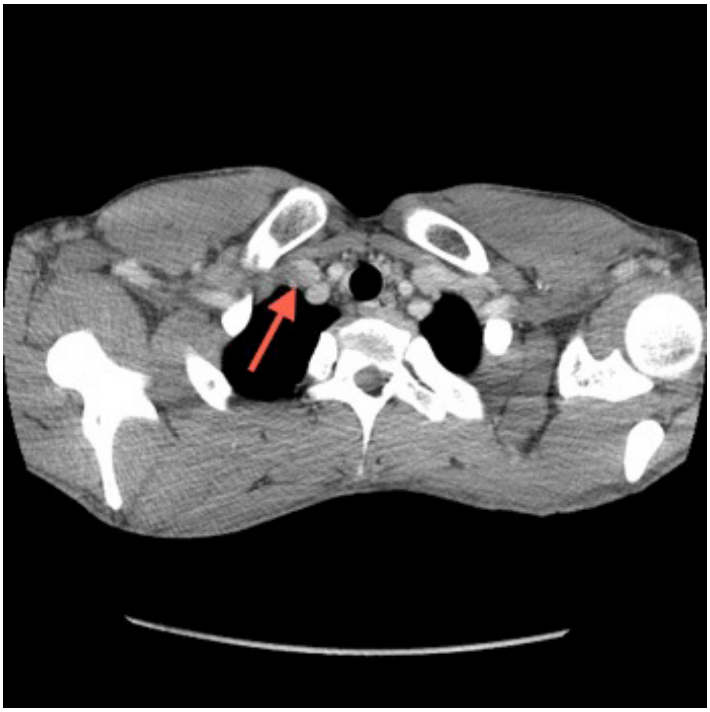

Figure. Computed tomography angiogram chest reveals a thrombosis of the right subclavian and axillary veins with subtle filling defect at the junction of the right subclavian, jugular and brachiocephalic veins (red arrow).

DIAGNOSIS

Thoracic outlet syndrome (TOS) with secondary Paget Schröetter Syndrome (Effort Thrombosis of the upper extremity)

Upper extremity deep vein thrombosis (DVT) is extremely rare (approximately 2/100,00 people per year), accounting for only 1 to 4% of all cases of DVT.[1]

Thoracic outlet syndrome is a compression of the neurovascular structures in the area superior to the first rib and posterior to the clavicle. Brachial plexus (95%), subclavian vein (4%), and subclavian artery (1%) are affected. Women more frequently have neurologic thoracic outlet syndrome (TOS) while men more frequently have venous TOS.[4]

Paget Schröetter Syndrome is an effort-induced thrombosis of upper extremity. First defined in 1884, it was described as a thrombosis of the axillary and subclavian veins. It is the leading vascular disorder in athletes, and males experience it more commonly than females.[2,3]

Diagnosis and treatment consists of a venous duplex and a confirmatory venogram.[2,3] Catheter directed thrombolysis with subsequent first rib removal is recommended to produce the best results.[2,3] Oral anticoagulation is generally recommended for 3 to 6 months.

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A Purple Ulcer

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CASE

A 42-year-old woman presented with a left lower extremity ulcer. Three weeks prior, she had been struck by a motor vehicle and developed bullae on her thigh, the main area of impact. She could not afford to see a primary doctor, and had been applying a low-cost, over-the-counter topical antiseptic solution to the site since the accident. On examination, she had a 26 by 14 centimeter ulcer on her left medial thigh without tenderness, purulence or crepitance. The ulcer was noted to be bright purple (Figure).

DIAGNOSIS

Gentian violet (hexamethylrosaniline), the basis of the gram stain, has been marketed as an antiseptic since the 1890s.[1] It was used intravenously in the early 20th century to treat sepsis, until being replaced by penicillin and other oral antibiotics. Its exact mechanism of action is unknown, although it is hypothesized to promote free radical formation, inhibit bacterial protein synthesis, and uncouple oxidative phosphorylation. *In vitro* studies have demonstrated its effectiveness against gram-positive bacteria and *Candida*, and clinical studies have shown effectiveness against some skin infections, including methicillin-resistant *Staphylococcus aureus* (MRSA).[2,3] Given its low cost, ready availability, and limited adverse effects, topical gentian violet may be a useful treatment in under-developed parts of the world as the incidence of MRSA and other skin and soft tissue infections increases.

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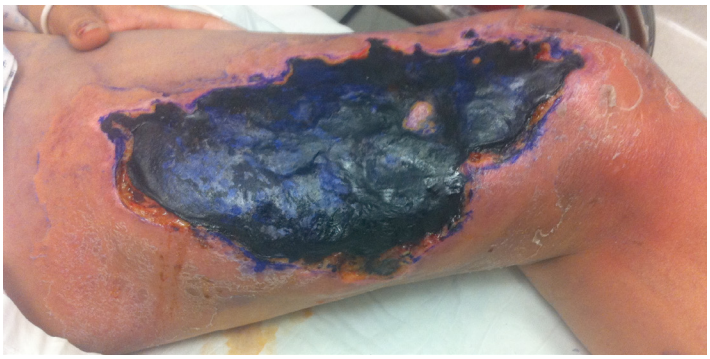

Figure. A purple ulcer on the left medial thigh.

Handlebar Trauma Causing Small Bowel Hernia with Jejunal Perforation

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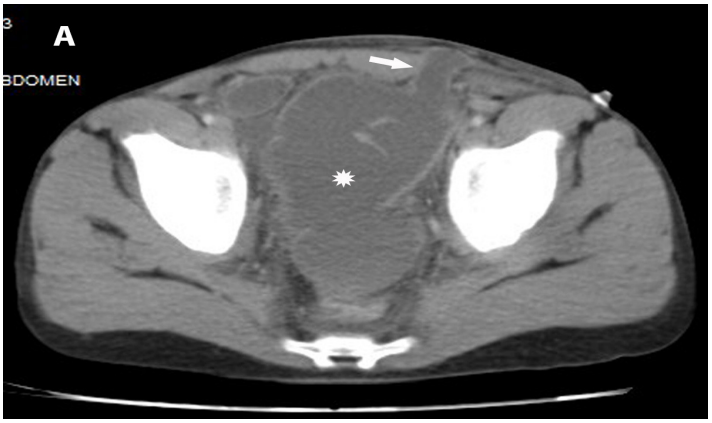
An 11-year-old boy was admitted to emergency department with abdominal pain, bilious vomiting and rectal bleeding one day after falling from bicycle. He stated that he landed directly onto the handlebar through his left lower quadrant of the abdomen. Physical examination revealed a soft tissue bulge, tenderness and defense in the left lower quadrant without any head or skeletal injury. His abdomen was soft with no evidence of peritoneal irritation. The patient's vital signs, radiographs and blood tests (hemoglobin, 14.4 g/dl; hematocrit, 43.0%; wight blood cell count, $6x10^3/mm^3$; C-reactive protein, 10 mg/dl; Sodium (Na), 130 mmol/L) were within normal limits. Ultrasound demonstrated intra-abdominal fluid and herniation of a small bowel loop through the abdominal wall at left lower quadrant. Computed tomography (CT) of the abdomen revealed the herniation of jejunal loop through a defect in the left lower abdominal wall just lateral to the rectus muscle, segmental ileus due to the herniated bowel segment, intraperitoneal fluid and pneumoperitoneum (Figure). Based on these findings, the patient was referred to pediatric surgery service with the diagnosis of intestinal perforation and abdominal wall hernia. Surgical exploration of the injured area demonstrated the disruption of all layers of the abdominal wall, and perforation of the jejunum at 110 cm distal to Trietz ligament. The postoperative period was uneventful.

Abdominal wall hernia and related visceral organ injuries should be considered following blunt abdominal trauma. In our case, high velocity impact by handlebar was able to disrupt abdominal muscle and fascia. In most handlebar hernias, the defect is in the lower abdominal wall and can be associated with intra-abdominal injury.[1,2] Injuries to the small bowel may occur secondary to high impact blunt trauma in a variety of deceleration mechanisms such as high-speed motor vehicle crashes, handlebar injuries, and falls.[3] Diagnosis is often delayed because there is usually no associated major blood loss. The small intestine is the most common site of perforation, and peritoneal irritation may not be evident initially. Plain radiograph is also unreliable



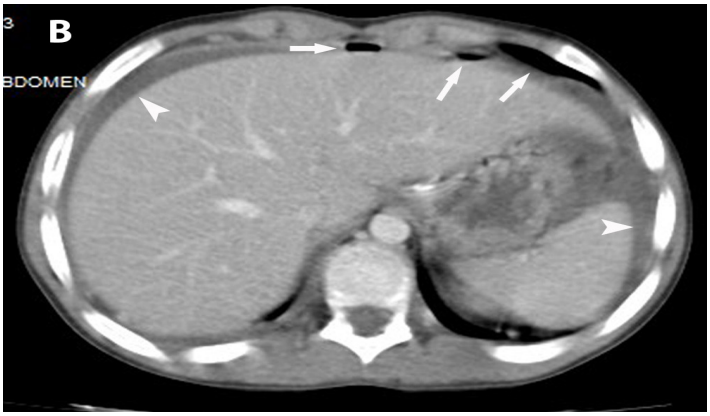


Figure. A. Axial computed tomography demonstrates the anterior abdominal wall defect and the herniated small bowel segment (arrow) with segmental ileus presented as dilatation of small bowel (*). B. Pneumoperitoneum (arrows) and free peritoneal fluid around the liver and spleen (arrowheads).

in diagnosis.[4] CT is useful to differentiate hernia and its content, to define the anatomy of disrupted abdominal wall layers, and to detect associated injuries accurately and surgery is the eventual management of these patients.

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Asystolic Cardiac Arrest from Near Drowning Managed with Therapeutic Hypothermia

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An estimated 200,000 cardiac arrests occur out-of-hospital annually in the United States.[1,2] The survival rates are 0-11% depending on the presenting rhythm.[3,4] Following cardiac arrest, the brain can tolerate anoxia up to 2-4 minutes, upon which irreversible neuronal damage commences in the absence of re-establishment of circulation.[5] Brain re-oxygenation with successful return of spontaneous circulation (ROSC) begins a deleterious chemical cascade that generates free radicals and other inflammatory mediators leading to devastating neurological outcomes termed post-resuscitation syndrome.[6] The harmful effects of reperfusion injury can be mitigated with the use of therapeutic hypothermia (TH) as demonstrated in case reports and dog models from as early as the 1950s.[7,8]

Physiological benefits of post-resuscitation therapeutic hypothermia include reduction in cerebral metabolic demands, reduction in intracranial pressure, and attenuation of an array of temperature dependent deleterious biochemical processes.[9] Therapeutic hypothermia may be neuroprotective in many causes of brain injury. There have been limited published data using therapeutic hypothermia to treat patients resuscitated from cardiac arrest after near drowning. To date, results from available studies enrolling patients resuscitated from asystolic cardiac arrest have failed to show statistically significant treatment benefit. We describe the management of a patient with asystolic cardiac arrest after drowning in whom therapeutic hypothermia was used.

CASE REPORT

A 44 year-old Caucasian male was found floating in the sea for an unknown duration of time and was pulled out by fire rescue paramedics. He was unconscious, pulseless, and in asystole as determined by emergency medical services. Cardio-pulmonary resuscitation (CPR) was commenced immediately. Advanced cardiac life support recommendations were followed and continued for the next 25 minutes. A total of 2 mg of epinephrine and 2 ampules of sodium bicarbonate given thru an intraosseus line resulting in return of spontaneous circulation, though with limited respiratory efforts. Subsequently, a supraglottic airway was inserted to facilitate ventilation. After a 15 minute ground transport the patient arrived in the emergency department in sinus tachycardia with a heart rate of 102 beats per minute, blood pressure of 140/90 mmHg, and oxygen saturation of 99% via supraglottic airway device with manual breaths every 6 to 8 seconds, rectal temperature was 37.1°C.

Despite return of spontaneous circulation, the patient was unresponsive with a Glascow Coma Scale (GCS) of 3. Pupils were fixed and dilated measuring 3 mm. The supraglottic airway was replaced with an endotracheal tube. Chest radiograph demonstrated patchy opacities bilaterally, and computed tomography of the brain and c-spine were negative for acute pathology. Bloodwork was unremarkable, with the exception of a blood alcohol level of 427. At this point, a decision was made to initiate therapeutic hypothermia following the hospital protocol.

Patient was transferred to the intensive care unit (ICU) with a diagnosis of hypoxic brain injury after a near drowning. We followed a three category treatment approach to our post cardiac arrest patient. This included airway management, circulatory management, and neuroprotection. We utilized a low tidal volume, lung protective strategy for mechanical ventilation with parameters in place to maintain a PaO_2 of 60-100 mmHg and $EtCO_2$ of 35-40 mmHg or $PaCO_2$ of 40-45 mmHg. In the emergency department, we utilized end tital CO_2, however in the ICU routine arterial blood gases were utilized. From a circulatory standpoint, a mean arterial pressure of over 70 mmHg was maintained via intravenous fluids with a plan for vasopressor use on a as needed basis. The neuroprotective measures that were begun in the emergency department continued in the ICU. This included our hospital's therapeutic hypothermia protocol

which includes a sedation and shivering prevention protocol via fentanyl, versed, and cisatracurium besilate as necessary. Patient was cooled rapidly using an external, commercially available cooling device to a target temperature of 34°C. Active cooling was stopped after 24 hours and the patient was allowed to passively re-warm. Pupils became responsive to light within 8 hours and reached normal size and reaction within 40 hours. GCS improved by day 3 to the point of spontaneous eye opening and obeying commands. A transthoracic echocardiogram showed an estimated ejection fraction of 55 percent without any structural heart disease. Patient continued to improve significantly over the course of his hospital stay. Patient was subsequently transferred on day 28 of his hospitalization to a rehabilitation facility with minimal cognitive deficits and mild upper extremity weakness bilaterally with a cerebral performance category of 1.

DISCUSSION

The International Liaison Committee for Resuscitation (ILCOR) has suggested that cooling may be beneficial for patients suffering cardiac arrest due to reasons other than an initial rhythm of ventricular fibrillation.[12]

Following ILCOR advisory statement of 2002, American Heart Association (AHA) incorporated therapeutic hypothermia in its 2005 recommendations for cardiac arrest patients as a class 2A recommendation. The AHA has since made therapeutic hypothermia a class 1 recommendation in cardiac arrest with initial rhythm of ventricular fibrillation and pulseless ventricular tachycardia and a class 2B recommendation for nonshockable rhythms. However, therapeutic hypodumas

thermia for nonshockable rhythms has not been subject to a formal randomized controlled trial, and we cannot plausibly prove that hypothermia contributed to the good outcome in this case. However, clinical trials of the use of therapeutic hypothermia for shockable rhythms in cardiac arrest, where the mechanism of neurological damage is likely to be similar, suggest that this treatment may have a role.[10,11] Dumas F et al[13] conducted an observational study to assess the effectiveness of therapeutic hypothermia in nonshockable rhythms, however failed to show any difference in outcome. Utilizing the available literature on the subject, we determined it reasonable to apply this intervention in our patient. Our goal was to start this therapy as soon as possible, given the results shown by Mooney et al[14], which demonstrated an increase in mortality of 20% for each hour that therapeutic hypothermia was delayed. In addition to therapeutic hypothermia, a more global approach to the management of our post cardiac arrest patient was followed. Stub D et al[15] recommended a three-category approach to the post cardiac arrest patient and condition known as post cardiac arrest syndrome. The three treatment categories include oxygenation/ventilation, circulatory support, and neuroprotection. These recommendations were followed and included avoidance of hyperoxia and hyperventilation, a lung protective ventilation strategy, a target mean arterial pressure between 70-100 mmHg as well as therapeutic hypothermia. Our patient was relatively young, without significant comorbidities and he was resuscitated after near drowning while severely intoxicated with alcohol. Either of these factors may actually have played a survival benefit role while he was resuscitated from asystolic cardiac arrest. Alcohol in particular is an interesting potential confounder as a neuroprotectant although a literature review revealed only data from rat models in ischemic stroke and traumatic brain injury.[15,16]

CONCLUSION

Given the outcome of this case, our experience supports the role of therapeutic hypothermia in the management strategy for patients subjected to hypoxic brain injury following resuscitation from asystolic cardiac arrest. In particular, this case supports the application of TH for patients resuscitated from asystole after a near drowning event as well as a more global approach to the management of the post cardiac arrest patient focusing on oxygenation/ventilation, circulatory support and neuroprotection.

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Pediatric Patient with a Rash

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A 2 year old fully immunized male with no personal history of chicken pox presented to the emergency department with a chief complaint of a rash for one week after returning from a hiking trip in a remote island in Canada. After initially being diagnosed with contact dermatitis, a diagnosis of herpes zoster was made by confirmatory viral polymerase chain reaction testing. The purpose of this case report is to examine the literature for the incidence and etiology of shingles in children without a prior history of a primary varicella rash outbreak. [West J Emerg Med. 2014;15(4):372–374.]

CASE REPORT

A 2 year old male presented with chief complaint of a rash on his left thigh and left lower back for 7 days. The mother of the child initially noted the rash on the child's left thigh after returning from a one week camping trip on a remote island in Canada. While the parents had gone hiking in the woods, the child was in day care during their trips and the parents said there was no point at which the child would have been exposed to any plants or other environmental exposures. After two days the mother took the child to an acute care clinic where the diagnosis of suspected contact dermatitis was made. The patient was treated with antihistamines and topical steroids. Over five days the rash progressed to involve the left lower back and appeared to spread outward from the initial area on the left thigh. It was at this time the patient presented to our emergency department for evaluation. The birth history was non-contributory. The patient was previously healthy, circumcised, and fully immunized through the age of two to include varicella. The patient was never exposed to chicken pox. The patient did not exhibit any signs of illness with the exception of a fever to 101.0˚F orally the day prior to presentation. Upon further questioning, the father of the patient recovered from shingles the previous week but was currently asymptomatic. The child had normal vitals on physical examination. The rash was maculopapular with small vesicular lesions on the left anterolateral thigh (Figure 2) and left lower lumbar back (Figure 1) in the L3 dermatome that blanched to palpation. There were two areas of coalescing papules located at the right paraspinous region of the mid-lumbar spine. There were no oral or anogenital lesions. The palms and soles were not involved. The rest of the examination was unremarkable.

Pediatrics were consulted for evaluation of the rash which was suspected to be herpes zoster. After admission to the pediatrics ward, viral deoxyribonucleic acid (DNA) polymerase chain reaction (PCR) studies were obtained via blood samples of the child, which were positive for varicella zoster DNA.

DISCUSSION

Initial herpes zoster infection in previously healthy children has been documented in the literature as a rare disease and to our knowledge, this is the first case reported in the emergency medicine literature. According to Leung et al[1], the incidence of zoster after primary exposure to varicella appears to be higher than in the vaccinated population. The incidence of herpes zoster is 14 cases per 100,000 person years among vaccine recipients and 20 to 63 (cases per 100,000 person years) among those with a natural varicella infection. A child, without experiencing a known primary outbreak of varicella zoster (chicken pox), may have his or her initial manifestation of the disease as herpes zoster (shingles). Leung et al[1] suggest that 2% of children exposed to varicella in utero may develop a subclinical chicken pox and are subsequently predisposed to a primary skin outbreak occurring in the form of herpes zoster. This is one of the mechanisms by which it is possible to see a child with a dermatomal rash without a known history of chicken pox. The rash may also

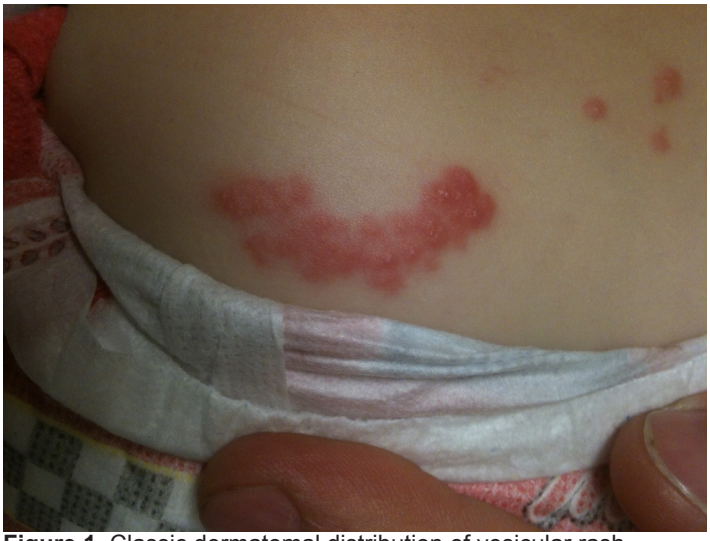

Figure 1. Classic dermatomal distribution of vesicular rash extending from the left lumbar back to the left anterolateral thigh.

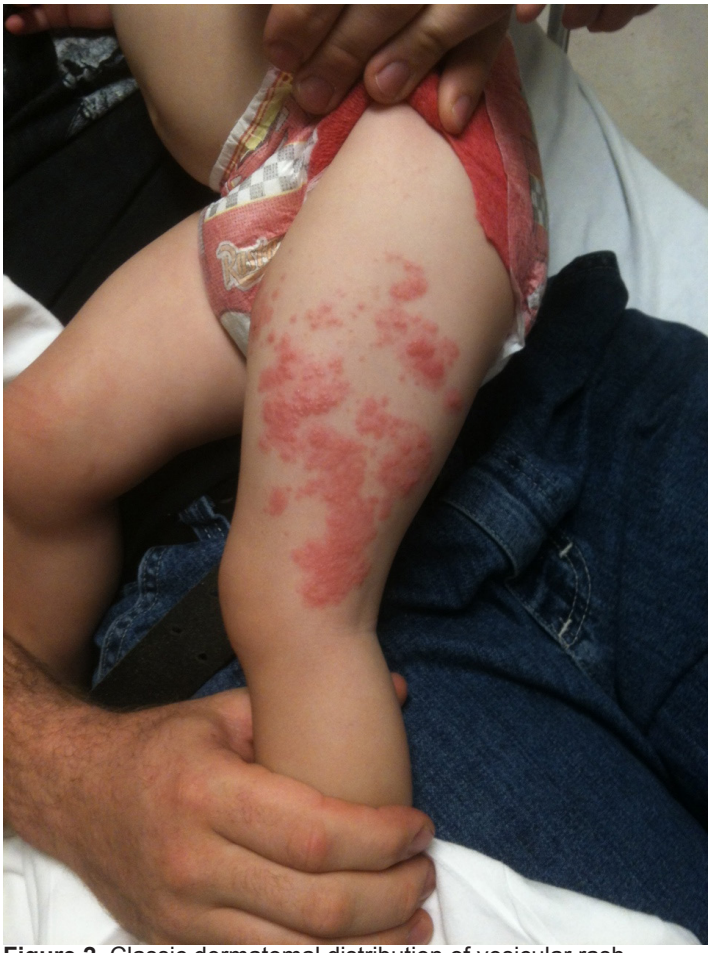

Figure 2. Classic dermatomal distribution of vesicular rash extending from the left lumbar back to the left anterolateral thigh.

develop in the setting of vaccination. Liang et al[2] reported a case of a child vaccinated for chicken pox who then developed a dermatomal rash four months later. This patient was a 19 month old previously healthy child that developed a dermatomal rash in her right upper extremity at the site of her prior vaccination at 15 months. PCR testing revealed the Oka vaccine strain virus from her right arm culture.[2] On another account, Kohl et al[3] presented a case report of a 6 year old boy without a known history of varicella exposure that presented with a wild type virus dermatomal rash. It was unknown whether or not the mother had varicella during her pregnancy with him. He was vaccinated in his right arm. He subsequently developed a dermatomal zoster rash 12 days later. This rash was subsequently confirmed to be wild type virus by viral PCR rather than vaccine type as anticipated.[3] Viral PCR and restriction fragment length polymorphism are currently used to verify the source as either vaccine DNA or wild type varicella.[1] Considering this, a number of mechanisms exist by which a child may present with a dermatomal rash without having any clear history of exposure to chicken pox.

After confirming the diagnosis of herpes zoster, the treatment depends on a variety of factors including the age of the patient, location of the rash, and whether or not the host is immunocompromised. Cohen[4] states that in adult patients, all immunocompromised and select immunocompetent individuals should receive antiviral treatment. Immunocompetent adult patients that should receive treatment include, but are not limited to, those with an age greater than 50, intractable pain, severe rash, and involvement of the face or eye.[4] In children, treatment caveats are similar. Antiviral treatment of herpes zoster in immunocompetent children should focus primarily on children with zoster ophthalmicus as well as children with a moderate to severe rash at onset.[5] The underlying goal of treatment with antivirals in all age groups should be the improvement of pain and healing of lesions, as current literature suggests that antivirals do not significantly lower the incidence of post herpetic neuralgia.[4] Of note, the incidence of post herpetic neuralgia is 0% in patients 0 to 29 years old and 34% in those over 80. Therefore, treating a pediatric patient with antivirals for the sole purpose of preventing post herpetic neuralgia would not likely confer benefit.[5]

If antiviral treatment is indicated, the treatments of choice for adults are the Food and Drug Administration (F.D.A.) approved medications acyclovir, famciclovir, and valacyclovir. Acyclovir remains the only F.D.A. approved medication for herpes zoster in children under 18 years old.[5] No matter the antiviral chosen, the goal to treat zoster within 72 hours of the onset of the rash is commonly mentioned. Some experts suggest that treating beyond this 72 hour window if the rash or disease continues to progress would be prudent, as it likely still confers benefit. The course of antiviral treatment should usually be 7 days.[4]

Other modalities used for treatment of zoster related pain for adults include opioids, lidocaine patches, gabapentin, and glucocorticoids. Glucocorticoid therapy remains in question, though some trials demonstrate benefits in pain and healing. Glucocorticoids also have not been shown to decrease the incidence of post herpetic neuralgia.[4] For most pediatric patients, ibuprofen provides adequate relief of acute zoster

related pain, although opioid medications like codeine should be considered for severe pain.[5]

The patient in this case report was discharged after starting on acyclovir and an uncomplicated overnight stay in the hospital. No glucocorticoids or novel treatments for zoster were prescribed.

The reason for the dermatomal rash on his thigh was not confirmed to be either wild or vaccine related, but this case supports the need for a thorough history and physical examination as well as retaining a high index of suspicion for any dermatologic disorders considered in the differential diagnosis.

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A Case of Rivaroxaban Associated Intracranial Hemorrhage

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Rivaroxaban is a newer anticoagulant initially approved by the Food and Drug Administration to treat nonvalvular atrial fibrillation. Rivaroxaban has several characteristics that are more favorable than warfarin. One of the characteristics is decreased risk of hemorrhage. We report one of the first case reports of severe intracranial hemorrhage associated with rivaroxaban in an elderly patient with decreased renal function. We aim to alert emergency medicine providers regarding the likelihood of encountering these patient as newer anticoagulants rise in popularity. [West J Emerg Med. 2014;15(4):375–377.]

INTRODUCTION

Rivaroxaban (Xarelto) is an oral factor Xa inhibitor that has been approved by the Food and Drug Administration (FDA) in 2010 to treat nonvalvular atrial fibrillation. New anticoagulants emerge as warfarin requires frequent monitoring, and has multiple drug and food interaction. Rivaroxaban was developed with the goal of predictable pharmacokinetics that eliminates the need for monitoring the international normalized ratio.[1-5] Several characteristics have made rivaroxaban an attractive alternative to warfarin; once daily dosing, obviate the need for monitoring the international normalized ratio, noninferiority to warfarin in treating atrial fibrillation, and decreased risk of bleeding in comparison to warfarin.[6] Although the risk of bleeding is decreased in comparison, the risk remains. We believe this is the first case report of intracranial hemorrhage secondary to rivaroxaban use.

CASE REPORT

CJ is a 92-year-old man with a past medical history of atrial fibrillation and ischemic stroke five months prior to emergency department (ED) presentation. He presented to the ED with left upper extremity and left lower extremity weakness, left facial droop and slurred speech. His initial vital signs in the ED at 9:38AM were temperature 97.4°Fahrenheit, blood pressure 175/59 mmHg, heart rate 111 beats per minutes, respiratory rate 28 times per minutes, oxygen saturation 97% on room air. On physical exam the patient was alert and followed commands intermittently, extraocular movement was intact bilaterally, pupils were equal and reactive bilaterally. Cranial nerve exam revealed left facial droop. Strength exam were 5/5 in right upper extremity and right lower extremities and 1/5 in left upper extremity and left lower extremity. Patient was transported to computed tomography (CT) immediately. CT head revealed an acute 6.7 cm x 5.3 cm right parasylvian and right basal ganglia hemorrhage with surrounding edema, as well as 7 mm leftward midline shift at the level of the septum pellucidum. When the patient returned from CT, his eyes deviated to the right side. Fosphenytoin was initiated for likely seizure. His blood pressure was elevated to 230/100 mmHg. Labetalol 20 mg was administered intravenously with improvement of blood pressure. The patient became progressively lethargic while in the emergency department. He was intubated under rapid sequence intubation at 10:20AM. Since the patient was on rivaroxaban, the plan was to administer prothrombin complex concentrate (PCC). However, PCC was not available at the facility. Two units of fresh frozen plasma were administered intravenously at 10:58AM.

Laboratory result revealed white blood cell 12.93 bil/L, hemoglobin 11.3 g/dL, hematocrit 33.4%, platelet 135 bil/L, sodium 137 mMol/L, potassium 4.2 mMol/L, chloride 101 mMol/L, CO2 22 mMol/L, BUN 30 mg/dL, creatinine 1.3 mg/dL, protime 11.3 seconds, INR 1.1 IU, PTT 23.8 seconds, plasma rivaroxaban level 95 ng/mL. Neurosurgery service was consulted, and recommended no surgical intervention at this time. The patient was admitted to the intensive care unit (ICU). Two days after ICU admission, the family withdrew care.

According to the patient's family members, the patient was on warfarin for many years. However, due to warfarin's interaction with food and frequent need for clinic visits to assess patient's coagulation panel, the patient's physician switched him to dabagatrin nine months prior to this ED

Table 1. Recommended dose of rivaroxaban per package insert.

Recommended dose of rivaroxaban	Renal function for recommended dose
20 mg once daily	CrCl >50 mL/min
15 mg once daily	CrCl 15 to 50 mL/min

Table 2. Recommended reversal agents for hemorrhage associated with rivaroxaban.

Recommended reversal agents
Prothrombin complex concentrate (PCC)
Factor VIII
Factor eight inhibitor bypass activity (FEIBA)
Fresh frozen plasma (FFP)

presentation. The patient had difficulty swallowing the dabagatrin's capsule, so his physician switched him to rivaroxaban four months prior to the ED presentation.

DISCUSSION

Rivaroxaban (Xarelto) is a new anticoagulant that was approved by the FDA in 2011 for stroke and systemic embolism prophylaxis in patients with nonvalvular atrial fibrillation. Rivaroxaban is also indicated for treatment and prevention of pulmonary embolism and deep vein thrombosis.[7,8] The Factor Xa inhibitor is a major new anticoagulant drug class that emerged as warfarin requires frequent monitoring, and has multiple drug and food interaction. Rivaroxaban was developed with the goal of predictable pharmacokinetics that eliminates the need for monitoring the international normalized ratio.[1,2,3,4,5] Several characteristics have made rivaroxaban an attractive alternative to warfarin; once daily dosing, obviate the need for monitoring the international normalized ratio, noninferiority to warfarin for preventing stroke in patients with atrial fibrillation, lower risk of intracranial hemorrhage compared with warfarin.[6]

Rivaroxaban inhibits factor Xa activity and prolonging plasma clotting time.[2] Traditional coagulation studies do not determine the degree of anticoagulation of rivaroxaban.[9] Methods that measure the degree of anticoagulation of rivaroxaban include tissue factor-activated clotting time.[10] In overdose situations, rivaroxaban does increase INR. Study by Mueck et al reveals that rivaroxaban plasma concentrations and prothrombin time (PT) correlates with a linear model.[11] APTT prolongation also occurs in dose-dependent fashion.[12] The coagulation panel was within normal limit in our patient. Furthermore, the measured rivaroxaban level was 95 ng/mL, (the range of level of 0–666 ng/ml was found in patients on therapeutic dose of rivaroxaban by van Veen).[13] The level was measured from the first set of blood that was drawn when the patient presented to the ED. The rivaroxaban level was measured by time of flight (TOF) at the University of California, San Francisco laboratory several weeks subsequent to the event. The intracranial hemorrhage in this patient is most likely associated with therapeutic dosing.

Although the study lead by Patel[6] revealed statistically significant reduction in intracranial hemorrhage with rivaroxaban versus warfarin (0.5% vs. 0.7%, p=0.02), some characteristics of rivaroxaban may prevent its wide application. In the EINSTEIN DVT, PE, and Extension clinical studies, both thrombotic and bleeding event rates were higher in patients over the age of 65 than in those under the age of 65.[7] Furthermore, rivaroxaban is not recommended in patient with decreased creatinine clearance as drug exposure is increased, and the risk of bleeding is elevated.[14-16] Rivaroxaban is also contraindicated in patients with hepatic disease associated with coagulopathy.[17] In addition, rivaroxaban is associated with increased risk of gastrointestinal bleeding compare to warfarin.[18] Our patient was 92 years old with mild renal dysfunction. The recommended dose of rivaroxaban per package insert is 20 mg once daily for CrCl >50 mL/min, and 15 mg once daily for patient with CrCl 15 to 50 mL/min (Table 1). The patient's CrCl was 46.15 mL/min. Therefore, his recommended daily dose of rivaroxaban was 15 mg once daily. According to his family member, the patient was compliant with his medications. Therefore, rivaroxaban may not be the optimal choice of anticoagulant for him.

According to ISMP (Institute for Safe Medication Practices), rivaroxaban was associated with 356 adverse event in the first quarter of 2012. Of those, 158 cases were associated with serious thrombus, ie pulmonary embolism. One hundred and twenty one cases were associated with hemorrhage. Possible suboptimal anticoagulation due to the predominance of thromboembolic event, in additional to the risk of bleeding, should be balanced against the favorable characteristics of rivaroxaban in patients who plan to use this newer anticoagulant.

Emergency medicine (EM) clinicians are more likely to care for these patients as newer anticoagulants rise in popularity. Recommended reversal agents for rivaroxaban associated hemorrhage are included in Table 2 for EM providers.

CONCLUSION

Rivaroxaban is a newer anticoagulant that has several advantages to traditional anticoagulants. However, adverse effect does occur rarely. We report the first case report documenting intracranial hemorrhage associated with rivaroxaban. Caution should be used in selective patient populations, such as elder's and patients with hepatic or renal dysfunction.

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Paralytic Shellfish Poisoning: A Case Series

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We describe a case series of seven patients presenting to an emergency department with symptoms of paralytic shellfish poisoning. They developed varying degrees of nausea, vomiting, diarrhea, weakness, ataxia and paresthesias after eating mussels harvested from a beach near their resort. Four patients were admitted to the hospital, one due to increasing respiratory failure requiring endotracheal intubation and the remainder for respiratory monitoring. All patients made a full recovery, most within 24 hours. The ability to recognize and identify paralytic shellfish poisoning and manage its complications are important to providers of emergency medicine. [West J Emerg Med. 2014;15(4):378–381.]

INTRODUCTION

Paralytic shellfish poisoning is a foodborne illness that typically develops after consumption of shellfish contaminated with saxitoxin. During blooms of toxic algae, especially dinoflagellates of the genera *Alexandrium,* feeding molluscan bivalves and other shellfish concentrate the toxin and are unsafe to consume.[1] Within hours of eating shellfish contaminated with toxic levels of saxitoxin, victims develop gastrointestinal distress and neurological symptoms, ranging from benign circumoral paresthesias and tingling of the extremities to ataxia, dysphagia, and changes in mental status.[2] Many patients describe a sensation of "floating" or dissociation. Hypertension and tachycardia have been reported.[3] While most patients recover without treatment, weakness may rapidly progress to respiratory paralysis and asphyxiation. Currently there are no antidotes to saxitoxin and treatment is supportive.[1]

While much is known about saxitoxin and its relationship to blooms of toxic dinoflagellates, reports of paralytic shellfish poisoning and descriptions of findings in its victims are infrequent in the medical literature. We describe seven patients with presumed paralytic shellfish poisoning, including one requiring intubation and respiratory support. Patients with paralytic shellfish poisoning most often present in coastal locations, but the international distribution of shellfish as a food substance expands the risk of paralytic shellfish poisoning to anywhere in the world. Knowledge of all shellfish poisoning syndromes is important, but the ability of the emergency medicine provider to recognize paralytic shellfish poisoning facilitates the anticipation and management of potentially rapidly progressive muscle paralysis and respiratory arrest.

CASE SERIES

The poison center was contacted by emergency medicine staff at a community hospital regarding management of seven patients presenting with suspected paralytic shellfish poisoning. The patients were part of a group visiting the area and staying at a nearby resort. Around midnight, they harvested mussels on the beach near their hotel and prepared them in a soup which they ate between midnight and 2 a.m. Approximately 1-2 hours later, they began experiencing various symptoms: peripheral paresthesias (7/7), nausea (5/7), vomiting (4/7), diarrhea (3/7), ataxia (3/7), weakness (2/7), and shortness of breath (1/7). There were 4 males and 3 females, aged 19 to 67 years. The most affected was a 62 year old female who developed dysarthria and a floating sensation in addition to nausea and vomiting. She was transported by emergency medical services after she became ataxic, fell and could not stand up. At the hospital, her exam revealed pronounced dysarthria and diminished gag reflex in addition to her subjective dyspnea, oral paresthesia, and sensation of her throat closing up. Due to concerns of impending airway compromise, the patient was emergently intubated, placed on a ventilator, and transferred to the intensive care unit (ICU). Her laboratory results were remarkable only for hypokalemia (2.5 mmol/L) which improved with repletion. She was extubated after 24 hours and then discharged home in good condition the following day.

The etiology of her low potassium is uncertain and a

literature search failed to find any known association with saxitoxin. Gastrointestinal loss from vomiting and diarrhea is unlikely considering the short duration of the symptoms. There was no documentation of beta agonists given in the Emergency Department; however emergency medical services records were not available and therefore unknown if any medications given en route. Since the patient was on an antihypertensive medication (patient did not know which one), she may have had underlying sub-acute or chronic hypokalemia. Basic electrolytes were checked on all of the patients and no one else exhibited hypokalemia, results ranged from 3.7 to 4.1 mmol/L.

After the initial patient was intubated, all remaining patients had serial peak flow measurements obtained (Table). The expected normal values based on heights and weights were not included in the records. Only patient "F" had height and weight recorded, allowing calculation of expected peak flow rate. His effort of 470 Liters per minute was 89% of expected per standard peak flow chart. Six of the patients were hypertensive, either at triage or during their hospital course. Tachycardia was present in four patients, three at triage and one later in the emergency department.

Three patients were admitted to the ICU for monitoring

Table. Serial peak flow measurements obtained after initial patient was intubated.

Patient age/ gender	Symptoms	Triage vital signs	Peak blood pressure, mm Hg	Peak heartrate, bpm	Vital signs at time of disposition	Peak Flow Rates*	Admitted?
A 19 Female	Dizzy, nausea	118/75 HR 95 RR16 96% RA	165/117	100	109/78 HR 74 RR12 97% RA	325 370 380	No
B 43 Female	Vomiting, diarrhea, facial numbness, ataxia, arm & leg weakness	149/10 HR 92 RR16 99% RA	151/87	93	99/58 HR 67 RR16 99% RA	290 280 320 330	ICU
C 47 Male	Vomiting, paresthesia	192/119 HR 110 RR14 99% RA	192/119	110	156/106 HR 101 RR18 96% RA	310 300 275 275	ICU
D 67 Male	Facial & fingertip paresthesia	149/100 HR 86 RR12 97% RA	158/95	89	158/95 HR 87 98% RA	450 400 500	No
E 49 Male	Floating sensation, dizzy, vomiting, diarrhea, facial & fingertip paresthesias	153/113 HR 96 RR12 96% RA	163/107	96	159/92 HR 95 RR15 99% RA	400 450	ICU
F 52 Male	Facial & fingertip paresthesia, dizzy	129/87 HR 112 RR16 97% RA	129/87	112	118/62 HR 86 RR14 96% RA	420 470	No
G 62 Female	Floating sensation, dyspnea, vomiting, diarrhea	175/84 HR 97 RR16 100% RA	226/128	123	114/72 HR 96 RR20 100% (vent)	none	ICU (Intubated)

HR, heart rate; *RR,* respiration rate; *bpm*, beats per minute; *ICU*, intensive care unit; *RA,* room air

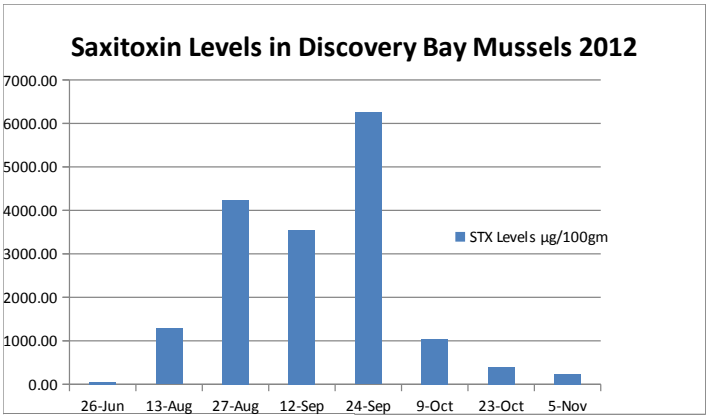

Figure. Saxitoxin levels found in shellfish meat.

of respiratory status and were subsequently discharged within 24 hours. The remaining patients were evaluated in the emergency department, monitored, and discharged with resolved or resolving symptoms. No urine or serum saxitoxin levels were obtained from the patients. The beach where the family had harvested their mussels was under restriction for collecting shellfish due to elevated saxitoxin levels; however the patients failed to see the Department of Health notice due to the darkness. On 24 September 2012, the day after the patients' presentation, saxitoxin levels obtained from shellfish from the beach were found to average 6250 mcg/100 gm of shellfish meat (Figure).

DISCUSSION

Shellfish poisoning occurs after ingestion of organisms contaminated by infectious agents or concentrated toxins. Toxins concentrated in the flesh of shellfish can produce syndromes that include paralytic shellfish poisoning, amnesic shellfish poisoning, diarrheic shellfish poisoning, and neurologic shellfish poisoning.[1] Shellfish poisoning syndromes provide a confusing array of overlapping signs and symptoms. Providers may fail to recognize these syndromes and may attribute findings to cerebrovascular events, intoxication, psychiatric illness, or other disorders.[4]

Paralytic shellfish poisoning is a growing problem worldwide and occurs seasonally in the coastal United States.[5] Saxitoxin is produced by certain dinoflagellates and concentrated in the flesh of filter feeding mollusks, including clams, oysters, and mussels. These dinoflagellates are bloom-forming microalgae that thrive in calm, warm waters. They include about ten *Alexandrium* species in the waters surrounding the United States. Dinoflagellate blooms are commonly called "red tide," but can occur with other color changes in water (green, brown, or yellow) and toxic levels of saxitoxin can occur in clear-appearing water. This has led to the recommendation that such events be called "harmful algal blooms" instead of "red tides."[6,7] First isolated from butter clams (Saxidomus gigantea), saxitoxin is a potent neurotoxin three orders of magnitude more toxic than sodium cyanide (Lethal Dose 50: saxitoxin 10mcg/kg, cyanide 10mg/kg).[8,9] Saxitoxin has also been associated with pufferfish, cyanobacteria, and other marine animals.[10]

Consumption of saxitoxin from any source produces a syndrome through the blockade of voltage-gated fast sodium channels, inhibiting signal propagation in neural tissue.[1] Symptoms commonly include paresthesias of the mouth, face, and lips; odd feelings of floating; tingling of the extremities; and rapidly-progressive weakness and paralysis. Gastrointestinal distress occurs in many victims and hypertension is commonly seen in paralytic shellfish poisoning patients.[3] Most victims fully recover without medical care, but some need control of gastrointestinal distress, and some require airway control and mechanical ventilation.[4] Predictors of the severity of neurological toxicity have not been identified. Symptom onset is rapid, usually within the first 1-2 hours, and recovery within 24 to 48 hours. Some patients describe fatigue for several days after paralytic shellfish poisoning.[1]

The diagnosis of paralytic shellfish poisoning is almost always made clinically, but can be confirmed by measurement of saxitoxin levels either in the shellfish meat or the patient's urine or serum.[11] In our case series, the diagnosis was based on clinical presentation, geographic location, and temporal association with eating bivalves from a beach with known toxic levels of saxitoxin. The Washington Department of Health (DOH) became involved at the onset of the case and tested shellfish from that beach for saxitoxin, domoic acid, & okadaic acid; only saxitoxin was above the safety threshold and measured 6025 mcg/100 gm (beaches are closed when levels are greater than 80 mcg/100 gm). During the course of its investigation, the DOH determined that paralytic shellfish poisoning was the causative agent. Although other toxins, especially tetrodotoxin, ciquatoxin, and brevetoxin can cause a similar constellation of symptoms, these are very unlikely since not endemic to this particular location and the onset occurred after eating mussels caught locally. In addition, the neurologic symptoms make a food borne illness such as Vibrio species unlikely. Chemical and nerve agents should also be considered, however, the short duration of symptoms and a known exposure to a biologic toxin, saxitoxin, makes this extremely unlikely as well.

Our cases of paralytic shellfish poisoning demonstrated the common findings of neurologic and gastrointestinal symptoms.[3] Five of the seven patients were hypertensive at triage and the most symptomatic patient showed the highest blood pressure in the group. Only one patient did not develop hypertension. Four of the patients were monitored in an intensive care setting, one required airway control and mechanical ventilation. Two of the patients described the characteristic "floating sensation" frequently seen in paralytic shellfish poisoning. In addition, six patients had peak expiratory flow rates measured to evaluate and monitor ventilatory status. Of note, the peak expiratory flow rates

of only two patients (A & B) progressively improved as symptoms resolved.

Three additional cases of suspected paralytic shellfish poisoning were identified by searching Washington Poison Center records from the 6-month period May to October 2012 for the key words "paralytic," "shellfish," "clams," "mussels," "oysters," and "food poisoning." The 10 cases of paralytic shellfish poisoning identified in Washington in 2012 represent a considerable increase over the average number reported in recent years (0-2 cases annually in Washington State since 1998). The actual number of cases of paralytic shellfish poisoning in Washington is likely underestimated, as many cases of paralytic shellfish poisoning go unreported.[4]

Saxitoxin levels are measured in shellfish collected from public beaches in Washington State every two weeks in the summer months.[12] Symptoms usually develop in humans at saxitoxin levels significantly above 80 mcg per gram of shellfish meat.[13] When saxitoxin levels exceed 80 mcg per 100 gram of shellfish meat, beaches are closed, marked with signs, and identified on the Washington State Shellfish Program website.[12] Such closures occur annually on the coastal areas of Washington; however the beaches of southern Puget Sound usually remain open. The summer of 2012 was unique with many days of sun and light wind in the Puget Sound, and may have promoted the growth of *Alexandrium,* necessitating beach closure much further south than usual.

Paralytic shellfish poisoning is a preventable condition. Because commercially harvested shellfish are routinely tested for saxitoxin, victims are typically hobbyists, collecting clams or mussels from local beaches. While avoiding non-commercially harvested shellfish is the best way to prevent paralytic shellfish poisoning, shellfish harvesting is a common practice for some citizens of Washington State and a cultural tradition for many members of the Pacific Northwest native tribes. The patients identified in this series harvested mussels in darkness and did not see warning signs posted on the beach. None of the victims checked the Washington State Shellfish Program website – they reported a practice of collecting squid and shellfish annually from that site and never needing to check for beach closure in the past. The unusual closure of southern Puget Sound beaches in 2012, failure to review online information, and darkness obscuring posted warning signs contributed to this outbreak of paralytic shellfish poisoning.

Patients with shellfish poisoning most often present in coastal locations. Knowledge of these syndromes and the ability to recognize them is important to Emergency Medicine providers in coastal areas. However, the wide distribution of shellfish as a food product makes knowledge of shellfish poisoning syndromes, especially paralytic shellfish poisoning with its risk of rapidly progressive paralysis of respiratory muscles and need for ventilation, important to all Emergency Medicine providers regardless of their location. Prompt recognition of cases of paralytic shellfish poisoning can prevent complications and death in individual patients, and provide an opportunity to limit the impact of an outbreak by coordinating investigation and intervention with the local health department and poison control center.

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Bilateral Hydronephrosis and Cystitis Resulting from Chronic Ketamine Abuse

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Ketamine associated urinary dysfunction has become increasingly more common worldwide. Point-of-care ultrasound (POCUS) is an established modality for diagnosing hydronephrosis in the emergency department. We describe a case of a young male ketamine abuser with severe urinary urgency and frequency in which POCUS performed by the emergency physician demonstrated bilateral hydronephrosis and a focally thickened irregular shaped bladder. Emergency physicians should consider using POCUS evaluate for hydronephrosis and bladder changes in ketamine abusers with lower urinary tract symptoms. The mainstay of treatment is discontinuing ketamine abuse. [West J Emerg Med. 2014;15(4):382–384.]

INTRODUCTION

Ketamine induced urinary dysfunction (KAUD) is a syndrome first described in the literature in 2007. Patients suffer from irritative lower urinary tract symptoms and can develop varying degrees of hydronephrosis and interstitial cystitis. We describe a case of a young man with a history of heavy ketamine abuse who presented to the emergency department (ED) with lower urinary tract irritation and flank pain.

Why should an emergency physician (EPs) be aware of this?

Although previously unreported in United States ED literature, ketamine associated urinary dysfunction has become increasingly more common in EDs worldwide. Point-of-care ultrasound (POCUS) is an established modality for diagnosing hydronephrosis in the ED. EPs should consider using POCUS evaluate for hydronephrosis and bladder changes in ketamine abusers with lower urinary tract symptoms. The mainstay of treatment is discontinuing ketamine abuse.

CASE REPORT

Twenty four-year-old Chinese-American male with a history of ketamine abuse (3-5 times daily for 4 years), as well as cocaine and intravenous drug abuse, who presented to the ED with bilateral flank pain for 2 weeks. He noted 2 days of increasing pain, described as dull, waxing and waning. Associated symptoms included fever, chills, urinary frequency, dysuria, urgency, and more recently, urinary incontinence (requiring diapers). There was no history of weakness, bowel incontinence, or saddle anesthesia. On physical examination, the patient appeared uncomfortable and anxious. He complained of severe urgency, requiring frequent urination during the interaction. Mild bilateral costo-vertebral tenderness was noted, with an otherwise unremarkable abdominal and genitourinary examination. Neurologic examination was normal except for slight ataxia when performing tandem gait.

The treating ED physician performed POCUS that revealed bilateral moderate hydroureteronephrosis (Figure 1) and a contracted bladder with an irregular shape and areas of focal wall thickening (Figure 2). The patient complained of frequency and urgency throughout the study and requested multiple times to pause the exam to urinate. Pain was elicited on suprapubic transducer application.

Laboratory studies revealed an elevated creatinine (1.32 mg/dL) and urinalysis was positive for red blood cells (5-10/high powered field), white blood cells (10-25/hpf), few bacteria, protein (75 md/dL) and trace leukocyte esteraste. The remainder of his lab work (CBC, chemistry, coagulation profile) was negative.

A computed tomography was ordered to rule out obstructive pathology and ultimately confirmed our POCUS findings. The final reading was "moderate bilateral hydroureteronephrosis, and a small deformed urinary bladder." A urology consult was obtained. An outpatient workup was recommended for ketamine induced urinary tract disease. The patient was sent home with antibiotics for a urinary tract infection and encouraged to discontinue ketamine abuse. Upon review, the urine culture was negative and the patient was lost to follow up.

DISCUSSION

Ketamine is an *N*-methyl-*D*-aspartate receptor antagonist, used therapeutically as a dissociative anesthetic. Recreationally, it is frequently abused at raves, parties, and nightclubs. Patients with acute ketamine toxicity most often present to EDs with neurologic complaints such as confusion, loss of consciousness, agitation, and drowsiness. Recent literature suggests that many patients with chronic ketamine abuse also experience ketamine-associated urinary tract dysfunction (KAUD). To our knowledge, this is the first case of KAUD associated with bilateral hydronephrosis reported from a United States ED. This may be due to the fact that recreational ketamine occurs with much higher frequency outside the U.S., especially in East and South-East Asian countries.[1-3]

Ketamine associated urinary tract dysfunction (KAUD) is a syndrome first described by Shahani et al in 2007.[4] Since then, there has been over 110 cases reported in the literature.[5] About 20-30% of patients who abuse ketamine suffer from lower urinary tract symptoms (LUTS).[6,7] Since most cases of KAUD have been reported in case reports, case series, and letters, the true prevalence of this disease is unknown. In a recent large community–based study, Pal et al[1], report a prevalence of LUTS of 30% among recent users. Furthermore, they conclude that recent ketamine users had increased odds of LUTS compared with non-users.

The exact mechanism of ketamine associated urinary destruction is unknown. Some proposed mechanisms include: direct epithelial damage, microvascular injury, or immune-related damage to the urinary tract by ketamine or its metabolites.[6,9] Damage to the lower urinary tract damage is more common than upper urinary tract, although the latter occurs relatively frequently. These symptoms can be attributed to chronic inflammation, low bladder capacities, decreased bladder compliance, and/or detrusor overactivity.[9] Symptoms can become quite debilitating, causing frequent urination every 15-45 minutes, as described in our case.

Currently, this disease entity is a diagnosis of exclusion that typically occurs after ruling-out obstructive lesions. Patients with severe irritative lower urinary tract symptoms, a history of ketamine abuse, and no other cause for symptoms should be considered to have KAUD.[5] We believe point-of-care ultrasound is a safe, rapid, first-line imaging modality to consider in patients with suspected KAUD. POCUS for the detection of hydronephrosis in the ED has a sensitivity and specificity of 80-87% and 82-83%, respectively.[10,11] In addition, it is rapid, available, and free of ionizing radiation. One limitation of POCUS is the ability to rule out obstructing lesions and masses.

Although the true incidence of positive findings of renal and bladder ultrasound in patients with KAUD is unknown, recent case series and reports suggest sonographic findings are frequent. Mason et al[12] reported that 12 of 23 patients in their case series had positive finding on renal ultrasound that included bladder wall thickening and small bladder volumes. Thirteen percent of these patients were found to have upper urinary tract involvement. Four patients were unable to fill their bladder and had to stop in the middle of the exam to empty their bladders.[12]

Chu et al[9] described 59 patients from two hospitals in Hong Kong with ketamine-associated cystitis. Fifty-one percent of these patients had unilateral hydronephrosis, while 44% had bilateral hydronephrosis. They report that most of these patients showed hydronephrosis and hydroureter that extended down to the vesiculo-uteric junction. It is postulated that upper

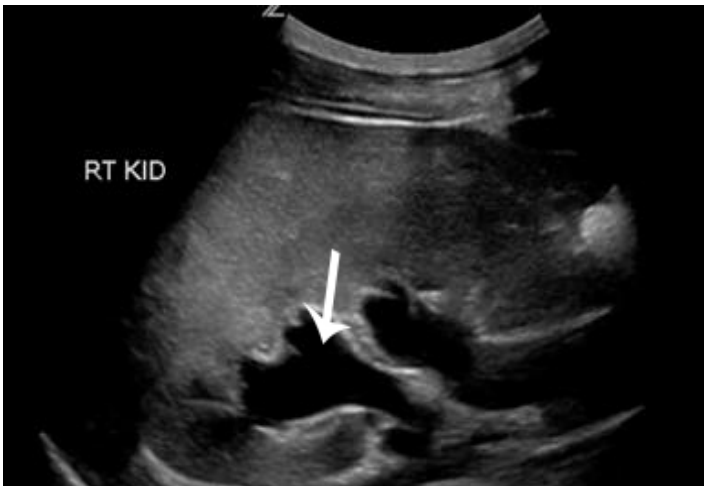

Figure 1. Longitudinal view of the right kidney showed moderate hydroureteronephrosis (arrow).

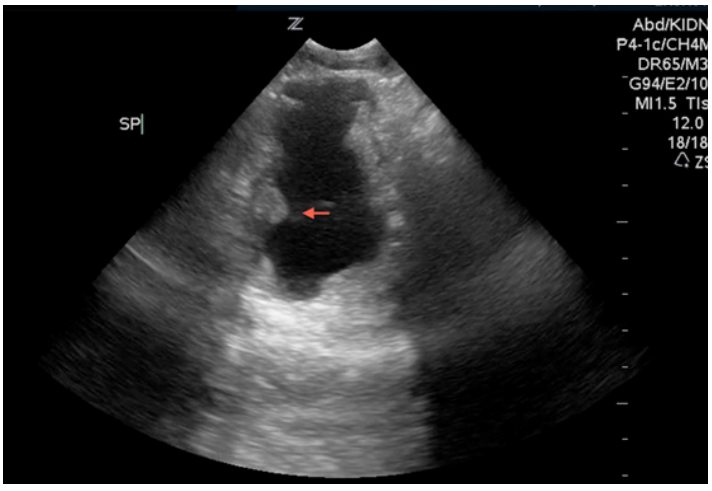

Figure 2. Transverse view of the bladder shows a small, irregularly shaped bladder wall with areas of focal thickening (arrow).

tract involvement likely results from long-term decrease in bladder compliance.[9,12] Tsai et al[8], reported 5 of 11 patients in their case series had bilateral hydronephrosis. These patients exhibited detrusor overactivity with small bladder capacities on urodynamic studies.[8]

Currently, the mainstay of therapy has been the discontinuation of ketamine use. Most patients have sterile pyuria where antibiotics are ineffective.[9] Other treatment modalities have included antimuscarinics and steroids, which have demonstrated limited efficacy for KAUD.[8] Surgical interventions (augmentation enterocystoplasty, ureteroplasty, cystectomy[9], and ileal neobladder[12]) have been performed for patients with continued use and refractory symptoms.

Ketamine associated urinary dysfunction is becoming an increasingly common and recognized syndrome associated with chronic ketamine abuse. Emergency physicians should consider the use of point-of-care ultrasound as a first-line imaging modality in patients with suspected KAUD. Patients should be advised to discontinue ketamine abuse and referred to a urologist to exclude alternative causes.

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Intestinal Obstruction Caused by Phytobezoars

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INTRODUCTION

A 55-year-old woman with a 3-month history of abdominal pain presented to the emergency department with chief complaints of worsening abdominal pain and per os intolerance since 3 days ago. Her medical history was noteworthy for watery diarrhea without fever, loss of appetite, weight loss, and nausea and vomiting. Examination revealed abdominal tenderness over right and left lower quadrant (LLQ). Plain radiography and computed tomography showed round calcified mass with small areas of air in cecum and 2.5 and 4.5 cm-diameter round masses in LLQ (Figure 1-3).

DISCUSSION

The intestinal obstruction caused by *Phytobezoars*. Bezoars are classified into 4 main types; phytobezoars, trichobezoars, pharmacobezoars, and lactobezoars. Phytobezoars, the most common types of bezoar, are composed of vegetable matter.[1] They are concretion of poorly digested fruit and vegetable fibers that usually become impacted in the narrowest portion of the small bowel.[2] Previous gastric resection or ulcer surgery predisposes to bezoar. Abnormal mastication, decreased gastric motility and secretion, autonomic neuropathy in patients with diabetes and myotonic dystrophy are some other predisposing factors.[3] The common presenting symptoms are vague feeling of epigastric fullness, nausea, vomiting, anorexia, early satiety, and weight loss.[4]

The masses were surgically removed in our patient. They consisted of 25-30 foreign bodies in various size including pits, seeds, small pieces of stones, and date kernels.

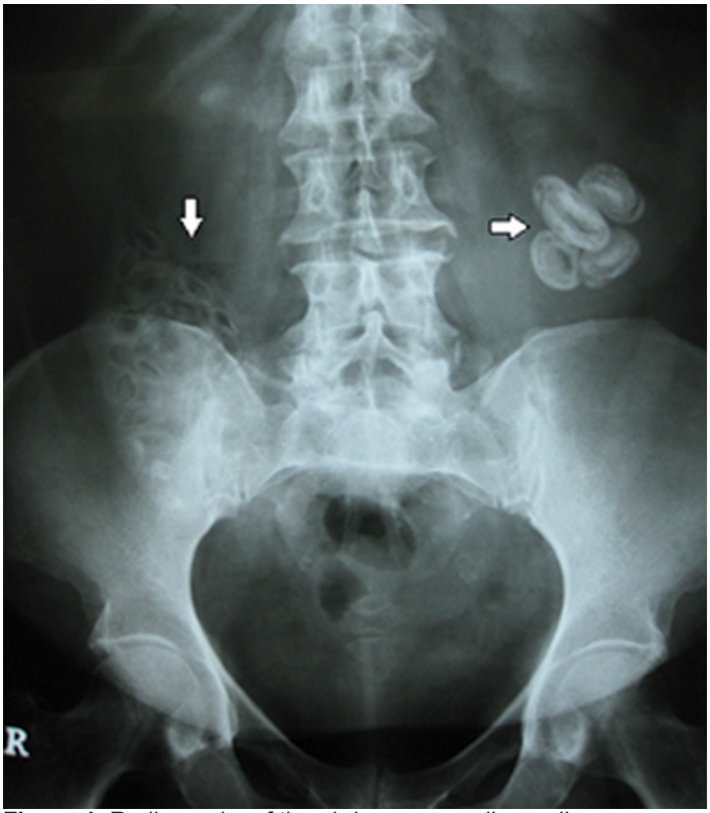

Figure 1. Radiography of the abdomen revealing radio-opaque shadows (arrowheads).

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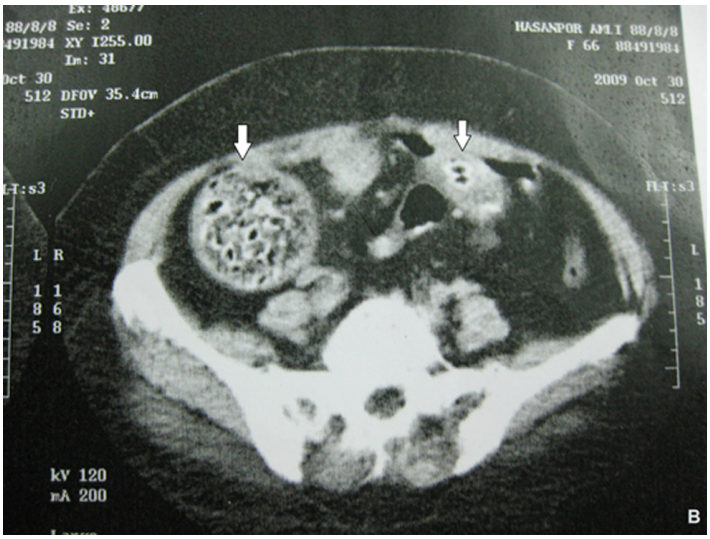

Figure 2. Contrast-enhanced abdominal computed tomography transverse image showing round calcified mass with areas of air (arrows).

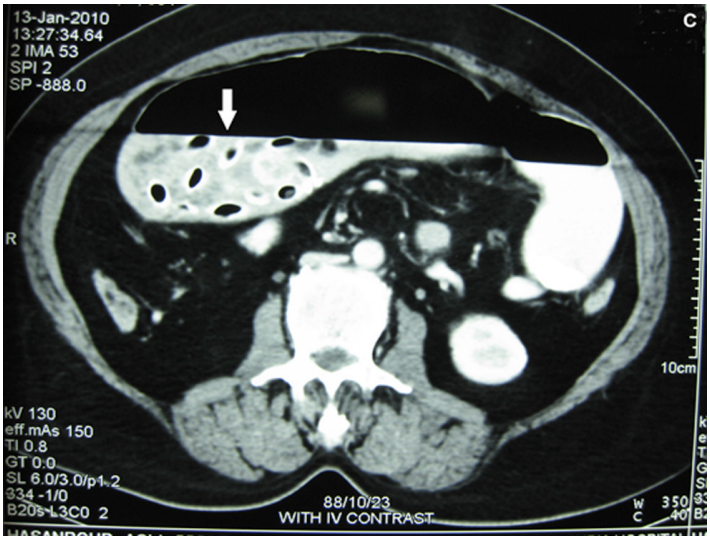

Figure 3. Contrast-enhanced abdominal computed tomography transverse image showing round calcified mass with areas of air (arrow).

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Facial Firework Injury: A Case Series

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Fireworks are used to celebrate a variety of religious, patriotic, and cultural holidays and events around the world. Fireworks are common in the United States, with the most popular holiday for their use being national Independence Day, also known as July Fourth. The use of fireworks within the context of celebrations and holidays presents the ideal environment for accidents that lead to severe and dangerous injuries. Injuries to the face from explosions present a challenging problem in terms of restoring ideal ocular, oral, and facial function. Despite the well documented prevalence of firework use and injury, there is a relatively large deficit in the literature in terms of firework injury that involves the face. We present a unique case series that includes 4 adult male patients all with severe firework injuries to the face that presented at an urban level 1 trauma center. These four patients had an average age of 26.7 years old and presented within 5 hours of each other starting on July Fourth. Two patients died from their injuries and two patients underwent reconstructive surgical management, one of which had two follow up surgeries. We explore in detail their presentation, management, and subsequent outcomes as an attempt to add to the very limited data in the field of facial firework blast injury. In addition, the coincidence of their presentation within the same 5 hours brings into question the availability of the fireworks involved, and the possibility of similar injuries related to this type of firework in the future. [West J Emerg Med. 2014;15(4):387–393.]

INTRODUCTION

Fireworks are used worldwide to celebrate a variety of religious, patriotic, and cultural holidays and events. Fireworks are extremely common in the United States (U.S.), with the most popular holiday for fireworks being national Independence Day, also known as July Fourth. We present a unique case series that includes 4 adult male patients, all with firework injuries to the face, who presented within 5 hours of each other during the July Fourth holiday at an urban level 1 trauma center. We explore in detail their presentation, management, and subsequent outcomes as an attempt to add to the very limited data in the field of facial firework blast injury.

CASE REPORT

Case 1

Patient 1 is a 26-year-old male that was transferred from an outside hospital secondary to a firework blast to the face. He was described as alert but "restless" upon presentation. The outside hospital physician was not able to intubate the patient after 2 attempts and a cricothyroidotomy was performed at the outside hospital for airway protection. He was hypoxic and tachycardic the majority of the time at the outside hospital. During transport the patient became asystolic and his blood pressure dropped. En route, the patient was started on dopamine drip, and percutaneous pacing was initiated. Upon arrival at the emergency department (ED), his cricothyroidotomy was in place and he was in pulseless electrical activity. His Glasgow Coma Scale (GCS) score was a 3T. Advanced cardiovascular life support was initiated and 3 rounds of epinephrine were given without return of spontaneous circulation. The patient was pronounced dead shortly after his rhythm deteriorated to asystole.

Case 2

Patient 2 is a 23-year-old male transferred from an outside hospital after being hit in the face from a firework blast. Upon presentation to our institution, the patient had a GCS score of 9T and he was intubated using direct laryngoscopy on the

second attempt. Etomidate and succinylcholine were given as the sedative and paralytic. He had extensive injury to his forehead, frontal head, orbits, with exposed facial bones. His face was covered with abrasions and lacerations, his right cornea was burned, and the left eye was ruptured (Figure 1). The patient's vital signs were stable.

A computed tomography (CT) of the head and face revealed a 5 mm left frontal epidural with a complex frontal sinus fracture involving the posterior wall of the sinus. Extensive facial fractures were noted involving the paranasal sinuses, the nasal orbital ethmoidal complex, the planum sphenoidale, and the left greater wing of the sphenoid. The left eye was ruptured.

Ophthalmology, neurosurgery, and plastic surgery services were consulted. Ophthalmology took the patient immediately to the operating room (OR) for enucleation of the left eye. Neurosurgery found that there was no surgical intervention appropriate at the time, and plastic surgery deferred any reconstruction until the patient stabilized.

The patient was then admitted to the intensive care unit (ICU), started on dilantin for seizure prophylaxis, and continued on antibiotics for the open wound to the forehead. He was extubated on the third day in the hospital. The patient also sustained a large soft tissue defect to forehead, requiring debridement in OR on the sixth hospital day.

While an inpatient, the patient required pain control, intravenous antibiotic therapy, and physical and occupational therapy. He was discharged and his wounds healed, but he declined further surgery. This patient was lost to follow up after his initial outpatient follow up.

Case 3

Patient 3 is a 30-year-old male who presented to the ED from the field with extensive facial trauma secondary to a firework blast to the face. His airway was secured immediately upon arrival due to an altered mental status with a GCS of 3 and poor oxygenation. A glidescope intubation with a size 7 tube was performed, with almost immediate replacement of a size 8 tube when an air leak was found. Exchange of the endotracheal tube was guided with the help of a bougie. He was hypotensive initially and had episodes of bradycardia. The hypotension responded to fluids. He had extensive facial blast

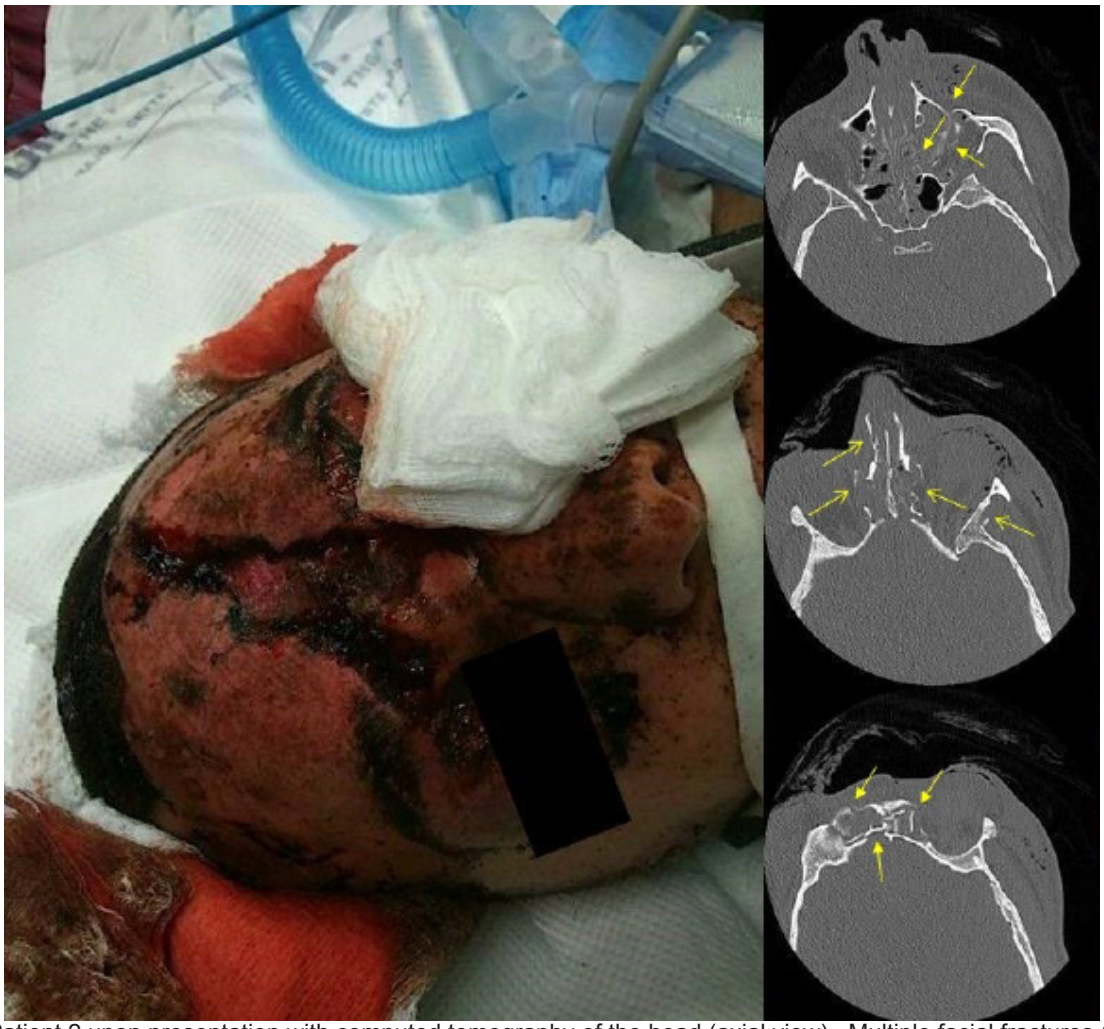

Figure 1. Patient 2 upon presentation with computed tomography of the head (axial view). Multiple facial fractures (arrows).

injury with a large amount of tissue loss of the eyes, forehead and nose (Figure 2). Both of the eyes were clinically ruptured. The maxilla was unstable upon examination. Focused assessment with sonography for trauma was performed and no free fluid was found. Ophthalmology, neurosurgery, and plastic surgery services were consulted.

CT head revealed diffuse cerebral edema with effacement of the 3rd and 4th ventricles, subarachnoid hemorrhage and bilateral frontal and temporal contusions. CT maxillofacial revealed multiple complex fractures as follows: frontal bone with a comminuted fracture involving the inner and outer table and displacement of both; large defect noted in the anterior and central skull base with destruction of the ethmoid complex and the sphenoid bone; left temporal bone fracture with involvement of the inner ear and mastoid sinus; bilateral orbital, pterygoid, zygomatic and maxillary sinus fractures; fracture of the hard palate with obvious diastases of the bone fragments; and a mandibular body fracture. In addition the CT of the face revealed bilateral globe ruptures with extensive edema of the ophthalmic nerves and extraocular muscles.

The patient was admitted to the ICU. Consultation of neurosurgery, ophthalmology and plastic surgery were obtained. Post injury the patient developed persistent high fevers and was treated with antibiotics, he developed central diabetes insipidus, and was minimally responsive with only a cough and a gag. Eventually he was able to intermittently move his upper and lower extremities with stimulus. No surgical intervention was planned for his injuries.

On hospital day six, the patient underwent tracheostomy, percutaneous endoscopic gastrostomy tube placement, and facial wound debridement, all of which were uneventful. On hospital day seven, the patient had an increasing pressor requirement and fevers. His responsiveness also diminished after the operating room and it was thought that he progressed to brain death. He was in the middle of a brain death workup when he went into cardiac arrest. After 3 cycles of cardiopulmonary resuscitation, the patient was pronounced dead.

Case 4

Patient 4 is a 28-year-old male that was hit in the face by a firework described as a mortar. The patient was described

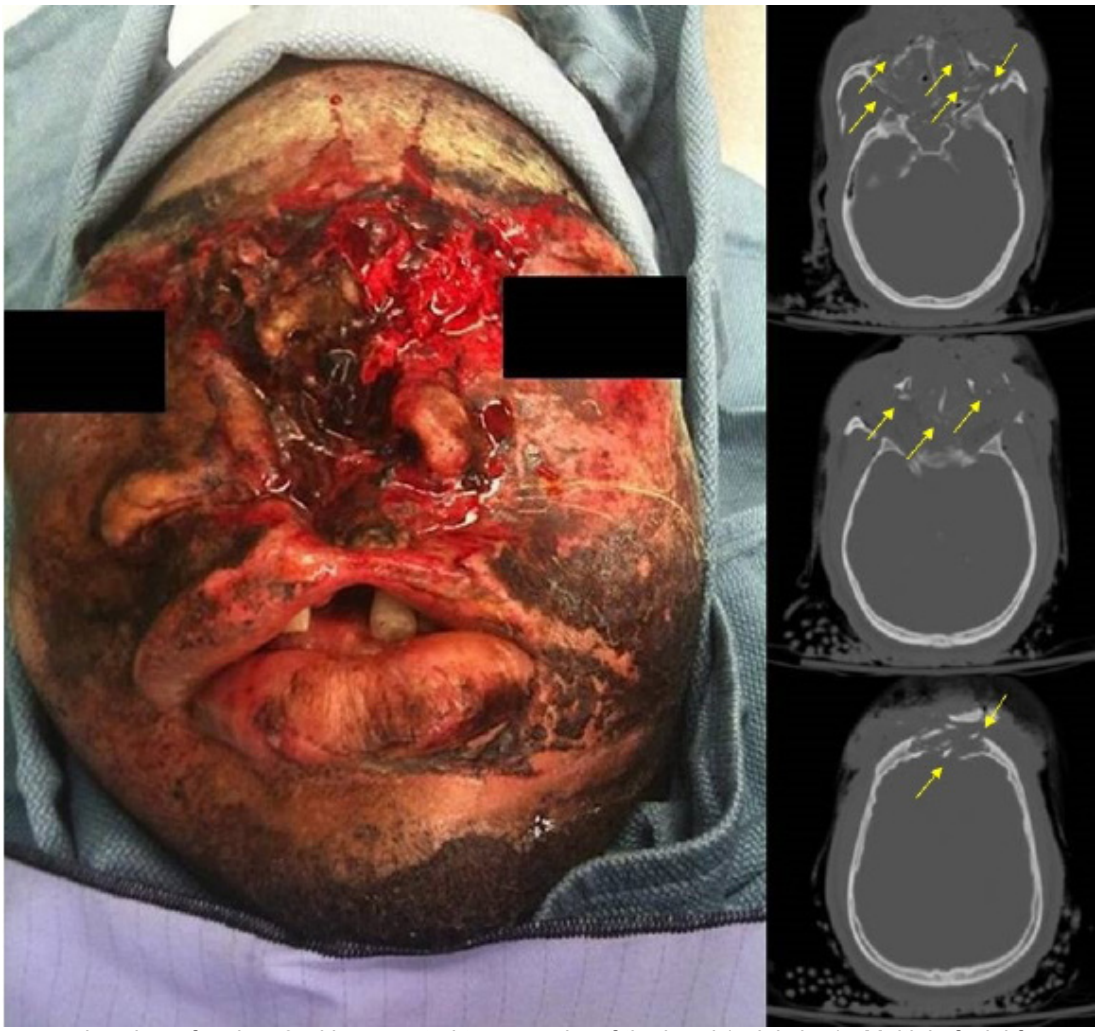

Figure 2. Preoperative view of patient 3 with computed tomography of the head (axial view). Multiple facial fractures (arrows).

as being combative during transport by emergency medical services. The patient was not speaking upon arrival, but saturating well on a non-rebreather mask. He was intubated in the ED due to the extensive facial trauma and the risk for loss of airway. Although the patient had lacerations on the mouth, oral intubation with an 8.0 tube was achieved using direct laryngoscopy while maintaining inline stabilization of the cervical spine. The patient was sedated and paralyzed with etomidate and succinylcholine. Glasgow coma scale was 10 (eyes 3, verbal 1, motor 6). Grossly, the patient had a laceration to the scalp, a frontal skull fracture, and avulsion of the left eye (Figure 3). Vital signs remained stable throughout his ED stay and he was admitted to the ICU after his workup was completed.

CT of the head revealed 3 mm left frontal contusion and bilateral frontal and right parietal subarachnoid hemorrhage. CT maxillofacial revealed multiple facial fractures as follows: bilateral frontal and frontal sinus fractures with involvement of the inner and outer tables; floor roof and lateral wall fractures of the left orbit with absence of the left globe; comminuted ethmoidal, nasal bone and left maxillary sinus fractures; and left sphenoid sinus fracture.

Ophthalmology, Neurosurgery, and Plastic Surgery services were consulted. Ophthalmology removed the remainder of the left globe and orbital debris. Neurosurgery did not offer any surgical intervention and plastic surgery determined that the patient would need reconstruction once stable

On hospital day five the patient underwent tracheostomy and percutaneous endoscopic gastrostomy. The facial wounds were debrided and the midline frontal scalp laceration was repaired. Swallow evaluation done and a soft mechanical diet was started. No progression of his intracranial hemorrhages noted.

On hospital day thirteen, the patient was taken to the OR by ophthalmology and plastic surgery services to begin reconstruction. Left eye enucleation was performed first. The reconstruction of the face included open reduction internal fixation of the left orbital roof and lateral wall, the left maxillary sinus, frontal sinus, left maxilla, upper and lower eyelid reconstruction and repair of complex laceration. On hospital day #21, the patient was discharged home decannulated. This patient had two subsequent operations, the first of which occurred 12 days after discharge. He developed a 1.5 cm dehiscence present at the level of the left orbital

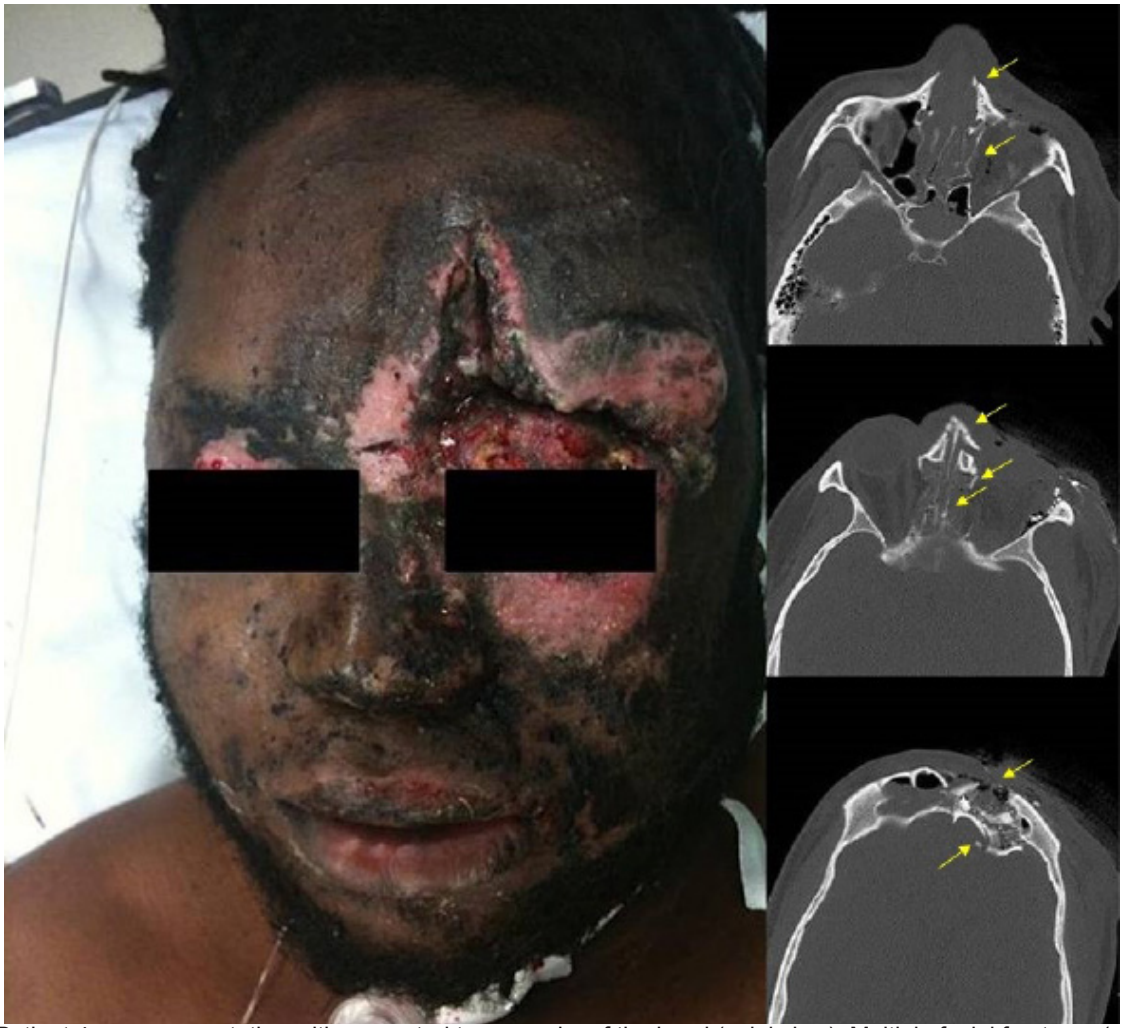

Figure 3. Patient 4 upon presentation with computed tomography of the head (axial view). Multiple facial fractures (arrows).

rim with exposed plate. A pedicle flap was made based on the previous scar and the area was closed without further difficulty. The second operation was performed 68 days after discharge due to severe contracture development in the left upper and lower eyelid.

DISCUSSION

The American Pyrotechnics Association (APA) estimates that the total firework consumption in 2011 was 234.1 million pounds and total firework revenue for 2011 to be over $950 million dollars.[1] The U.S. Consumer Product Safety Commission (CPSC) estimated that 9600 (95% confidence interval of 7600-11600) fireworks related injuries were treated in U.S. ED in 2011 with 65% of the injuries occurring between June 17, 2011 and July 17, 2011[2]. Only four firework related deaths were reported in 2011 by the CPSC, but the Commission states that this is likely an underestimation. All deaths reported were due to either illegal or homemade fireworks.

As defined by the federal explosives laws, fireworks are separated into two broad categories: display and consumer fireworks. Consumer fireworks are those available to the general public and defined by as any small firework device designed to produce visible effects by combustion and which must comply with the construction, chemical composition, and labeling regulations of the U.S. Consumer Product Safety Commission.[3] These include rockets, firecrackers, smoke balls, roman candles, sparklers, artillery shells, and air bombs. All consumer fireworks include a trade name and manufacturing information displayed clearly on them. In the state that these patients were treated, firework laws are quite strict, whereas the patients transferred from bordering states are more relaxed. Regardless, the force necessary to cause such damage was likely illegal in either state. Unfortunately, due to the retrospective nature of this study, information regarding the specific firework and method of injury was unavailable for each patient. Previous reports have been sparse in regards to the types of fireworks associated with injuries, making the mechanism and object of injury an important piece of history that can influence the management of these often complicated patients and vital to initial assessment of these patients.

The use of fireworks in the context of celebrations and holidays presents the ideal environment for accidents that lead to severe and dangerous injury. Studies conducted in China and Iran in conjunction with the Chinese annual spring festival and Iranian Last Wednesday Eve Festival respectively have found that private use of fireworks increases the incidence of injury.[4,5] Further, the two most common causes of injury with firework were found to be due to illegal firework use and improper handling [4], with no reduction in incidence of firework injury in those with increased socioeconomic or education level. Another survey conducted in Iran found that during festival times, civilians that have a lower perceived injury risk and a higher perceived ability of managing injury were more likely to participate in the use of fireworks and had a higher incidence of injury.[6] It can be concluded that firework use and associated injury is an individual choice, making education and awareness of safety and risk reduction methods all the more necessary.

Explosive injuries to the face present a challenging problem in terms of restoring ideal ocular, oral, and facial function.[7-9] Firework injury is often associated with extensive soft tissue trauma complicated by fractures, burns, accompanying traumas, and the presence of foreign bodies[8]. Reconstruction, if deemed necessary, is recommended to be completed as soon as possible after the injury, with the most useful techniques including microsurgical reconstruction, nerve, vessel, and soft tissue grafting, fracture fixation, and the use of free flaps to address large defects[9-10].

Despite the well documented prevalence of firework use and injury, there is a relatively large deficit of published work regarding firework injury involving the face. While extensive literature exists characterizing isolated ocular firework trauma[11], there are only a few isolated case reports and retrospective studies characterizing other facial firework trauma and subsequent management and reconstruction.[8-10] Previous literature describes the most common victims to be male, children, and innocent bystanders.[10,11] The most common locations for injury have been found to be the hand and face, with burns being the most common associated injury.[10,11]

Of the 4 patients that suffered firework blasts to the face, two expired, one immediately upon arrival to the ED and one after spending six days in the ICU, confirming the potentially fatal consequences of firework injuries. One of the 2 surviving patients was handled with debridement and ophthalmologic surgical management, and was discharged after seven days without complication. The other surviving patient had more extensive facial reconstruction, requiring five operations, including enucleation, open reduction and internal fixation, extensive soft tissue repair, along with two follow up surgeries due to dehiscence and contracture formation around the orbit. Despite the survival of two patients, both lost vision in one eye and required multiple follow ups.

Our case report confirms that males are highly likely to be victims of firework injury, although all of them were directly involved with the fireworks and were not innocent bystanders. The average age of victims was 26.7 years old, which is of young adult age, while literature states that children are the most frequent victims of these injuries. Reconstructive techniques documented for our patients match those cited as the most commonly used in the literature, with debridement, open reduction and internal fixation, eye enucleation, Z-plasty, and complex soft tissue repair being used in our patients.

According to Advance Trauma Life Support (ATLS) guidelines (ACS COT)[12], one of the most important principles in taking care of patients with such severe facial injuries is

management of their airway and a potential avoidance of early preventable death. As demonstrated with these 4 cases, airway management was immediately addressed in each of the patients with one patient receiving a cricothyroidotomy. Given the location and the extent of some of the blast injuries that can occur from fireworks or penetrating injuries to the face, swelling, anatomical distortion, obstruction and aspiration can be a consequence of the injury and an airway can be quickly compromised. When the lower part of the face is involved (i.e. mandible, neck), airway protection often becomes more challenging. In addition, the need for establishment of an airway and mechanical ventilation for airway protection in the event of a concomitant severe head injury is important to avoid exposure of the patient to secondary brain injury as a result of an unstable airway.

One of the most highly characterized areas of facial trauma is that of ocular injury. A recent meta-analysis of ocular blast injuries found that as much as 28% of blast survivors suffer from ocular injury.[13] The most common injuries suffered by victims are corneal abrasions, deposition of foreign bodies on the conjunctiva, cornea and fornix, hyphema. Open globe injuries and the presence of intraocular foreign bodies are less prevalent, but are associated with loss of vision, occurring in a majority of patients. Other risk factors for poor visual outcome included poor initial visual acuity, retinal detachment and development of endophthalmitis.[13,14] Ocular injuries were found to be most prevalent from secondary blast injuries, resulting not from direct injury to the eye, but from shrapnel and projectile debris, with periorbital location of injury having the highest associated morbidity.[13,15]

The use of antibiotics perioperatively has been shown to reduce the incidence of surgical site infection and is the current standard of care in elective clean-contaminated head and neck surgery.[16,17] The most feared infectious complication in maxillo-facial injuries is meningitis due to the communication of the face with the intracranial space, making surgical site infection prevention an important part of management in these cases. However, there currently exists no guideline for management of surgical traumatic facial injury patients with prophylactic antibiotics. Some literature suggests the use of prophylactic antibiotics in complex traumatic oral and facial wounds.[18] However, recent studies have found no difference between infection rates in surgical patients with maxillofacial fractures[19] and midface or frontal sinus trauma[20] between those who were given prophylactic antibiotics and those who were not. Overall, there is a severe lack of literature to address the use of prophylactic antibiotics for open skull or facial blast injuries. The authors believe that prophylactic antibiotics may have a role in reducing postoperative infection and support their use in complicated and open facial injuries caused by fireworks, but recognize the need for more research into this topic.

The utility of prophylactic antibiotics in basilar skull fractures is also not clear. Ratilal et al[21] performed a Cochrane review of antibiotic use in basilar skull fractures with and without cerebrospinal fluid leak and noted there was no difference in the rates of meningitis, all-cause mortality, meningitis-related mortality and need for surgical correction in patient with cerebrospinal fluid leakage. The patients in this case series all had a combination of severe facial injuries and intracranial injury with basilar skull fracture. Even less literature exists regarding the severe combination of injuries that this case series of patients sustained.

Firework injuries to the face are a unique and often times devastating injury scheme in emergency rooms and trauma hospitals. From this case series and review of literature, the authors agree that principles of airway management are of utmost importance for facial firework injury patients' initial management. Further, the use of prophylactic antibiotics may be useful while patients are undergoing complex surgical reconstruction. However the paucity of information regarding the types of fireworks, mechanism of injury, and individual behavior influenced injury calls for more research and education regarding firework injury to the face in order to prevent future injuries and develop optimal management of these patients.

CONCLUSION

We outline the clinical course and outcomes for four patients that suffered firework blast injuries to the face. As previously described, firework blast injuries can prove to be very dangerous to patients, with fatal outcomes, and patients often prove to be challenging and complicated in their surgical management when surgery is deemed necessary. In describing these patients, we hope to shed light on a severely under published area of the literature and guide future research, investigative work, and clinical/surgical management of these patients. In the United States, fireworks have various regulations of sale depending on the state. These patients came from both a state which has laws against fireworks and one which has very little restriction. In addition, with the presence of individuals in combat areas and the age where explosives are sadly becoming more frequent, management of facial blast injuries and firework injuries are only going to become more prevalent.

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Ocular Ultrasound Identifies Early Orbital Cellulitis

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A 36 year-old man with a history of a complicated oral surgery from a complex mandibular fracture months prior presented with traumatic right eye swelling, tearing, and redness. The patient was afebrile (36.7º C) and normotensive (121/79). Physical examination revealed upper and lower lid swelling and erythema without crepitance or proptosis, accompanied by conjunctival injection and copious tearing. His pupillary exam and intraocular pressures were normal. He had painless and unlimited extra-ocular movements. His visual acuity was 20/30 *oculus dexter*, 20/20 with pinhole; 20/40 *oculus sinister*, 20/40 with pinhole. A bedside ocular ultrasound using a Sonosite MTurbo® 7.5 MHz linear high frequency probe was performed showing edema along the anterior aspect of the orbit with nonspecific thickening of the orbital wall (Video). Based on these findings, an orbital computed tomography (CT) with contrast was performed, confirming the diagnosis of orbital cellulitis. The patient was admitted for intravenous antibiotics (vancomycin and ceftriaxone) and ophthalmology consultation.

While there are numerous studies supporting the use of orbital ultrasound to diagnose ocular trauma, the presence of intraocular foreign bodies, and other ocular abnormalities, there is limited evidence to suggest orbital ultrasound may have a role in diagnosing orbital cellulitis.[1-7] It is not likely that ocular ultrasound will negate the need for advanced imaging with CT and magnetic resonance imaging in patients with symptoms highly suggestive of orbital cellulitis (i.e., ophthalmoplegia, proptosis, and impaired vision.) However, ocular ultrasound may have a role in risk stratification for patients with more nonspecific symptoms, such as ocular pain, eyelid swelling, and erythema. Future observational studies are needed to better evaluate if orbital ultrasound has a role in identifying patients without obvious clinical features of orbital cellulitis who may benefit from advanced imaging.

Video. Edema along the anteriorlateral aspect of the orbit with nonspecific thickening of the orbital wall (white arrows).

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Acute Mesenteric Venous Thrombosis with a Vaginal Contraceptive Ring

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Mesenteric venous thrombosis is a rare cause of abdominal pain, which if left untreated may result in bowel infarction, peritonitis and death. The majority of patients with this illness have a recognizable, predisposing prothrombotic condition. Oral contraceptives have been identified as a predisposing factor for mesenteric venous thrombosis in reproductive-aged women. In the last fifteen years new methods of hormonal birth control have been introduced, including a transdermal patch and an intravaginal ring. In this report, we describe a case of mesenteric venous thrombosis in a young woman caused by a vaginal contraceptive ring. [West J Emerg Med. 2014;15(4):395–397.]

INTRODUCTION

Mesenteric venous thrombosis (MVT) is a well-described cause of intestinal ischemia, accounting for approximately 15% of all mesenteric ischemia cases.[1] It is distinctly different from mesenteric arterial occlusion. A rare condition, MVT accounts for only 0.002% to 0.06% of all inpatient admissions and 0.01% of all emergency surgical admissions.[2] Given its nonspecific initial symptoms, MVT is not an easy diagnosis to make. Patients often complain of vague abdominal pain and nausea for days to weeks before seeking medical attention.[1,3]

An etiologic factor causing a prothrombotic state can be found in approximately three-quarters of patients with MVT, with inherited or acquired disorders of coagulation, cancer, intra-abdominal inflammatory conditions, the postoperative state and portal hypertension being the most commonly reported causes.[4] MVT can occur at any age, but is more common in the sixth and seventh decades of life.[1] Oral contraceptive use accounts for 9% to 18% of the episodes of MVT in young women.[4] In this case we describe a patient who developed MVT from the use of a vaginal contraceptive ring (NuvaRing ®).

CASE REPORT

A previously healthy 18-year-old woman presented to our emergency department (ED) with 5 days of worsening intermittent periumbilical, epigastric and right upper quadrant (RUQ) abdominal pain. She had nausea with the pain, though no vomiting or fever. The pain was crampy in nature and not exacerbated by eating. She was sexually active with one partner and had used the NuvaRing as contraception for the previous two years. She smoked approximately 5 cigarettes per day and denied any family history of coagulation disorders. On physical examination she was afebrile, with tenderness in the periumbilical, epigastric and right upper quadrant (RUQ) areas of her abdomen. She had no rigidity, guarding, or other peritoneal signs.

Laboratory examinations sent from the ED included: a complete blood count, renal profile including electrolytes, liver function tests, serum lipase, urinalysis and a urine pregnancy test. The only abnormality noted was a mildly elevated serum alanine-amino transferase (ALT) level of 46 IU/L. A RUQ ultrasound of the abdomen was ordered to evaluate for cholelithiasis. While no abnormalities of the biliary tract were seen, splenomegaly was noted as an incidental finding. Because of the patient's ongoing and unexplained pain, a computerized tomographic (CT) scan with intravenous (IV) contrast of the abdomen and pelvis was performed. A large superior mesenteric vein thrombosis was identified with enlargement of the liver and spleen (Figure).

The patient was anticoagulated with IV heparin and admitted to the hospital with surgical and hematologic consul-

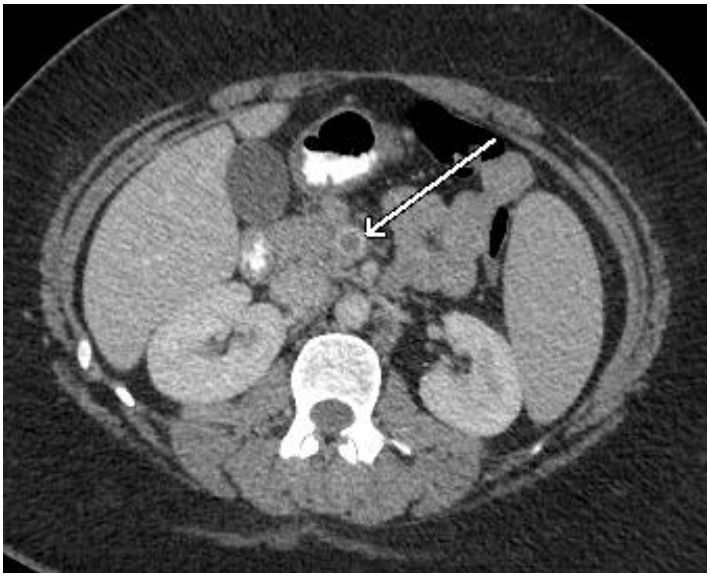

Figure. Computed tomography of the abdomen showing a large filling defect in the superior mesenteric vein (arrow) indicating the presence of thrombus.

tants. The NuvaRing was removed at the time of admission. Evaluations for prothrombotic conditions including: protein C, protein S and antithrombin III deficiency; factor V, prothrombin and MTHFR gene mutation; lupus anticoagulant, cardiolipin IgA and IgG antibodies were all negative. The patient's hospital course progressed without complication as she was bridged to anticoagulation with warfarin sodium, and she was discharged on day 5 with instructions to refrain from using hormonal birth control in the future.

Table. Reported predisposing conditions for mesenteric vein thrombosis.

Predisposing conditions
Prothrombotic states
Protein C or S deficiency
Factor V Leiden deficiency
Antithrombin III deficiency
Prothrombin gene mutation G20210A
Hyperhomocysteinemia
Antiphospholipid antibodies
Polycythemia vera
Nephrotic syndrome
Essential thrombocythemia
Paroxysmal nocturnal hemoglobinuria
Pregnancy
Oral contraceptive use
Malignancy
Intra-abdominal causes
Cirrhosis and portal hypertension
Inflammatory bowel disease
Intra-abdominal infection
Pancreatitis
Intra-abdominal surgery
Other causes
Blunt abdominal trauma
Congestive heart failure

DISCUSSION

Mesenteric venous thrombosis was first recognized as a distinct clinical entity by Warren and Eberhard in 1935.[5] The superior mesenteric vein is involved the majority of the time, with inferior mesenteric vein thrombosis representing only 0% to 11% of cases.[6] Several predisposing factors have been identified for the development of MVT (Table).[1,2,4,6] Impairment of venous return from the bowel by MVT results in venous engorgement and eventually ischemia. Unlike mesenteric arterial occlusion, the transition from normal to ischemic bowel is typically gradual with MVT. In those cases with rapid and complete occlusion of mesenteric veins, there is insufficient time for development of collateral circulation and transmural bowel infarction may occur.

Abdominal pain and anorexia are the most consistent symptoms of MVT, though patients often complain of other nonspecific symptoms such as diarrhea, nausea and vomiting.[3,7] Seventy-five percent of patients are symptomatic for more than 48 hours at time of presentation, with the mean duration of symptoms varying from 6 to 14 days.[6] The pain associated with MVT is classically described as a colicky, mid-abdominal pain which, early on, is out of proportion to the abdominal findings on physical exam. Approximately one-third of patients will have blood noted on rectal exam.[3] Those patients with transmural bowel infarction will have physical findings consistent with peritonitis.

Routine laboratory evaluations are rarely helpful in the diagnosis of MVT, though lactic acidosis is a late finding and predicts a poor outcome.[6] Recent improvements in imaging techniques have allowed for earlier diagnosis and treatment of MVT.[8] CT with IV contrast is the current diagnostic test of choice for MVT with an accuracy of approximately 90%.[2,4,6,9-11] Magnetic resonance angiography has also been found to have excellent sensitivity and specificity.[8,12] Doppler ultrasound is of limited value in the evaluation for MVT due to operator dependency and its inability to image vascular anatomy in the presence of overlying bowel gas.[12]

Immediate anticoagulation with heparin is the standard initial treatment of MVT, with the presence of gastrointestinal bleeding rarely a contraindication to its use.[2,4,6,11] Transcatheter thrombolytic therapy and thrombectomy have both been used with success in small case series.[13,14] Those patients with signs of peritonitis require emergent resection of the infarcted bowel. Mortality rates with MVT range from 11% to 33% in the most recently published studies.[8,15,16]

MVT associated with hormonal contraception was first

described in 1963, three years after the approval of the first oral contraceptive pill in the United States (U.S.).[17] Since then, several other cases have been reported.[18] Since 2002, a contraceptive transdermal patch (Ortho Evra ®) and a contraceptive vaginal ring (NuvaRing) have been available in the U.S., each offering some advantages over oral contraceptives. A study conducted by the U.S. Food and Drug Administration concluded the transdermal patch and the vaginal ring were associated with an increased risk of venous thromboembolism similar to that of oral contraceptives.[19] Other reported thrombotic complications of the vaginal contraceptive ring have included cerebral venous sinus thrombosis, axillary vein thrombosis and aortic thrombosis.[20-23] We are aware of only one other reported case of MVT associated with a vaginal contraceptive ring, this having been reported in the hematology literature.[24]

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Emergency Medicine Clerkship Directors: Current Workforce

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Introduction: The emergency medicine clerkship director serves an important role in the education of medical students. The authors sought to update the demographic and academic profile of the emergency medicine clerkship director.

Methods: We developed and implemented a comprehensive questionnaire, and used it to survey all emergency medicine clerkship directors at United States allopathic medical schools accredited by the Liaison Committee on Medical Education. We analyzed and interpreted data using descriptive statistics.

Results: One hundred seven of 133 (80.4%) emergency medicine clerkship directors completed the survey. Clerkship Director's mean age was 39.7 years (SD-7.2), they were more commonly male 68.2%, of Caucasian racial backgrounds and at the instructor or assistant professor (71.3%) level. The mean number of years of experience as clerkship director was 5.5 (SD-4.5). The mean amount of protected time for clerkship administration reported by respondents was 7.3 hours weekly (SD-5.1), with the majority (53.8%) reporting 6 or more hours of protected time per week. However, 32.7% of emergency medicine clerkship directors reported not having any protected time for clerkship administration. Most clerkship directors (91.6%) held additional teaching responsibilities beyond their clerkship and many were involved in educational research (49.5%). The majority (79.8%), reported being somewhat or very satisfied with their job as clerkship director.

Conclusion: Most clerkship directors were junior faculty at the instructor or assistant professor rank and were involved with a variety of educational endeavors beyond the clerkship. [West J Emerg Med. 2014;15(4):398–403.]

INTRODUCTION

In the past three decades, emergency medicine (EM) as a distinct clinical specialty has undergone tremendous growth. Recent surveys report that close to 40% of United States (U.S.) medical schools offer a mandatory EM clerkship in the clinical years of medical school, with the majority being in the senior year.[1-3] Job responsibilities of the clerkship director (CD) typically involve clerkship administration, clinical and didactic teaching, and participation in scholarly activity.[4] In 2005, a study by Coates et al[5] provided the first insight into the demographics and characteristics of the EM CD. In that study, the authors reported that: 72% of the

EM CDs were junior faculty (at the instructor or assistant professor level); EM CDs were only provided an average reduction of 2.7 hours per week from their clinical work to perform clerkship administration and teaching duties; and that most CDs (51%) received no reduction in clinical time for clerkship related duties. The lack of protected time afforded to EM CDs should be viewed in context of the national CD organizations that have recommended a clinical reduction of 0.25 FTE to perform clerkship administrative duties and up to 0.55 FTE for the additional time required for teaching and educational scholarship.[4,6-8]

Since the publication of the Coates review (2005), a number of developments in the specialty of EM have occurred. In May 2007, the Clerkship Directors in Emergency Medicine (CDEM) was formed establishing a unified national voice for EM CDs and medical student educators to advance education, research and faculty development within the specialty.[9] In 2008, CDEM became the first academy within the Society for Academic Emergency Medicine (SAEM). In November, 2008, CDEM was inducted as a full voting member of the Alliance for Clinical Education (ACE), a multidisciplinary group formed to enhance the clinical education of medical students.[10] In addition, members of CDEM have worked closely with the Council of Emergency Medicine Residency Directors (CORD-EM) to develop the CDEM / Medical Student Educators Track at the CORD Annual Academic Assembly and with the SAEM Program Committee to increase the educational content at the SAEM Annual meeting. In light of all the recent changes to the emergency medicine profession, our objective for this study was to provide an updated demographic and academic profile of the EM CD including; general characteristics, participation in scholarly activities, perceived support from their home institution, and satisfaction with their job.

METHODS

Study Design and Population

We conducted a survey of EM CDs at U.S. medical schools fully accredited by the Liaison Committee on Medical Education (LCME). A roster of medical schools was obtained from the Association of American Medical Colleges (AAMC) web site (www.aamc.org). EM CD's names and contact information were obtained from the SAEM membership directory, individual medical school websites and through direct phone contact with the medical schools if the information was otherwise unavailable. The final roster included one representative identified as the EM CD at the primary clinical training site from each of the 133 targeted medical schools. The study met criteria for exemption from human subjects review and informed consent by the institutional review board at The Ohio State University College of Medicine.

Survey Content and Administration

Authors (DEM and SK) selected survey items and item formats based on the literature covering similar efforts to profile CDs. The initial draft of the survey instrument was primarily modeled off of one reported by Coates, et. al. who studied EM CDs specifically. All other authors, including one with formal training in survey development (DPW) reviewed survey items until a final survey draft was agreed upon by consensus opinion. Before implementation, the survey instrument was piloted by five EM CDs, not affiliated with the study. These individuals provided suggestions for improving clarity, readability, and comprehensiveness.

Surveys were disseminated to the target population of U.S. medical school EM CDs using an electronic survey service (SurveyMonkey,™ Palo Alto, CA). An initial personalized email with a link to the electronic survey was sent to each EM CD in August, 2010. The email included an outline of the study and an assurance of confidentiality. Reminders and follow-up emails were sent to non-respondents monthly from September, 2010 – February, 2011. In April, 2011, an attempt was made to contact non-responders directly and a final survey was distributed. Over these 9 months, every medical school was directly contacted at least twice to enlist their participation in this study.

Data Analysis

Descriptive statistics were used to report general characteristics and demographics of the EM CD. Comparisons between medical schools which required students to take an EM clerkship and those which offered EM as an elective rotation were made when possible. All analyses were performed using IBM SPSS Statistics for Windows, Version 19. (IBM Corp. Released 2010. IBM SPSS Statistics for Windows, Version 19.0. Armonk, NY: IBM Corp).

RESULTS

One hundred seven (80.4%) of 133 EM CD's completed the survey. Although most EM CDs (71.3%) were reported to be junior faculty, e.g. at the clinical instructor or assistant professor rank; over a quarter (27.8%) of EM CDs had achieved the rank of associate or full professor. The mean number of years that a faculty member had served as CD was 5.5 (SD-4.5). More than one third (35.2%) had been in their current role as CD for 6 or more years. Many EM CDs reported having held or were currently holding leadership positions in their department other than CD. These included: assistant / associate residency director (22.4%), assistant clerkship director (9.3%), clinical director / associate clinical director (9.3%), chairman / division chief (7.5%), director of undergraduate medical education (4.7%) and residency director (3.7%).

The mean amount of protected time for clerkship administration reported by respondents was 7.3 hours weekly (SD-5.1), with the majority (53.8%) reporting 6 or more hours of protected time per week. However, 32.7% of

EM CDs reported not having any protected time at all for clerkship administration.

We asked respondents to report how much financial support they received from their departments, in dollars, for continuing medical education (CME). Most respondents (76.6%) said that they receive some level of financial support for CME, with the median amount reported as $2750 (semi-interquartile range= $1250). This means that 50% of the 82 respondents who said they received CME funding, reported receiving between $1500 and $4000 for CME support.

Another form of financial support we asked about was support for professional development beyond CME through conference attendance. Many (45.8%) CDs report receiving this type of financial support from their departments.

We asked CDs to tell us about the type of administrative or clerical support they receive for carrying out their clerkship duties. Responses varied widely with 15% (16 of 107) report having the support of a full-time coordinator, 24.3% (26 of 107) have a secretary/receptionist, while most (59.8%; 64 of 107) share a coordinator with other programs. Only 10 CDs (9.3%; 10 of 107) report that they have no clerical support.

We also asked CDs to rate the level of general support they receive from their department using a Likert-type response set ranging from high (excellent) to low (poor).

Forty two percent noted departmental support as excellent (19.6%; 21 of 107) or good (22.4%; 24 of 107). Almost a third (30.8%; 33 of 107) said that support was satisfactory, while a quarter (25.2%; 27 of 107) said that it was less than satisfactory (fair).

Almost half (46.7%; 50 of 107) said that they had some formal preparation for their role as CD. More than one third of the faculty (35.5%; 38 of 107) reported receiving brief training from a senior faculty member; 11.2% (12 of 107) had extensive mentorship; 10.3% (11 of 107) received a written job description and another 10.3% (11 of 107) were given a handbook of clerkship guidelines. However, (53.3%; 57 of 107) of respondents said that they had no formal training.

We also assessed how many CDs had formal training as educators. We found that more than one quarter of EM CDs (27.1%; 29 of 107) had completed the American College of Emergency Physicians (ACEP) Teaching Fellowship and 4.7% (5 of 107) had earned a Masters in Education degree. Additional faculty development programs completed by EM CDs included: the Harvard Macy Program (3.7%; 4 of 107), Medical Education Research Certificate / AAMC (2.8%; 3 of 107) and the Stanford Faculty Development Program (1.9%; 2 of 107). Additional information regarding general characteristics of the EM CD is presented in Table 1.

CDs also reported that they commonly engage in a wide range of teaching activities, with most (91.6%; 98 of 107) having teaching responsibilities beyond running the clerkship. Many of these activities involve pre-clinical medical students. CDs also engaged in formal academic scholarship with 79.4% (85 of 107) of CDs reporting having had peer

Table 1. General characteristics of the emergency medicine (EM) clerkship director.

Characteristics/demographics	Percentage (SD)
Age	39.7 years (SD-7.2)
Gender	
Male	68.2
Female	31.8
Ethnicity	
White/Caucasian	83.2
Asian/Pacific Islander	11.9
Hispanic/Latino	3.0
African American	2.0
Academic rank	
Instructor	2.0
Assistant professor	69.3
Associate professor	22.8
Professor	5.0
No academic appointment	1.0
Board certified/prepared in EM	
Yes	98.1
No	1.9
Years as clerkship director	5.4 (SD-4.5)
<1	3.7
1-2	27.2
3-5	33.7
6-10	24.1
>10	11.1
Protected time for clerkship administration	7.3 (SD-5.1)
< 5 hours	46.2
6-10 hours	33.8
>10 hours	20.0
Job satisfaction	
Very satisfied	35.6
Somewhat satisfied	45.2
Neither satisfied nor dissatisfied	2.9
Somewhat dissatisfied	7.7
Very dissatisfied	8.7
Career aspirations	
Assistant/associate dean	36.2
Clerkship director	21.6
Residency director	13.8
Chairman	11.2
Assistant/associate residency director	8.6
Vice chairman	5.2
Dean	2.6
Research director	0.9

Table 2. Teaching outside of the clerkship and other scholarly endeavors of the emergency medicine (EM) clerkship director.

	Percentage (SD)
Educational responsibilities beyond the clerkship within the medical school	
Yes	91.6
No	8.4
Specific educational responsibilities	
Simulation	45.8
Introduction to clinical medicine	37.4
Advanced EM elective	35.5
Procedural curriculum	26.2
Physical examination course	22.4
Preclinical curriculum	16.9
Basic science curriculum	15.9
Clinical assessment/problem solving course	15.0
Leadership role in addition to the clerkship	
Director of advanced EM elective	15.9
Director of simulation	14.0
Director of procedural curriculum	6.5
Director of introduction to clinical medicine	4.7
Director of clinical assessment/problem solving course	3.7
Director of physical examination course	3.7
Peer reviewed publications	4.7 (SD-5.9)
None	20.6
1-5	53.3
>5	26.2
Peer reviewed educational topics	1.4 (SD-3.5)
Textbook chapters	3.6 (SD-5.5)
None	28.0
1-5	54.2
>5	17.8
Textbook educational topics	0.6 (SD-1.4)
Involvement in educational research	
Yes	49.5
No	50.5
Involvement in non-educational research	
Yes	64.5
No	35.5

SD, standard deviation

reviewed publications and 72% (77 of 107) having published textbook chapters. Approximately one quarter (23.4%; 25 of 107) of CDs reported that they had previously applied for an educational grant, with 64% (16 of 25) of those applying having received grant support. Information regarding teaching outside of the clerkship and participation in other scholarly endeavors are reported in Table 2.

When we looked at protected time, ratings of departmental support, level of clerical support and level of satisfaction with their job, we found that CDs whose medical school curriculum consist of "required" EM clerkships were slightly more likely to receive protected time for their CD position when compared to those whose schools only offered "elective" clerkships (75% (42 of 56) vs. 58.8% (30 of 51)). The associated Chi-Square test for this comparison was not considered statistically significant ($X^2 = 3.173$; df=1; P=.099).

With regard to perceived level of support from their departments, both groups (required v. elective) were virtually the same in their ratings, with CDs with required clerkships having a mean rating of 3.357 (SD of 1.09) on this 5 Likert-Type scale and CDs with elective clerkships having a mean rating of 3.388 (SD of 1.08). CDs from institutions with required clerkships received slightly more clerical support than their elective institution counter-parts. More CDs of required clerkships had full-time clerkship coordinators (12 of 56, 21.4%) vs. (4 of 51, 7.8%) and fewer of them had no support at all (3 of 56, 5.4%) vs. (7 of 51, 13.7%). The primary clerical support model is a shared duty or half-time coordinator. This was true of both required clerkships (33 of 56, 58.9%) and those with elective clerkships (31 of 51, 39.2%). Support in the form of a secretary or receptionist was reported by 13 of 56 (23.2%) institutions with required clerkships and 13 of 51 (25.5%) institutions with elective clerkships.

Finally, ratings of job satisfaction were compared across the two institution types. Those CDs who have required clerkships rated their level of satisfaction with their job slightly higher than those who have electives, however this difference was not statistically significant.

DISCUSSION

In 2009, Margo et al[11] compared CD characteristics using data available from surveys published in 7 medical specialties. This study used the data that was previously reported by Coates in 2005.[5] At the time of the Margo study, EM CDs were younger, more likely to be junior faculty at the clinical instructor or assistant professor rank and had less protected time afforded to support their role as CD when compared to their counterparts in other specialties.[11,12] Little has changed over the 6 years since the Coates study. The mean age of the EM CD is roughly the same; 38.9 years (SD-7.0) v. 39.7 years (SD-7.2). This compares to the mean age of CDs in other core specialties which is; mean 46.7 years (mean range 45-47.7 years). Regarding gender, 68.2% of EM CD's are male which is similar to the other core specialties (mean 62% males, range 50-75%).[11] When looking at the distribution of academic rank of the EM CD, in 2005, 72.1% of EM CDs were at the instructor or assistant professor level. Our more recent data shows that 71.3% of EM CD's are currently at this level.

When broken down by specific academic rank, we observed that more EM CDs are at the assistant professor level than in 2005; 69.3% v. 61.3%. When we look at CDs at the senior faculty level (associate professor or professor), there is a small but positive trend. Currently, more than one quarter (27.8%) of EM CDs are at the associate professor or professor rank compared to 21.6% in 2005. These comparisons alone may not fully reflect the changing faculty rank of EM CDs as institutional promotion and tenure committees vary in requirements across medical schools.

Protected time for clerkship administration, teaching and participation in academic scholarship are necessary for CD success in fulfilling their role. A recent CDEM – Association of Academic Chairs of Emergency Medicine (AACEM) combined Taskforce publication outlines the expectations of the EM CD.[8] This document mirrors many of the same expectations set forth by other national CD organizations.[4,6,7] Despite the recognized importance of the role of the CD, the support afforded to the CD is variable across disciplines.[11,12]

Regarding protected time afforded for clerkship administration, EM CDs have made some headway in recent years. Of the faculty reporting that they receive protected time for clerkship administration, the majority (53.8%) report receiving 6 or more hours of protected time weekly. However, less than one third (32.7%) report that they do not receive protected time for their role as CD as compared to 2005 when the majority of CD's (51.4%) reported that they had zero release time to perform clerkship administration.[5]

Despite this positive trend noted in the amount of protected time allotted, there appears to be a discrepancy between EM CDs and their counterparts in other specialties.[11] However, a direct comparison between EM and other clinical specialties is difficult to perform for a number of reasons. CDs in the other core specialties report their clinical workload as a combination of weekly outpatient clinic sessions and inpatient responsibilities.[13] In addition, there is significant variability regarding inpatient clinical responsibilities across specialties further confounding a direct comparison. With regards to time committed to the clerkship, the other core specialty CDs report devoting an average 33% (range 30 – 48%) of their professional time towards the clerkship.[13] Translating this to a typical 40 hour work week would mean that CDs devote approximately 13 hours per week to clerkship administration. Meanwhile, the average protected time for the EM CD is only 7.3 hours per week or 18.5% of time based on a 40 hour work week. This means that EM CDs are only being supported for about half of the time that CDs from other disciplines receive to run their clerkships and falls far short of the expectations outlined by various national organizations.[4,6-8]

Rapid turnover in the CD position was reported as a common problem in 2005 by Coates, when approximately 45% of EM CDs reported being in their position for 2 years or less. More recently it appears that some headway has been made in addressing turnover, with just a little more than one third (36.5%) of EM CDs report being in their current position for 1-2 years. In addition, almost one third (32.0%) of CDs have been in their current position as CD for 6 or more years as compared to 22.4% in 2005. Currently, the mean number of years a CD has been in their current position is 5.4 years. In comparison, as reported in a multispecialty review published in 2010, the mean number of years as CD for all of the core clinical specialties was 6.8 years (range 5.5 to 7.5 years).[12]

Administrative support for the clerkship is important as it has been reported to have a positive correlation with the academic productivity of the CD.[11] We found administrative support for the clerkship, to be quite variable, with more than half (59.8%) of EM CDs reporting a shared / half time coordinator and only 15% reporting a full time clerkship coordinator. This is far less administrative support than reported for other core clinical specialties.[14,15]

Overall, the role of CD is viewed positively by the faculty who perform these duties. More than two thirds of CDs (70%) across multiple specialties have reported that the role has had a positive effect on their academic achievement (core clerkship directors). In addition, more than three quarters of these same CDs (90%) reported that being a CD enhanced their satisfaction with their professional work. As for EM CDs, our data support that the vast majority (80.8%) are satisfied in their current job.

LIMITATIONS

Our study fell short of profiling all EM CDs. We did not attempt to survey CDs from osteopathic medical schools nor did we attempt to survey CDs from community hospitals and secondary or regional affiliates of LCME accredited medical schools. We did not address many confounders such as year of training, length of rotation, and volume of students.

CONCLUSION

The majority of EM CD's are still junior faculty at the clinical instructor or assistant professor rank. We found that CDs had 7.3 hours of protected time per week and that this has generally improved since 2005. However, this still falls below expectations set forth by CDEM EM CDs are engaged in a wide variety of teaching activities in addition to the clerkship, and many perform educational research and scholarship. The majority of EM CDs are satisfied in their current position.

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Effect of Prior Cardiopulmonary Resuscitation Knowledge on Compression Performance by Hospital Providers

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Introduction: The purpose of this study was to determine cardiopulmonary resuscitation (CPR) knowledge of hospital providers and whether knowledge affects performance of effective compressions during a simulated cardiac arrest.

Methods: This cross-sectional study evaluated the CPR knowledge and performance of medical students and ED personnel with current CPR certification. We collected data regarding compression rate, hand placement, depth, and recoil via a questionnaire to determine knowledge, and then we assessed performance using 60 seconds of compressions on a simulation mannequin.

Results: Data from 200 enrollments were analyzed by evaluators blinded to subject knowledge. Regarding knowledge, 94% of participants correctly identified parameters for rate, 58% for hand placement, 74% for depth, and 94% for recoil. Participants identifying an effective rate of ≥100 performed compressions at a significantly higher rate than participants identifying <100 (μ=117 vs. 94, p<0.001). Participants identifying correct hand placement performed significantly more compressions adherent to guidelines than those identifying incorrect placement (μ=86% vs. 72%, p<0.01). No significant differences were found in depth or recoil performance based on knowledge of guidelines.

Conclusion: Knowledge of guidelines was variable; however, CPR knowledge significantly impacted certain aspects of performance, namely rate and hand placement, whereas depth and recoil were not affected. Depth of compressions was poor regardless of prior knowledge, and knowledge did not correlate with recoil performance. Overall performance was suboptimal and additional training may be needed to ensure consistent, effective performance and therefore better outcomes after cardiopulmonary arrest. [West J Emerg Med. 2014;15(4):404–408.]

INTRODUCTION

Cardiopulmonary arrest (CPA) is a major public health problem, and despite advances in cardiopulmonary resuscitation (CPR), survival and recovery remain suboptimal.[1] Early and effective CPR has been shown to improve survival after CPA.[2] However, both out-of-hospital and in-hospital providers often fail to provide high quality CPR.[3-5] Poor quality CPR has been shown to have similar outcomes to patients receiving no CPR, whereas increased survival is associated with high quality CPR, particularly the quality of chest compressions (CCs).[5,6] Therefore, recent recommendations have focused on CCs as the focus of compression optimization, which is reflected in the *2010 AHA Guidelines for CPR and ECC*[7], as well as the *ERC Guidelines for Resuscitation 2010*[8] and *2010 CoSTR Guidelines*.[9]

Specific components of CCs, including rate, depth, and recoil, have been found to affect outcome measures. Rates below published guidelines are associated with poor return of spontaneous circulation, which is particularly concerning given that many providers deliver CCs at suboptimal rates.[4]

Inadequate compression depth is associated with defibrillation failure.[10] In animal models, incomplete (< than 75%) chest recoil, as compared to full (100%) recoil between CCs, impeded venous return and resulted in lower mean arterial pressures and decreased cerebral and coronary blood flow.[11]

Despite training in effective CPR techniques, providers often fail to perform CCs that adhere to AHA guidelines.[4] Studies have found that both knowledge of guidelines and motor skills for CPR are not well retained and degrade in relation to time since last training, with extensive decline and suboptimal performance within 6 to 12 months after training.[12-15]

One study showed that knowledge of guidelines correlated with better performance of CCs, namely compression rate; however, overall knowledge as well as performance was poor.[16] Another study found that kinesthetic memory, i.e. motor skills, as well as overall performance of CPR, degrades faster than knowledge of guidelines.[12] These findings would suggest that although retention of guidelines is poor, this has little impact on performance, and instead, the decay of motor skills is the cause for degradation of CPR performance.[12,13] These studies also found that increased training, experience, and more frequent performance of CPR leads to better performance.[12,13] However, at least one other study opposed this finding.[16]

The objective of our analysis was therefore 2-fold. First, we sought to evaluate the CPR knowledge and CC performance in a representative sample of in-hospital providers with various levels of training and experience. In addition, we investigated whether knowledge of CPR parameters, as defined by correct identification of current AHA guidelines[7], affected the performance of effective CCs during a simulated cardiac arrest scenario.

METHODS

Study Design

This was a cross-sectional analysis of pre-intervention data from an experimental study measuring the effect of prior CPR knowledge and simulation-based training on the performance of CCs. The research was approved via exemption by the human subjects research protection board.

Participants

Between July 2011 and October 2011, we enrolled emergency department (ED) personnel and medical students who had completed a Basic Life Support course in the previous two years. All participants were 18 years of age or older. Participation was voluntary and represented a convenience sample.

Protocol

During enrollment periods in the ED, potential study participants (technicians, nurses, physicians) were asked to participate if time permitted. Arrangements were made for staff members to participate at a later time if requested. We recruited all medical and nursing students by e-mail for participation. Interested students were enrolled at the Clinical Simulation Center. We assessed knowledge of guidelines through a pre-intervention questionnaire, asking them to identify the AHA guidelines for rate, hand placement, depth, and recoil.[16] An example is given in Appendix A.

Participants were then informed that a nearby mannequin (Laerdal Resusci Anne® Simulator, #150-0001, Wappingers Falls, NY) was "experiencing" a CPA with a known shockable rhythm. All subjects were asked to complete 1 minute of CCs on the simulation mannequin. The mannequin was located on a stretcher with a fixed height. A stool was made available to all participants, but its use was not required.

Measurements

Following performance of CCs, we collected data regarding depth, recoil, hand placement, and rate for each participant (Laerdal PC SkillReporting System, #317000, Wappingers Falls, NY). The rate was defined as the number of CCs performed in 1 minute. We considered a rate of over 100 CCs per minute to be effective. Depth was defined as the percentage of CCs that achieved a depth between 38 and 51 mm. We defined recoil as the percentage of CCs that allowed the chest to return to the fully expanded position prior to starting the next compression. Hand placement was defined as the percentage of CCs for which the hands were placed midline and at the nipple-line.

We collected and managed study data using Research Electronic Data Capture (REDCap) electronic data capture tools hosted at our facility. REDCap is a secure, web-based application designed to support data capture for research studies.

Table 1. Demographics of participants in study measuring the effect of prior cardiopulmonary resuscitation (CPR) knowledge and simulation-based training on the performance of chest compressions (n = 200)*

Mean age ± SD, years	28.5 ± 8.2
Gender (male)	93 (46.5)
Previous CPR experience	97 (48.5)
Level of training	
Medical student	102 (49)
Nursing student	9 (4.5)
EMT-Basic, EMT-Paramedic	18 (9.0)
Registered nurse	54 (27.0)
Physician assistant	1 (0.5)
Doctor of medicine (resident)	16 (8.0)

*Data are presented as # (%) unless otherwise specified.
n: sample size; #: number of subjects; %: percentage of subjects; *SD*, standard deviation; *EMT,* emergency medical technician

Table 2. Cardiopulmonary resuscitation chest compression guidelines, survey responses, and performance (n = 200).

	Guidelines	Survey correct, # (%)*	Performance outcomes, mean (95% CI)
Rate	≥ 100 beats per minute (bpm)	187 (93.5%)	115 bpm (113 – 118)
Hand placement	Centered on chest, along nipple line	116 (58.0%)	80% (75 – 85)**
Depth	≥ 2 in (~51 mm)	148 (74.0%)	41% (35 – 46)**
Recoil	Fully recoil between compressions	187 (93.5%)	83% (79 – 88)**

* Number and percentage of subjects; Based on *2010 AHA Guidelines for CPR & ECC*[1]
** Percentage of compressions performed which meet AHA criteria for each respective chest compression component
n: sample size; #: number of subjects; %: percentage of subjects or chest compressions as indicated; *CI*, confidence interval

Table 3. Analysis of chest compression performance by survey response.

	Correct survey response		Incorrect survey response	*p*-value
Rate	***≥ 100 bpm***		***< 100***	
Mean (95% CI), beats per minute (bpm)	117 (114-119)		94 (80-107)	< 0.001
# (%)*	160 (86%)		6 (46%)	< 0.01
Hand placement	***Centered on chest***		***All others***	
Mean (95% CI), % CCs**	86 (80–92)		72 (63-80)	0.01
Depth	***2 inches***	***> 2 inches***	**< 2 inches**	
Mean (95% CI), % CCs**	41 (35-47)	44 (32-56)	25 (5-45)	0.24
Recoil	***Fully recoil***		**Partial recoil**	
Mean (95% CI), % CCs**	83 (78-87)		97 (93-100)	0.42

* Number and percentage of subjects meeting criteria, ≥100 bpm, during performance of chest compression (CC)
** % CCs = Percentage of compressions performed meeting criteria for respective CC component
#: number of subjects; %: percentage of subjects or CC as indicated; *CI*, confidence interval

Statistical Methods

Distributions of outcomes variables were non-normal; therefore, we used Mann-Whitney U-Test, and Kruskal Wallis H-Test to compare compression performance for rate, hand placement, depth, and recoil between questionnaire response groups. We used Fisher Exact Test for categorical analysis of rate. All analyses were performed using Microsoft Excel 2011 (Microsoft Corporation) with 2011 MegaStat 10.2 Add-in (McGraw Hill).

RESULTS

During the period of July 2011 to October 2011, we recruited a total of 200 students and staff for participation in this study. Demographic data for all study participants are shown in Table 1. While most participants were medical students, subjects also included nursing students, technicians, nurses, and physicians. The participant mix was considered potentially representative of hospital-based resuscitation team membership. Roughly half of all subjects reported having previously performed CCs during a real patient resuscitation and were noted as "experienced providers." However, there was no significant difference in performance between "experienced" and "novice" providers for any of the measured outcomes.

Knowledge of guidelines pertaining to components of effective CCs was variable as shown in Table 2. Of all participants, 93.5% (187) correctly identified an effective rate, 58% (116) correctly identified an effective hand placement, 74% (148) correctly identified an effective depth, and 93.5% (187) correctly identified an effective recoil.

Overall performance is shown in Table 2. For rate, participants performed CCs at a mean rate of 115 bpm with 83% (166) of participants performing CCs at a rate ≥ 100. Of all CCs performed during the study, 80% met criteria for hand placement, 41% met criteria for depth, and 83% met criteria for recoil.

Table 3 presents the differences in performance outcomes between questionnaire response groups. Participants who identified an effective rate of ≥100 performed CCs at a significantly higher rate than participants who felt an effective rate was <100 (μ=117 bpm vs. 94 bpm, $p<0.001$). In addition, a greater percentage of participants in the ≥100 response group

met rate criteria during performance of CCs (86% vs. 46%, p<0.01). Participants who knew appropriate hand placement performed a greater number of CCs adherent to guidelines than those who did not know the correct placement (μ=86% vs. 72%, p=0.01). There were no significant differences in adherence to depth guidelines based on prior knowledge (p=0.24) with all groups achieving an effective depth in less than 50% of CCs performed. For recoil, those identifying incorrect parameters achieved full recoil in 97% of CCs versus 83% for those responding correctly; however, this difference was not significant (p=0.42).

DISCUSSION

To our knowledge, this study represents the first to quantify the effect of knowledge on performance for all CC components outlined in the AHA guidelines, expanding on previous work by Brown et al.[16] This studied included an analysis of recoil and hand placement in addition to compression rate and depth, which was investigated previously. Additionally, rather than EMS providers outside of the hospital, our study investigated the efficacy of CPR administered by in-hospital providers including medical students. Our analysis shows that knowledge of guidelines has a significant impact on CPR performance for at least some components, namely rate and hand placement, which supports prior findings. Of participants identifying a rate of greater than or equal to 100 bpm, 86% met guidelines and the overall mean rate exceeded 100 bpm. Also, participants correctly identifying hand placement administered a greater percent of CCs meeting these guidelines. However, for rate and recoil we saw no significant differences in performance based on knowledge of guidelines.

Our study showed that there is variable retention of guidelines, with rate and recoil parameters being correctly identified by almost all participants, but deficiencies in knowledge for depth and hand placement. In addition, for rate, depth, and recoil, participants demonstrated better retention of guidelines than performance of these CC components. However, despite poor knowledge of guidelines for hand placement, this component was performed unexpectedly well.

Data for effective CC rate in our study were similar to those of Albella et al[3] and Losert et al,[17] which looked at ED staff. In contrast, participants in our study performed a greater amount of effective CCs than participants of 2 previous studies.[4,16] However, one of those studies with poorer performance assessed CC rate during an actual resuscitation and for longer than 1 minute,[4] which was beyond the scope of our study. Although both knowledge and performance were relatively high for this component, in light of the focus on importance of CC rate, even these results are suboptimal.

Unlike rate, depth performance in our study did not parallel the high quality performance of participants in the Losert et al[17] study; instead performance was poor, similar to Abella et al[3] and Brown et al.[16] Depth was the least well performed component in our study, and this could be due to fact that the computer software available at the time of data collection was set to recognize the 2005 AHA recommendations for appropriate compression depth (38-51 mm, approx. 1.5-2 in) and did not discriminate between CCs that were too shallow versus too deep. The newest guidelines have since changed the recommendation to achieve a minimum depth of 51 mm. While it is likely that many of the participants who registered an ineffective depth were too shallow, it is possible that a fraction of participants were compressing too deep. Thus, it is possible that the reported mean percentage of CCs reaching appropriate depth was lower than it would have been if the software had recognized the updated guidelines. However, even with this in mind, performance was relatively poor, and there is significant room for improvement in performance of CCs with appropriate depth as well as retention of depth guidelines.

Despite a high recall for recoil guidelines and a good overall performance, these results are suboptimal in light of studies that show small decreases in complete recoil can affect outcomes.[11] To our knowledge there are no previous studies recording data on hand placement. Even though it was the least correctly identified guideline, overall accuracy of hand placement was good,; however, there was still room for improvement on an individual basis.

There have been several studies on the effectiveness of different teaching methods for CPR training and knowledge retention, suggesting that additional and/or more frequent training may be required to improve retention of guidelines, both in knowledge and performance.[18-20] Additional studies are needed to determine best practice for retention of guidelines, which this study shows would help ensure efficacious CPR performance and therefore improved outcomes, including survival.

LIMITATIONS

This study had several limitations. Foremost, the software recognized 2005 AHA guidelines rather than the most current 2010 guidelines. Additionally, this study was conducted in the controlled environment of a simulation laboratory and CCs were performed on a mannequin. The pre-CPR knowledge survey may have spurred on some recall by participants, but is largely no different than other reminder strategies that have failed to improve CPR performance. Additional factors, such as patient size and number of available providers, may prevent adequate CCs during an actual patient resuscitation. A large portion of the participants in this study were medical students; therefore, the sample of providers studied may not be reflective of the usual makeup of resuscitation teams at some hospitals. Data regarding patient outcomes and the performance of CCs during true resuscitations should be collected to determine the impact of guideline retention on resuscitation.

CONCLUSION

This analysis illustrates that identification of current

AHA guidelines correlates with better performance of at least some components of CPR, namely rate and hand placement, whereas other parameters such as depth and recoil are not affected. Overall, retention of guidelines is variable and performance is suboptimal. As quality of CCs influence efficacy of CPR, more frequent reinforcement may be needed to ensure consistent, effective performance.

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Assessing Knowledge Base on Geriatric Competencies for Emergency Medicine Residents

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Introduction: Emergency care of older adults requires specialized knowledge of their unique physiology, atypical presentations, and care transitions. Older adults often require distinctive assessment, treatment and disposition. Emergency medicine (EM) residents should develop expertise and efficiency in geriatric care. Older adults represent over 25% of most emergency department (ED) volumes. Yet many EM residencies lack curricula or assessment tools for competent geriatric care. Fully educating residents in emergency geriatric care can demand large amounts of limited conference time. The Geriatric Emergency Medicine Competencies (GEMC) are high-impact geriatric topics developed to help residencies efficiently and effectively meet this training demand. This study examines if a 2-hour didactic intervention can significantly improve resident knowledge in 7 key domains as identified by the GEMC across multiple programs.

Methods: A validated 29-question didactic test was administered at six EM residencies before and after a GEMC-focused lecture delivered in summer and fall of 2009. We analyzed scores as individual questions and in defined topic domains using a paired student t test.

Results: A total of 301 exams were administered; 86 to PGY1, 88 to PGY2, 86 to PGY3, and 41 to PGY4 residents. The testing of didactic knowledge before and after the GEMC educational intervention had high internal reliability (87.9%). The intervention significantly improved scores in all 7 GEMC domains (improvement 13.5% to 34.6%; p<0.001). For all questions, the improvement was 23% (37.8% pre, 60.8% post; P<0.001) Graded increase in geriatric knowledge occurred by PGY year with the greatest improvement post intervention seen at the PGY 3 level (PGY1 19.1% versus PGY3 27.1%).

Conclusion: A brief GEMC intervention had a significant impact on EM resident knowledge of critical geriatric topics. Lectures based on the GEMC can be a high-yield tool to enhance resident knowledge of geriatric emergency care. Formal GEMC curriculum should be considered in training EM residents for the demands of an aging population. [West J Emerg Med. 2014;15(4):409–413.]

INTRODUCTION

The field of emergency medicine (EM) is constantly generating new knowledge, and a rapidly shifting world presents ever additional demands on emergency care. This creates a drive to cram more breadth and depth of topics into a crowded residency conference schedule. The EM management of older adults is the perfect example of this pressure. Emergency older adult care is more time-consuming, difficult, and resource intensive than the care of younger adults.[1] Emergency physicians believe insufficient time is spent on geriatric issues in EM residency training.[2]

A large volume of geriatric-specific knowledge essential

to emergency care exists. Additionally because aging increases both risk of disease and overall mortality, physicians should generally treat the elderly more aggressively than younger patients.[3] Still, multiple studies show age-related treatment bias with rates of life-saving therapies lower in older patients.[4-7]

In response to the imperatives above, specific geriatric curricula for EM residency training have been developed.[8-11] Some programs have created fellowship training in the new subspecialty of geriatric EM.[12,13] Emergency departments (ED) nationwide are developing geriatric EDs or geriatric treatment areas.[14-16] These have improved healthcare delivery to older adults with fewer adverse drug reactions, higher patient satisfaction and decreased hospital admission rates.[17]

However, the adoption of geriatric curricula is left to the discretion of individual programs. Time constraints and multiple demands to teach new technologies and topics hinder the insertion of geriatric curricula into overcrowded lecture schedules. The American College of Emergency Physicians (ACEP) has called for members to "prioritize and provide support for the development of an enhanced geriatric core curriculum for resident training."[18] However, despite national efforts by groups such ACEP, as well as the American Geriatrics Society, the John Hartford Foundation, and the American Medical Association, the lone geriatric-specific training requirement by the RRC-EM in 2012 addresses only the very limited topic of elder abuse.[19]

Educators question how we can optimize geriatric training in limited time. We know learning experiences based on objective practice-needs assessment or knowledge testing alter aspects of physician performance.[20,21] Similar to the principal core competencies of the ACGME, the Geriatric Emergency Medicine Competencies (GEMC)[8] are the core competencies of geriatric emergency care. Core competencies address the imperative to fit pivotal components into full residency curricula. The GEMC was developed to focus on high-yield pivotal content areas most substantive to practice. The purpose of this study was to see if a 2-hour educational intervention based on the GEMC could significantly improve didactic knowledge in the core domains representing the spectrum of geriatric emergency care.

METHODS

The GEMC are high impact geriatric topics developed by Hogan et al and identified through expert consensus as most important in the emergency care of older adults.[22,23] The GEMCs were used as a basis for development of an educational intervention, and multiple choice assessment tool. The intervention consisted of a 1-hour didactic lecture delineating the clinical relevance of the 7 GEMC domains. This was followed by a 1-hour workshop using 4 geriatric cases, each based on 2 domain topics presented in small group discussion format. The assessment tool was a multiple-choice test also based on the GEMC.[24]

Table 1. Distribution by year of residents who participated in geriatric competency training and were evaluated in pre and post test administration.

PGY	Pre	Post
1	49	37
2	50	38
3	54	32
4	30	11
All	183	118

PGY, post graduate year

The test was developed by an expert panel consisting of 8 emergency physicians from 5 institutions, and led by a National Board of Medical Examiners (NBME) item writer trainer. All members were trained in NBME item writing and were focused in geriatric EM resident teaching. This panel created 42 questions covering 7 key domains of geriatric knowledge. The test was piloted and validated on a sample of 48 graduating EM residents from 3 separate programs. Starting with 42 items and using an iterative process with Cronbach's Alpha as the measure of internal validity, individual question items were removed until an optimal balance of questions and validity remained in each of the 7 domains.

Then this validated 29-question didactic test was administered at 6 EM residencies. IRB approval was obtained at all 6 programs. Individual resident participation was voluntary, and consent was obtained as the first step in test administration. The 6 EM residencies varied by geographic location, clinical settings, educational curricula and numbers of years in existence. The same test was administered via email one week before and the week after the above educational intervention in the summer and fall of 2009. A single educator delivered the educational intervention at all sites and directed the small group format delivered by the educator and 3 members of volunteer faculty from each program. The educator is an EM-trained former EM program director, who completed the Brookdale Leadership in Aging Fellowship. We analyzed test scores as individual questions and in the 7 defined topic domains using a paired student t test. Overall internal reliability of the didactic test was measured using Cronbach's Alpha. We determined that a sample size of 300 exams had 80% power to find at least 15% difference before and after the educational intervention.

RESULTS

A total of 301 exams were administered, as illustrated in Table 1. There was equal distribution by postgraduate year (PGY). A total of 29 questions were asked. The testing of didactic knowledge before and after the GEMC educational intervention had high internal reliability (87.9%). The results indicate that the test is indeed reflective of EM resident knowledge in this area.

Table 2. Test performance by Geriatric Emergency Medicine Competencies domain.

Domains	# Questions	Pre	Post	Change	P-value*
Atypical presentation of disease in the elderly	8	41.5%	63.0%	21.5%	<0.001
Modification of emergency intervention	5	38.0%	69.8%	31.8%	<0.001
Medication in the elderly	3	37.5%	61.0%	23.5%	<0.001
Falls and trauma	4	44.8%	62.5%	17.8%	<0.001
Care transition (disposition) in the elderly	3	30.8%	47.5%	16.7%	<0.001
Cognitive and behavioral problems in the elderly	3	13.7%	40.3%	34.6%	<0.001
Palliative care in the elderly	3	50.1%	63.6%	13.5%	<0.001
Entire test	29	37.8%	60.8%	23.0%	<0.001

*Paired t-test

Table 3. Percentage improvement by Geriatric Emergency Medicine Competencies domain and post graduate year (PGY) level.

Domains	PGY 1	PGY 2	PGY 3	PGY 4
Atypical presentation of disease in the elderly	19.7%	22.3%	27.1%	18.1%
Modification of emergency intervention	26.8%	33.1%	37.9%	33.3%
Medication in the elderly	16.4%	29.8%	23.8%	28.6%
Falls and trauma	13.9%	23.2%	21.5%	9.7%
Care transition (disposition) in the elderly	13.8%	20.7%	20.2%	5.2%
Cognitive and behavioral problems in the elderly	30.0%	37.3%	40.6%	25.0%
Palliative care in the elderly	9.1%	20.7%	12.8%	11.4%
Entire test	19.1%	26.3%	27.1%	19.3%

Table 4. Test improvement by program.

Residency	n	Pre	Post	Change	P-value
A	72	43.6%	57.4%	13.7%	0.001
B	56	32.4%	75.7%	43.4%	<0.001
C	45	32.8%	56.0%	23.2%	<0.001
D	59	35.1%	70.0%	35.0%	<0.001
E	33	43.0%	53.4%	10.4%	0.158
F	36	39.2%	46.4%	7.2%	0.426
all	301	37.8%	60.8%	23.0%	<0.001

For analysis questions were grouped into 7 individual domains as shown in Table 2.

The educational intervention using the geriatric competencies for EM residents significantly improved test scores in all domains at every resident training level, as shown in Table 3. Graded increase in geriatric knowledge occurred by PGY year with the greatest improvement seen at the PGY 3 Level. All of the 6 programs showed improvement in test scores after the brief education intervention. Four of the six residencies had a significant improvement as shown in Table 4.

DISCUSSION

This study highlights that a 2-hour educational intervention based on the GEMC had a significant impact on resident knowledge of geriatric emergencies. These findings are consistent with those of Beise at al,[22] demonstrating that a geriatric curriculum improved knowledge among the 25 residents. However, the Beise curriculum required more time and used a non-validated 35-question author- designed multiple-choice test, at a single institution. Our study used an exam with pilot testing and internal validation, in content specific areas, and demonstrated positive impact on resident knowledge at all PGY levels and across multiple institutions.

In the teaching of EM, myriad topics vie for time in overcrowded conference schedules. For this reason, the GEMC were designed to be a high-impact series of topics important to the practice of EM to create maximal educational impact in minimal time. Our findings support that a 2-hour

didactic and case-based session when focused on proven GEMC topics result in significant improvement of resident test performance.

The concept of curricula tailored to teach broad topics in a short time through concentration on high- impact areas has not been extensively studied. The GEMC were developed through expert consensus. The goal was to identify areas most relevant to EM practice and design a sharply focused curriculum with maximum ability to enhance knowledge in this topic.

The success of this intervention spanned PGY level. Residents at all levels showed significant improvements in their knowledge. Interestingly, our study found that the percentage improvement increased by PGY year, with the highest improvement in PGY 3 participants. We had anticipated that the greatest improvement would in PGY 1 residents with the least knowledge and the most to gain from every educational exposure. This finding demonstrates that focused didactics are important irrespective of residency level. Perhaps those with greatest levels of knowledge are best able to capitalize and assimilate more intensive and rapid-fire concepts, as were delivered in our intervention.

Additionally this educational intervention improved scores across varied programs, each with diverse geriatric learning opportunities. Thus it can be hypothesized that the strength of our positive results across varied programs may be a product of this specific curriculum. This curriculum could possibly be used across multiple sites with expectation of improving resident knowledge.

The Model of the Clinical Practice of Emergency Medicine[23] (EM Model) serves as the basis for the content specifications for all American Board of Emergency Medicine (ABEM) examinations.[24] The knowledge required to practice competent EM increases daily. Perhaps the EM Model could adapt the GEMC high-impact focus based on expert consensus, to other topic areas with the goal of improving knowledge delivery and maximizing teaching time while enhancing didactic mastery of other EM core topics.

As a result of the demographic imperative of elders in our EDs, and the known failures of EM to provide elders with optimal care, time for geriatric specific teaching must be made. The GEMC were designed to provide optimal high-yield focus for the teaching of geriatric emergency care. The GEMC curricula can be used to maximize EM knowledge of geriatric emergency care in minimal time.

LIMITATIONS

The geriatric education product used in this study is one of many products available to EM resident education. The programs involved in this study all have faculty sympathetic to the teaching of geriatric topics. This may skew resident learning positively toward geriatric care.

Although a single educator presented the didactic lecture and directed the small group sessions, faculty from each site administered individual cases. Although they were provided identical clearly written oral boards-style cases, common stimuli, and scripted discussion points, variable teaching points inevitably occurred. Group specific variation in teaching, learning and test scores could have occurred as a result.

Tests were administered electronically, and delivered to resident emails the week prior to and the week following the conference attendance. A linked survey tool was used so that each resident could only respond once. Only residents that completed the pretest and then attended the educational session were able to complete the post test. This accounts for the attrition of residents from pre to post intervention.

There are many other confounding factors that contribute to gain in medical knowledge. Beyond lectured didactic sessions, residents can improve upon their knowledge base through reading assignments, journal club, clinical lessons and practice-based improvement. The multi-site nature of this study and short time frame between pre and post testing is intended to minimize the effect of these confounding forces.

CONCLUSION

A brief geriatric EM competency-based intervention had a significant impact on EM resident knowledge of critical geriatric topics. Lectures based on the GEMC can be a high yield tool to enhance resident knowledge of geriatric emergency care. A formal GEMC curriculum should be considered in training EM residents for the demands of an ageing population.

Footnote: If interested in using the tool, please contact corresponding authors. The survey has not been published here because it is still being used as an education tool.

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Improving Community Understanding of Medical Research: Audience Response Technology for Community Consultation for Exception to Informed Consent

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Introduction: The Department of Health and Human Services and Food and Drug Administration described guidelines for exception from informed consent (EFIC) research. These guidelines require community consultation (CC) events, which allow members of the community to understand the study, provide feedback and give advice. A real-time gauge of audience understanding would allow the speaker to modify the discussion. The objective of the study is to describe the use of audience response survey (ARS) technology in EFIC CCs.

Methods: As part of the Rapid Anticonvulsant Medication Prior to Arrival Trial (RAMPART), 13 CC events were conducted. We prepared a PowerPoint™ presentation with 4 embedded ARS questions,according to specific IRB guidelines to ensure that the pertinent information would reach our targeted audience. During 6 CCs, an ARS was used to gauge audience comprehension. Participants completed paper surveys regarding their opinion of the study following each CC.

Results: The ARS was used with minimal explanation and only one ARS was lost. Greater than 80% of the participants correctly answered 3 of the 4 ARS questions with 61% correctly answering the question regarding EFIC. A total of 105 participants answered the paper survey; 80-90% of the responses to the paper survey were either strongly agree or agree. The average scores on the paper survey in the ARS sites compared to the non-ARS sites were significantly more positive.

Conclusion: The use of an audience response system during the community consultation aspects of EFIC is feasible and provides a real-time assessment of audience comprehension of the study and EFIC process. It may improve the community's opinion and support of the study. [West J Emerg Med. 2014;15(4):414–418.]

INTRODUCTION

There is a critical need for research in certain emergency medical conditions to improve outcomes. Given the acute nature of some of these conditions, such as sudden cardiac arrest, strokes, and status epilepticus, obtaining an informed consent may be impossible.[1,2] To address this ethical issue, the Department of Health and Human Services (DHHS) and the Food and Drug Administration (FDA) described guidelines in 1996 to allow research to be carried out with an exception from informed consent (EFIC).[3] The federal policies require that the research subject be in a life-threatening condition for which available modalities of treatments are thought to be

unsatisfactory. The potential subject must be unable to consent and there is no time to contact the legal representative. For the subject to take part in the study, there must be a possibility that the subject will benefit.[4-5] The federal regulation that governs EFIC – 21 CFR 50.24 – requires that both community consultation (CC) and public disclosure (PD) occur in that local community and that local institutional review board (IRB) approval be obtained prior to EFIC activities and enrollment of subjects.[6] Public disclosure requires that researchers inform the community that a study will be taking place, usually done through mass media, such as the internet, television and radio advertisements. Community consultation is designed to allow members of the community and stake holders to understand the study, provide feedback and act in an advisory role.[7] It is also an opportunity to hear concerns, suggestions and questions that may have not been considered. An important part of community consultation is to sufficiently educate the community members about the study so that they are able to provide meaningful feedback.[2] A lack of understanding may complicate the evaluation of community feedback by the investigators and IRBs. It can be difficult for the speaker to gauge the level of audience understanding. A real- time gauge of audience understanding would allow the speaker to modify the presentation, reiterate important aspects of the study, and ensure appropriate communication. Several studies have been published on the role of community consultation and how the general population views them, but we have not found evidence that demonstrates that the community groups understand the proposed study.

1- Which of the following are risks of the study?
- A- Allergic reaction
- B- Slowed breathing
- C-Pain at the injection site
- D-All of the above

2- We will start the study without the consent of the patient.
- A- True
- B- False

3- Which of the following people will NOT be enrolled?
- A- Prisoners
- B- known pregnant women
- C- Any person who opts out with a bracelet
- D- All of the above

4- Can I opt out of the study?
- A- Yes
- B- No

Figure 1. Audience response questions.

Question
This study offers more benefit than harm for the seizing patient
I would be willing to participate in such a research study if I were having a serious seizure and unable to give my permission
If a family member was enrolled in this study and I was told about it afterwards, I would agree to their continued participation, until they could consent for themselves
Are you supportive of this study being done in your community?

Figure 2. Paper survey questions regarding community members' opinion of study.

An audience response system (ARS) is an electronic device that creates an interaction between the presenter and his audience in real time and allows for immediate feedback. ARS have been playing an important role in medical education and have been shown to have more student appeal and satisfaction than didactic sessions in continuing medical education learners.[8,9] This paper describes the novel use of audience response systems in community consultation for EFIC.

METHODS

Study Design

This study describes the use of an ARS during EFIC community consultations for a single site of the RAMPART study.[10] We retrospectively compared ARS and non-ARS CC sites for potential differences in baseline demographic characteristics and average rank scores of the final paper survey. Our IRB approved this study as a part of the RAMPART EFIC process.

Study Setting and Population

During the EFIC process, our site carried out 13 CC events in the spring of 2009 and winter of 2010 in the local metropolitan area. CCs were organized with various community groups in the greater metropolitan area, such as churches, schools, and support groups. Six of the community consultations used the ARS presentations. The ARS and non-ARS consultations were chosen based on convenience.

Study Protocol

We prepared a PowerPoint™ presentation with audience response technology from Turning Point Technologies, Inc (Youngstown, OH) according to specific IRB guidelines to ensure that the pertinent information would reach the targeted audience. We embedded the slide set with 4 ARS questions that were thought to address the most important issues a community needs to understand prior to the study's start (Figure 1). At the ARS sites, we used the pooled answers to the embedded questions to guide any necessary additional explanations of the study during the presentation. The same

Table 1. Demographics of community members attending a community consultation event.

	ARS sites	Non ARS sites	p-value
Participants	76	29	
Mean age	49.9 ± 14.2	41.8 ± 13.8	0.011
Female	38 (49%)	22 (76%)	0.014
White	21 (28%)	6 (21%)	0.276
Hispanic or Latino	0 (0%)	1 (3%)	
African American	46 (61%)	22 (76%)	
Asian	5 (7%)	0 (0%)	
Pacific Islander	1 (1%)	0 (0%)	
Native American	0 (0%)	0 (0%)	
Other	3 (4%)	0 (0%)	
No school	0 (0%)	0 (0%)	0.296
Elementary	0 (0%)	(0%)	
Some high school	2 (3%)	4 (14%)	
High school	7 (12%)	3 (10%)	
Some college	21 (35%)	8 (28%)	
College	30 (50%)	14 (48%)	

ARS, audience response system

slide presentation was given to all of the ARS consultations.

At the end of all of the CCs, an anonymous final written survey was completed by individuals to obtain feedback from the audience and to gauge whether the audience was supportive of the study and willing to participate in it. The survey collected basic demographic information, qualitative comments, and had 4 questions related to opinions about the study with a Likert scale (Figure 2). Not all of the CCs were amenable to a slide presentation and the ARS slide set was not used there. Also, every participant did not complete a final paper survey.

Data Analysis

We reported age as mean and standard deviation in both groups and compared it using a 2-sided 2-sample t-test. Gender and ethnicity were reported as frequency and percent for each category and compared between groups using a Chi-square test and a Fisher's exact test, respectively. We evaluated educational level using a 2-sided Cochran-Armitage trend test to determine whether or not there was a significant trend in education level when compared between the 2 groups. The 4 questions related to opinions about the study were assigned ranked values from 1 to 4 (1: strongly disagree, 2: disagree, 3: agree, and 4: strongly agree). The average rank scores for ARS and non ARS were reported for each question and compared between groups using 2-sided Wilcoxon rank-sum tests.

Table 2. Audience response data summary.

Question	% Correct (Total N)
Which of the following are risks of the study?	81% (80)
We will start the study without the consent of the patient.	61% (80)
Which of the following people will NOT be enrolled?	92% (86)
Can I opt out of the study?	93% (87)

RESULTS

The investigators presented information on the RAMPART study to 13 groups during the CC process. At 6 of these meetings, the presentation was augmented by the use of ARS to understand audience comprehension. The ARS process required minimal explanation, and only 1 unit was lost. There was a significantly higher average age and lower proportion of females in the ARS group compared to the non-ARS group. There was no significant difference in ethnicity or educational level between the 2 groups (Table 1).

During the ARS presentations, greater than 80% of the participants correctly answered 3 of the 4 questions. However, the question referencing EFIC and enrollment without the patient's informed consent was correctly answered 61% of the time. The ARS results for these 6 groups are shown in Table 2.

The final paper surveys were intended to obtain written feedback from the community regarding the study. Overall, the survey respondents had an 80-90% favorable response (strongly agree or agree) to the questions presented. Agreement scores were significantly higher in the ARS sites compared to the non-ARS sites for 3 of the 4 questions (Table 3).

DISCUSSION

Since the ARS technology was invented in the 1960s, it has been used in evaluating the response of large audiences. As the technology advanced, its application increased to cover a broad range of industries and organizations, such as marketing, corporate training, game shows, universities and continuing medical education.[9] Miller et al evaluated the role of ARS for the continuing education of health professionals and found that ARS enhanced audience attention and learning.[8] Homme et al concluded that ARS significantly increased attendance and participation during weekly residency board review courses, and the residents perceived that the experience was educational.[11] During the RAMPART CCs, ARS was found to be a feasible method to measure the audience's understanding of the presentation. From a financial aspect, it may be a cost-effective investment to ensure the message is understood. Furthermore, ARS is an easy way to automatically capture data, allowing the researcher to bypass the tedious data entry process that is

Table 3. Paper survey question with results for sites that used audience response versus those that did not.

Question		Strongly agree (4)	Agree (3)	Disagree (2)	Strongly disagree (1)	Average score	p-value
This study offers more benefit than harm for the seizing patient	ARS sites 76 (100%)	36 (47%)	36 (47%)	3(4%)	1(1%)	3.4	0.035
	Non ARS sites 28 (96%)	7 (26%)	18 (67%)	2 (7%)	1 (4%)	3.1	
I would be willing to participate in such a research study if I were having a serious seizure and unable to give my permission	ARS sites 75 (98%)	30 (38%)	34 (47%)	9 (12%)	2 (3%)	3.2	0.661
	Non ARS sites 29 (100%)	10 (34%)	14 (48%)	3 (10%)	2 (7%)	3.1	
If a family member was enrolled in this study and I was told about it afterwards, I would agree to their continued participation, until they could consent for themselves	ARS sites 76 (100%)	32 (42%)	42 (55%)	1 (1%)	1 (1%)	3.4	0.010
	Non ARS sites 29 (100%)	5 (17%)	21 (72%)	1 (3%)	2 (7%)	3.0	
Are you supportive of this study being done in your community?	ARS sites 79 (100%)	43 (57%)	30 (39%)	2 (3%)	1 (1%)	3.5	0.024
	Non ARS sites 29 (100%)	8 (30%)	20 (67%)	0 (0%)	1 (3%)	3.2	

ARS, audience response system

necessary when written surveys are used. ARS also works for various size audiences. It is convenient for large audiences and also allows for anonymous feedback in small groups.[12]

The ultimate goal of community consultation is to provide the audience with an advisory role through which they can channel concerns, questions and feedback to the IRB and the study investigators.[13] Based on their feedback, the IRB and investigators can modify some aspects of the protocol to protect the potential subjects. In a 2007 review article on CCs, Baren et al asked if the community grasped this advisory concept.[14] While most of the literature addresses how CCs should be organized, and how much information should be divulged during the event, no literature has addressed the issue of audience comprehension. [15] The local community enrolled in this study was primarily composed of minorities and African Americans. This subset of the population has been shown to be reluctant to participate in clinical trials due to previous experience with research, such as the Tuskegee experiments.[16] Through the use of ARS, the speakers were able to identify that 40% of the audience at the CCs did not understand the concept of EFIC and that the study would be started without informed consent. Therefore, the presenters were able to review and reiterate this information. This ultimately may have led to a greater understanding of the presentation's content and overall purpose of the study and more support from the community. Alternatively, the ARS group may have felt more engaged and therefore more likely to support the study. For a different study, better understanding may possibly lead to less support if there are concerns with the study protocol.

To make the CCs more credible to the audience, the presentations were given by a physician. While a physician would have the knowledge to answer most of the audience's questions, he/she can also be a source of intimidation to a lay person. While questions were encouraged during CCs, a lay person may be reluctant to ask simple questions to a physician. Similarly, given the large size of audience at CCs, an individual person might be reluctant to voice an opinion in such a large forum.[14] However, through the use of the ARS, the audience has an anonymous method to voice their opinion.[12, 13]

LIMITATIONS

There are many limitations to this study. We did not prospectively design the CCs to compare ARS and non-ARS sites. Therefore, the 2 groups are not matched cohorts and we cannot draw definitive conclusions regarding their comparison. Also, we did not assess understanding of the study during the final paper survey; therefore we cannot comment on the effectiveness of either presentation with

regards to comprehension.

Also, not all of the participants completed a paper survey, and everyone at the ARS sites may not have answered the ARS questions. Therefore, we do not have data to determine the overall response rate for the ARS presentations or the final survey.

Due to the anonymous nature of the paper surveys and the ARS responses we could not directly compare the responses of individuals.

CONCLUSION

The use of an audience response system during the CC aspects of EFIC is feasible, and provides a real-time assessment of audience comprehension of the study and EFIC process. It may improve the community's opinion and support of the study. This article will hopefully inspire future research in improving community consultations.

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Analysis of the Evaluative Components on the Standard Letter of Recommendation (SLOR) in Emergency Medicine

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Introduction: The standard letter of recommendation in emergency medicine (SLOR) was developed to standardize the evaluation of applicants, improve inter-rater reliability, and discourage grade inflation. The primary objective of this study was to describe the distribution of categorical variables on the SLOR in order to characterize scoring tendencies of writers.

Methods: We performed a retrospective review of all SLORs written on behalf of applicants to the three Emergency Medicine residency programs in the University of Arizona Health Network (i.e. the University Campus program, the South Campus program and the Emergency Medicine/Pediatrics combined program) in 2012. All "Qualifications for Emergency Medicine" and "Global Assessment" variables were analyzed.

Results: 1457 SLORs were reviewed, representing 26.7% of the total number of Electronic Residency Application Service applicants for the academic year. Letter writers were most likely to use the highest/most desirable category on "Qualifications for EM" variables (50.7%) and to use the second highest category on "Global Assessments" (43.8%). For 4-point scale variables, 91% of all responses were in one of the top two ratings. For 3-point scale variables, 94.6% were in one of the top two ratings. Overall, the lowest/least desirable ratings were used less than 2% of the time.

Conclusions: SLOR letter writers do not use the full spectrum of categories for each variable proportionately. Despite the attempt to discourage grade inflation, nearly all variable responses on the SLOR are in the top two categories. Writers use the lowest categories less than 2% of the time. Program Directors should consider tendencies of SLOR writers when reviewing SLORs of potential applicants to their programs. [West J Emerg Med. 2014;15(4):419–423.]

INTRODUCTION

Background and Importance

Medical student applicants to emergency medicine (EM) residency training programs are required to supply letters of recommendation with their applications through the Electronic Residency Application Service (ERAS), an online service that transmits applications electronically from medical students to residency programs. Applicants are evaluated by residency programs based on various components of their application including United States Medical Licensing Examination (USMLE) scores, the dean's performance evaluation, clinical rotation grades, extracurricular experiences, the medical school's reputation, and letters of recommendation.[1-4]

In 1996, the Council of Residency Directors in Emergency Medicine (CORD) developed a Standard Letter of Recommendation (SLOR) in an attempt to normalize the evaluation of applicants, improve inter-rater reliability of letters of recommendation and to discourage the "upward creep of superlatives."[5,6] The SLOR includes student evaluation on the following categorical variables: commitment to EM (CEM), work ethic (WET), ability to develop a treatment plan (DTP), ability to interact with others (IWO),

ability to communicate with patients (CWP), guidance predicted during residency (GUI), prediction of success (PRS), global assessment score (GAS), and likelihood of matching assessment (LOMA). Each variable rates students on a three or four point categorical scale that includes anchors such as "outstanding," "excellent," and "good". Despite widespread use and expectation in EM, the validity of the SLOR has not been well studied, and functional responses to the SLOR categorical variables have not been well characterized.

While the CORD EM has chosen to revise the format of the SLOR to the Standardized Letter of Evaluation (SLOE), most of the categories of the SLOE correspond directly to those of the SLOR. The changes made in revision of the SLOR to the SLOE reflect a greater emphasis on evaluation in addition to recommendation, and a simplification of the form in order to promote standardization across institutions.

Goals of this investigation

Each year, approximately 900 students apply to at least one of the EM residencies at the University of Arizona. The majority of students submit one or more SLORs with their application. Our primary objective was to describe and characterize the distribution of responses to categorical variables on the SLOR to gain an understanding of the scoring tendencies of letter writers.

METHODS

Study design and setting

This was a retrospective review of all SLORS written on behalf of all applicants to the three Emergency Medicine residency programs in the University of Arizona Health Network system in Tucson, Arizona.

The University of Arizona Health Network hosts two categorical EM residency programs (a university-based residency and a community/county hospital-based residency) and a combined EM-Pediatrics program.

Table I. Variables and categories on the standard letter of recommendation with assigned scoring.

Variable	Categories	Scoring
Commitment to emergency medicine (CEM)	Outstanding	1
	Excellent	2
	Very good	3
	Good	4
Work ethic (WET)	Outstanding	1
	Excellent	2
	Very good	3
	Good	4
Development of treatment plan (DTP)	Outstanding	1
	Excellent	2
	Very good	3
	Good	4
Personality: ability to interact with others (IWO)	Superior	1
	Good	2
	Quiet	3
	Poor	4
Personality: ability to communicate with patients (CWP)	Superior	1
	Good	2
	Quiet	3
	Poor	4
Amount of guidance anticipated (GUI)	Almost none	1
	Minimal	2
	Moderate	3
Prediction of success (PRS)	Outstanding	1
	Excellent	2
	Good	3
Global assessment score (GAS)	Outstanding	1
	Excellent	2
	Very good	3
	Good	4
Likelihood of matching assessment (LOMA)	Very competitive	1
	Competitive	2
	Possible match	3
	Unlikely match	4

Participants

All SLORs written on behalf of all the applicants to the three University of Arizona EM programs in the 2011-2012 application cycle were reviewed and included in the analysis. All candidates' applications were reviewed, and all SLORs submitted with their applications were included. SLORs were extracted from ERAS applications by the program coordinators of the University, South Campus, and EM/Pediatrics programs. Members of the study group, which included Program Directors, Associate Program Directors, Clerkship Director, and Core Medical Student Teaching Faculty, then abstracted responses for each SLOR variable. Abstraction instructions were provided by email, and spot checking of the abstraction process was conducted during data collection. Duplicate SLORs from applicants who applied to more than one of the University of Arizona EM residency programs were recorded only once. If a letter writer used more than one answer to a variable, for example an outstanding (scoring a 1) and an excellent (scoring a 2) for the GAS, the less favorable score was recorded for that variable on that application. Once the data collection was complete, data was de-identified by removing the applicants' ERAS number and institution and centrally collated for analysis.

Measurements and outcome variables

Anchors for each SLOR variable are listed in Table 1, along with the corresponding numerical score they were assigned in this study.

Data Analysis

Data analysis consisted of descriptive statistics of the distribution of all categorical variables collected, using Microsoft Excel for Mac 2011. The local institutional review committee approved this study.

Table 2. Descriptive analysis of variables on the standard letter of recommendation in emergency medicine (Tier 1 = highest rating, Tier 4 = lowest rating).

Variable	Rating tier 1	Rating tier 2	Rating tier 3	Rating tier 4
Commitment to emergency medicine (CEM) (n=1457)	733 (50.31%)	611 (41.94%)	104 (7.14%)	9 (0.61%)
Work ethic (WET) (n=1455)	865 (59.45%)	507 (34.85%)	77 (5.29%)	6 (0.41%)
Development of treatment plan (DTP) (n=1451)	470 (32.39%)	694 (47.83%)	270 (18.54%)	17 (1.17%)
Personality: ability to interact with others (IWO) (n=1451)	889 (61.27%)	502 (34.60%)	59 (4.06%)	1 (0.07%)
Personality: ability to communicate with patients (CWP) (n=1445)	863 (59.72%)	549 (38.00%)	33 (2.28%)	0 (0%)
Amount of guidance anticipated (GUI) (n=1448)	557 (38.47%)	797 (55.04%)	94 (6.49%)	N/A
Prediction of success (PRS) (n=1448)	776 (53.59%)	611 (42.20%)	61 (4.21%)	N/A
Global assessment score (GAS) (n=1422)	469 (32.98%)	640 (45.01%)	277 (19.48%)	36 (2.53%)
Likelihood of matching assessment (LOMA) (n=1419)	587 (41.37%)	607 (42.77%)	198 (13.95%)	27 (1.91%)

RESULTS

Characteristics of subjects

During the 2012 interview season, there were a total of 917 unique applicants with a total of 1,457 SLORs that were submitted to the three University of Arizona EM programs. Applicants had up to 4 SLORs to support their application. The average number of SLORs per applicant was 2. Twenty percent (n=184) of the total applicants did not have a SLOR included in their application. Our sample represents 26.7% of the total number of ERAS applicants for the academic year 2012.

Main results

Many of the categorical variables for these SLORs contained missing data. 2.5% of GAS scores were missing; 3.0% of LOMA scores were missing. All other variables were missing less than 1% of the time. Data from 32 applications had a variable with more than one response (<0.1% of all data). For these cases the less favorable rating was chosen.

The percentages of responses in each category for each variable are represented in the figure and Table 2. Students were placed in the top variable rating for all variables in 47% of all responses. For variables with a 4-point scale, <1% were in the lowest variable rating. One variable, CWP, had no responses in the lowest variable rating. For the two variables with 3-point scales, 6.5% (GUI) and 4.2% (PRS) of responses were in the lowest variable rating. Combined, the lowest categories were used less than 2% of the time. In total for 4-point scale variables, 91% of all responses were in one of the top two ratings. For 3-point scale variables, 94.6% of all responses were in the top two ratings.

DISCUSSION

The SLOR is an effort to standardize recommendations on behalf of medical students applying to Emergency Medicine residency programs. However, letter writers rely disproportionately on the top two categories rather than the full scale for assessment. Our findings are consistent with another recently published description of SLOR distribution of responses.[7] There may be a number of explanations for this, including that students may only choose writers with whom they have an outstanding rapport, in effect maximizing the likelihood of an outstanding evaluation. In addition, the SLORs analyzed in this study were those submitted for emergency medicine residency applications. It is unknown how many and what the distribution of variable scores were for SLORs written but not submitted on behalf of applicants. Students frequently waive the right to see the SLOR; however they may choose not to upload a SLOR from a site where they received an unfavorable grade. Letter writers may decline writing a SLOR if they feel it will not be a favorable one for a particular student. In addition, Dean's offices have withheld SLORS with uncomplimentary categorizations. It is likely that there is a selection bias associated with our analysis in that SLORs with lower assessments were not chosen by students or their Dean's offices to support their application.

It is unclear what training, if any, on using the SLOR as a tool to evaluate and differentiate students potential evaluators receive. Although there are instructions for completing the SLOR (now SLOE) on the CORD website, it is unknown how many authors are aware of or have read the instructions. Without definitions of specific behaviors that make one

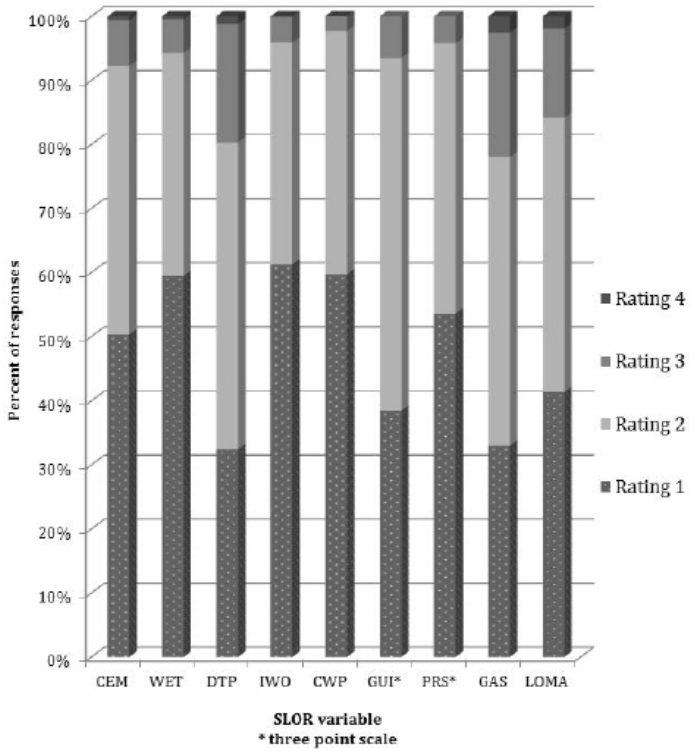

Figure. Ratings for qualifications and global assessment variables on the emergency medicine standard letter of recommendation.

student "outstanding" versus "excellent" it is left to individual SLOR writers to determine the distinction themselves. The SLOR writer's breadth of experience working with students, as well as their experience using the SLOR as an evaluative tool limits the generalizability of the information in the SLOR when comparing students evaluated by different SLOR writers and from different medical institutions. A recent study by Beskind et. al. found that SLORs written by less experienced letter writers were more likely to have a GAS of 'outstanding' and a LOMA of 'very competitive' than more experienced letter writers.[8]

And finally, even experienced and objective letter writers may be reticent to rank a student as anything but "excellent" or "outstanding" for fear of the stigma it may carry, and potential damage to a student's residency application.

SLOR writers were less hesitant to use lower categories on the GAS and LOMA, which are both "Global Assessment" variables rather than on the "Qualifications for EM" variables. It is possible that the qualifications variables represent a place where letter writers feel they can convey, "this is a great student, just not for our program," rather than give the student what may be perceived as a negative letter in comparison to the other SLORs for other students in the applicant pool.

Some institutions have moved to a composite or committee SLOR. A group or departmental letter may be more objective and more likely to include the full spectrum of scaled categories for each variable. However, this may not reflect the personal experience that individual faculty have had with an applicant. Ideally, a SLOR would accurately reflect a student's qualifications for EM as well as a global assessment.

Recently, the CORD EM has chosen to revise the format of the SLOR to the Standardized Letter of Evaluation (SLOE). The changes made in revision of the SLOR to the SLOE reflect a greater emphasis on evaluation in addition to recommendation, and a simplification of the form in order to promote standardization across institutions. While the categories and anchors in the SLOE are very similar to those of the SLOR, it may be that our analysis does not accurately reflect the distribution of scores across the SLOE.

LIMITATIONS

This study was a cross sectional description of all SLORs written on behalf of applicants in EM at the University of Arizona, and is subject to many of the flaws of this study design. Although letter writers most commonly rank students in the highest two categories, we can only speculate as to why this occurs.

Incomplete or missing data for each variable may have affected the analysis. For example, letter writers occasionally did not rank students on one or more variables. 2.4% of GAS data and 2.6% of LOMA data were missing. Only 5 (0.3%) SLORs were missing both GAS and LOMA data. Less than 1% of all other variables were missing. We assumed this data was missing at random and simply excluded them from our analysis, rather than try to impute data. Some letter writers indicated two responses for the same variable. Data from 32 applications had a variable with more than one response. For these cases, the less favorable rating was chosen. Due to our a priori hypothesis that ratings were skewed to the more favorable side of each scale, coding these type of responses as less favorable would have had the effect of biasing our results in the opposite direction from our findings. In addition, duplicate responses were present for <0.1% of all data. Although generally low percentages of SLORs had incomplete, missing or duplicate data, this may have potentially changed the results.

While we did collect data on who wrote each SLOR and how many they wrote in the current applicant pool, we do not report that information in this analysis. It is possible that a handful of writers were responsible for a significant percentage of the total. Even though our sample size was quite large, it may be that one or two "superwriters" could skew the results because of individual tendencies in how they evaluate students. These writers could have been inclined to be more or less lenient, thereby affecting the results.

Finally, this analysis is based solely on the applicant pool of the University of Arizona EM residency programs. While the three programs received 26.7% of the total applicant pool, it is possible that this sub-population is not representative of the entire student population of interest—i.e. the total applicant pool to EM residencies – and therefore results cannot be generalized to all applicant SLORs. For example,

applicants to EM programs in the Western United States may have different SLORs than their counterparts in the Eastern or Southern regions of the country. Or, we may simply have very competitive EM residency programs, thereby limiting the number of applicants in the bottom half of the categories. Despite this, and regional differences aside, we were able to capture applicants to both a university residency program as well as community/county hospital based program representing two very common applicant pools.

CONCLUSION

SLOR letter writers were very likely to use the highest two categories for the descriptive variables when writing their letters. They were more likely to use the highest category on "Qualifications for EM" variables (CEM, WET, IWO, CWP, GUI and PRS) and to use the second highest category on Global Assessments (GAS, LOMA) and rarely used the lowest one to two categories. The lowest categories were used less than 2% of the time. Program Directors should consider the tendencies of the rating on the SLOR when reviewing SLORs of potential applicants to their programs. Although our analysis may not accurately reflect the distribution of scores across the SLOE, the categories and anchors in the SLOE are so similar to those of the SLOR the distribution of scores is unlikely to differ greatly from our findings.

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Deliberate Apprenticeship in the Pediatric Emergency Department Improves Experience for Third-year Students

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INTRODUCTION: The Pediatric Emergency Department (PED) provides medical students with learning in a high-volume, fast-paced environment; characteristics that can be stressful for new students. Shadowing can improve transitioning, yet this alone does not facilitate students' development of independent medical care competencies. This study evaluates if third-year medical students' deliberate apprenticeship with senior residents increases students' comfort and patient exposure in the PED.

METHODS: This study took place over the 2011-2012 academic year, and study participants were all third-year medical students during their pediatric clerkship rotation. This was a prospective educational intervention assigning students to randomized control blocks of deliberate apprenticeship (DA) intervention or control. DA students were paired with a senior resident who oriented and worked with the student, while control students were unpaired. All students completed a 20-question structured survey at shift end, which included questions about their perception of the learning environment, comfort with, and number of patient care responsibilities performed. We used independent Mann-Whitney and t-tests to compare experiences between the groups. Statistical significance was defined as $p<0.05$. We used the constant comparative method to qualitatively analyze students' comments.

RESULTS: Response rate was 85% (145/169). Students also rated on 5-point Likert-scale their level of comfort with defined aspects of working in the PED. DA students (n=76) were significantly more comfortable obtaining histories (4.2 versus 3.8) and formulating differential diagnoses (3.9 versus 3.4). DA students also performed more physical exams (2.9 versus 2.4). We categorized themes from the qualitative analysis of the students' comments about their PED experience. The titles for these themes are as follows: PED provides a good learning experience; uncertainty about the medical student's role in the PED; third-year medical students compete with other learners for teaching attention; opportunities provided to medical students for inclusion in patient care; personal knowledge deficits limit the ability to participate in the PED; PED pace affects learning opportunities.

CONCLUSION: DA constitutes a feasible approach to the clinical learning environment that increases students' patient care experiences and may ease transitioning for undergraduate medical students to new clinical environments. [West J Emerg Med. 2014;15(4):424–429.]

INTRODUCTION

The transition to new clinical environments can be a stressful experience for medical students. Lack of knowledge of their roles and lack of familiarity with their environments contributes to the anxiety-provoking nature of transitioning work places.[1] The pediatric emergency department (PED), in particular, is a high-volume, fast-paced environment that provides rich learning and training opportunities not found in other healthcare settings. Yet these very characteristics can be stressful for students not accustomed to this environment. Orientations, however, allow students to understand the "mechanics and processes of the healthcare team.[2] Expectations, such as how many patients to see, what information should be conveyed to the preceptor, and how much time to spend with each patient, are valued by the student.[3,4]

Deliberate apprenticeship (DA) is the process of how learners gradually become part of a profession through progressively shared activities with established professionals. This concept of DA, in conjunction with orientation to learning objectives, is a key theoretical framework of how learning occurs.[5,6] For instance, existing research shows that shadowing of current house officers can improve transitioning from the undergraduate to graduate medical training years, as well as comfort in a new practicing physician's role.[7,8] Emergency department (ED) observational experiences have been shown to increase career interest in emergency medicine for first-year medical students by linking these students with well-entrenched learners in the field.[9] DA extends the principle of simply shadowing, by incorporating active involvement and participation as necessary steps to developing independent medical skills. Although there have been qualitative studies investigating the socialization and transition to new environments for house staff, there have been few educational interventions on how DA can improve the overall experience of the transition from the pre-clinical to the clinical years for undergraduate medical students.

From our post-clerkship surveys conducted prior to the initiation of this study, it appeared that third-year medical students' ratings of their experience in the PED varied based on how actively the student was oriented and engaged during their shift. The absence of assignment responsibility for orientation for specific trainees leaves considerable variability in students' contacts with residents at different levels of training, as well as with attendings. We hypothesized that DA of third-year medical students with senior residents in the PED would improve medical students' overall experience in this setting compared to the usual practice, at this institution, of students just showing up for their shifts.

METHODS

Study Population

The study population was the third-year class of 169 medical students completing their pediatric clerkship for the academic year of 2011-2012.

Study Setting

This was a prospective educational intervention study conducted at the PED at a tertiary care children's hospital over a 12-month (rotation) period. This study was deemed exempt by the local institutional review committee. The pediatric clerkship at this institution consists of a total of eight weeks: four weeks in the inpatient hospital setting and four weeks of ambulatory experience. The PED experience consists of two eight-hour shifts that occur during the ambulatory period. Prior to the start of the overall pediatric clerkship, students receive a four-hour orientation. An online website contains additional information regarding various aspects of their pediatric clerkship. Included is a PowerPoint presentation about the PED that students are encouraged to review before their ED shifts. Specifics about the PED experience are not verbally presented during the four hour orientation. Instead, the overall orientation instructs students to simply "show-up" and "jump-in" during the PED shifts.

Study Protocol

Students were assigned in randomized blocks to DA (intervention) or control groups. The DA group consisted of students specifically paired with the senior residents whose shift schedule had the most significant overlap with the students' schedule. This resident was in charge of not only orienting, but also closely working with the student. These senior residents received an email with the date, shift time, student name, and specific instructions on how to orient their medical student. The control group consisted of students who received the traditional pediatric orientation: i.e. showed up for their shifts without a pre-assigned resident. The third-year medical students not paired with senior residents were not aware that other groups of students had specific pairings to residents.

Outcome Measurements

We evaluated this educational intervention by collecting medical students' perceptions about their experience during their PED shifts. Students were asked to complete a web-based (Qualtrics™) 20-question anonymous online instrument via email approximately one hour after completion of their first PED shift. Outcome data elicited from students included the number of patients seen, histories/physicals performed, and procedures observed. Students also rated on 5-point Likert-scale their level of comfort with defined aspects of working in the PED. We also provided a section for written comments regarding their PED experience. Students were explicitly informed that their participation was voluntary and anonymous.

Data Analysis

Quantitative

We analyzed the data using SPSS, Version 19 (Armonk, NY). Descriptive statistics for each variable were calculated.

Table. Differences between deliberate apprenticeship (intervention) of third-year medical students in a pediatric ED and control groups.

	Control mean (SD)	Intervention mean (SD)	p-value
Comfort obtaining histories†	3.8 (1.0)	4.2 (1.0)	0.02*
Comfort with physical examinations†	3.7 (1.1)	4.1 (1.0)	0.07
Comfort with formulating a differential diagnosis†	3.4 (1.0)	3.9 (0.9)	0.001*
Overall, comfort level working in the pediatric emergency department†	3.7 (1.1)	4.0 (1.0)	0.11
Overall teaching†	3.4 (1.0)	3.4 (1.1)	0.88
Overall experience†	3.4 (1.0)	3.5 (1.1)	0.40
Number of patients seen	5.8 (1.7)	5.5 (1.6)	0.31
Number of histories performed	2.6 (1.4)	3.0 (1.4)	0.08
Number of physical exams performed	2.4 (1.3)	2.9 (1.5)	0.03*
Number of procedures observed	2.0 (1.0)	2.0 (1.2)	0.76

*p<0.05, †Likert-type scale very uncomfortable (1) to very comfortable (5).

We used independent Mann-Whitney analyses, for ordinal-level ratings of comfort and overall PED teaching and experience, to compare the experiences of students in the DA and the control groups. We compared the number of patients that DA and control students saw and procedures they observed, as well as the number of histories/physical examinations they independently performed, using independent t-tests. We studied this over an academic year to determine empirically whether differences emerged over time, i.e. early versus late rotation periods with analysis of variance over the 12 rotations. Statistical significance was defined as $p<0.05$. We used a Cohen's d to calculate effect size; based on a population of 169 students, with 95% confidence level, effect size 0.5, power level of 0.8 and 80% response rate, this was a total of 102 students.

Qualitative

Using the constant comparative method, consistent with grounded theory, the comments provided by the medical students were independently read and coded for emergent themes by three investigators, who were blinded to the comment status as generated by the DA or the control group.[10] The analysis proceeded iteratively until all comments were coded into themes consistently across reviewers.

RESULTS

Quantitative Results

A total of 145 out of 169 (85%) students responded to the online survey instrument. Figure illustrates the breakdown of individuals completing the survey. Most (74.1%) of the students reported that they had read the online orientation PowerPoint prior to their PED shift. The majority of students (85%) reported receiving an individual orientation during their PED shift. Table summarizes the findings comparing the DA and control groups. At a statistically significant level, DA students were more comfortable with taking histories and with creating a differential diagnosis. In addition, DA students performed significantly more physical examinations. There was no significant difference in students' rating of their overall PED experience in comparing mean ratings of the two groups. No statistically significant difference occurred in comparing mean number of professional care responsibilities across the 12 rotations during the academic year.

Qualitative Results—Themes from Student

There were 58 comments from the students. Six themes emerged from the analysis of these comments. A summary of each theme, noting the percent of students contributing comments categorized within the theme category, is provided. The themes were as follows: PED provides a good learning experience (39.7%); uncertainty of the medical student's role in the PED (27.6%); opportunities provided to medical

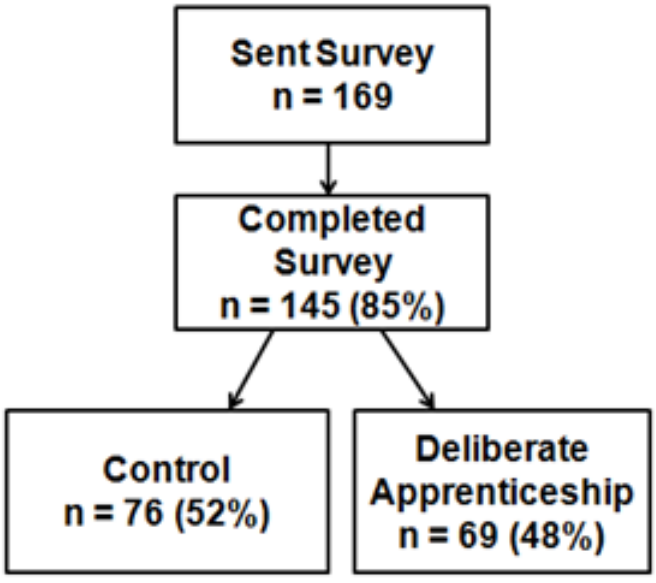

Figure. Study population.

students for involvement/inclusion in patient care (12.1%); third-year medical students compete with other learners for teaching attention (3.4%); personal knowledge deficits limit the ability to participate in the PED (3.4%); and PED pace affects learning ability (13.8%). A description of each theme, with illustrative quotations, is provided below.

PED Provides a Good Learning Experience

Many medical students characterized the PED as a valuable part of their training. One student commented, "I think that it is an important experience because you get to see/hear very pertinent findings that are often not present in clinic (ex: real nasal flaring and retractions or even in my case a patient in status (control)." Faculty and residents were also individually acknowledged as contributing to the medical students' having an overall good experience. For instance, one student wrote, "Dr. [X] was GREAT, so was [Y] the resident… they were great teachers and definitely included teaching as well as feedback (DA)."

Uncertainty of the Medical Student's Role in the PED

Many medical students reported that faculty and house staff did not know how to incorporate them into the flow of patient care. One medical student commented, "It was a little hectic when I arrived and I wasn't informed of exactly what I would be expected to do—nobody seemed to know what my role was exactly and whether I should see patients on my own, etc (control)." Students reported that if expectations were provided, they would be better suited to participate in this environment. One student wrote, "At the beginning nobody looked like they were expecting to see an M3 show up for the shift; nor were we given instructions at peds orientation to ask for Dr. X (attending, resident, etc.) on arriving at the ED. Once I introduced myself and got setup with a resident everything was great, but knowing who on staff to talk to when you get there would make things run smoother" (control).

Opportunities Provided to the Medical Student for Involvement/Inclusion in Patient Care

Students reported that when they were afforded the opportunity to participate directly in patient care, their overall learning improved. A student commented that, "[I] loved my time in the ED, as I was able to jump from patient to patient,…and really able to see whatever patients I wanted to…[I] loved working with residents who let me take the history myself, and gave me more autonomy in the physical exam, ordering tests, discharging patients" (DA).

Third Year Medical Students Compete With other Learners for Teaching Attention

Medical students are not the only trainees in the PED. Medical students characterized this presence of other levels of learners as working against medical students seeing patients. One of the students wrote that, "There were so many providers (1 intern, 1 resident, 1 M4 and a faculty member plus myself)…I didn't get to do an interview, I barely talked to a patient all day" (control).

Personal Knowledge Limit the Ability to Participate in the PED

Medical students felt that their own knowledge gaps, as well as being new to the clinical environment, affected their ability to participate in the PED. One student exclaimed that, "as an early M3 who hasn't yet completed internal medicine I felt woefully under-prepared to work with most ER patients and without having done anything except two weeks of well child exams on outpatients I feel even less prepared to take histories on pediatric patients" (control).

PED Pace Affects Learning Ability

The PED is often a hectic place, yet there are also times when there is low volume. One student expressed this experience of environmental variability by writing that this is a "busy place even when it's not 'busy'" (control). Another student reported that "both shifts I was there, the PED was pretty quiet, so I didn't get to see as many interesting things as I otherwise would have" (DA).

DISCUSSION

Medical educators have recognized that traditional medical education may insufficiently prepare students for the transition from preclinical to clinical education.[11,12] One response to this challenge has been the development of transitional courses.[1,7,8] We know that the PED is a rich learning environment and that some EM educators have noted should be incorporated into early training.[13-15] In this study, we tested if DA for third year medical students would improve their experience in the PED. Yet, the qualitative themes show that students found the PED to be problematic in terms of uncertainty of role, level of inclusion, and self-perceived knowledge deficits. We found that our DA intervention helped in these domains by performance of more physical examinations and increased comfort with taking histories and formulating differential diagnoses.

The theory of situational learning has been prominent in identifying the active social methods that learners and professionals use in DA to facilitate the progressive awarding of participation and autonomy of learners. In DA, the apprentice student observes the master demonstrating how to do different parts of the task.[5,6] The master deliberately makes the target processes visible, often by explicitly showing the apprentice what to do, for example describing how they evaluate a patient and thinking out loud through the clinical reasoning. This extends what has previously been described as simply "orientation," "shadowing," to "legitimate peripheral participation in a community of practice."[16] By pairing students with senior residents who not only oriented, but also closely engaged the students, DA enhanced students' perception of their learning. Further, students who were actively engaged

during their PED shifts commented on having better individual experiences. In particular, comments on students' level of inclusion with residents and/or faculty allude to the idea that DA increases participation in the unique clinical environment of the PED.

As medical school curricula evolve, there is a move towards earlier emergency medicine experiences.[17,18] In light of this, it is important to know and address some of the pitfalls of third-year students in the potentially chaotic PED. One key issue is uncertainty with their role, with some students requesting a clear orientation. This study also showed that the majority of students reported receiving an orientation to the PED, whether or not they were assigned to a senior resident. Even so, they remained uncertain of their role. This concept of providing information to a student, yet the student not perceiving that it has been provided, is not uncommon. For example, one study on feedback for medical students showed statistically significant differences in the regularity of feedback provided by faculty as compared to that perceived by the student.[19] Another potential reason for this discrepancy is that, although they were oriented to the PED, they did not receive further instruction for the duration of their shift or simply could not independently perform without direct instructions. This is best put in the words of one student who wrote, "I did appreciate one of the residents had me look up a treatment regimine [sic] for one of the cases we saw and present that to her." Such directed learning may be necessary for some individuals to have an overall better experience in the PED.

The themes culled from student comments help us to understand the experience of students in the PED. We recognize that we need to be more intentional in orienting and engaging students in clear roles, inclusion in patient care and learning. DA may help with many of these issues but further study is warranted.

LIMITATIONS

Although the senior residents did receive an email with specific instructions on what/how to orient their students, we studied only the medical students' experiences. It is therefore possible that some of the seniors were not able to orient their pre-assigned medical students during their shift, or oriented students to whom they were not paired, raising the issue of the fidelity of the study with its intended implementation. The study did not explore the extent to which participation in DA might have enhanced faculty engagement. In our institution, as is true for other clerkships, the length of the PED rotation is limited. Our medical students completed two shifts in the PED, thus limiting assessment of improvement over time. Furthermore, DA students were not necessarily paired with the same senior resident each shift. In addition, not all students entered comments. Although the number of students participating in the study enabled detecting a statistically significant difference between the DA and control groups at alpha=0.05, the effect size was moderate, with some overlapping confidence intervals. Furthermore, we made 10 comparisons between the DA and control group in regards to comfort levels in various domains, as well as number of medical skills completed. These multiple comparisons may have led to a Type 1 error. Moreover, in seven of these comparisons, there were no differences between our groups, thus the full extent of DA needs to be further elucidated. If the alpha levels are further adjusted for multiple comparisons with the conservative Bonferroni Correction, which divides alpha by the number of comparisons made, only comfort in making a differential diagnosis remains as a comparison representing a statistically significant difference between the groups. Finally, the study was performed at a single institution, thus limiting generalizability.

CONCLUSION

This educational intervention study extends existing research on DA by providing insights into the kinds of outcomes such intentional allocation of resources may achieve. This study adds to our current professional discourse on the move from time-based to competency-based education. Much of the discussion about this move focuses on the need to be more intentional in designing education promoting cognitive and procedural competence. This randomized controlled block study, using mixed quantitative and qualitative approaches, builds on and extends this literature by focusing on intentional approaches to student socialization to the work-place learning site. The intervention evaluated represents a theoretically-grounded and feasible course of action amenable to being adopted in other clinical learning sites.

The emergent themes from analysis of the students' comments illuminate how active engagement can improve experience. Although students' ratings of their overall experience in the PED did not differ across the two groups, students who underwent DA performed more physical exams, and had greater comfort in obtaining histories and formulating a differential diagnosis. Above all, DA is a novel, simple, and feasible technique to ease the transition to new clinical environments for undergraduate medical students.

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Unrecognized Hypoxia and Respiratory Depression in Emergency Department Patients Sedated For Psychomotor Agitation: Pilot Study

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Introduction: The incidence of respiratory depression in patients who are chemically sedated in the emergency department (ED) is not well understood. As the drugs used for chemical restraint are respiratory depressants, improving respiratory monitoring practice in the ED may be warranted. The objective of this study is to describe the incidence of respiratory depression in patients chemically sedated for violent behavior and psychomotor agitation in the ED.

Methods: Adult patients who met eligibility criteria with psychomotor agitation and violent behavior who were chemically sedated were eligible. SpO_2 and $ETCO_2$ (end-tidal CO_2) was recorded and saved every 5 seconds. Demographic data, history of drug or alcohol abuse, medical and psychiatric history, HR and BP every 5 minutes, any physician intervention for hypoxia or respiratory depression, or adverse events were also recorded. We defined respiratory depression as an $ETCO_2$ of $\geq$50 mmHg, a change of 10% above or below baseline, or a loss of waveform for $\geq$15 seconds. Hypoxia was defined as a SpO_2 of $\leq$93% for $\geq$15 seconds.

Results: We enrolled 59 patients, and excluded 9 because of $\geq$35% data loss. Twenty-eight (28/50) patients developed respiratory depression at least once during their chemical restraint (56%, 95% CI 42-69%); the median number of events was 2 (range 1-6). Twenty-one (21/50) patients had at least one hypoxic event during their chemical restraint (42%, 95% CI 29-55%); the median number of events was 2 (range 1-5). Nineteen (19/21) (90%, 95% CI 71-97%) of the patients that developed hypoxia had a corresponding $ETCO_2$ change. Fifteen (15/19) (79%, 95% CI 56-91%) patients who became hypoxic met criteria for respiratory depression before the onset of hypoxia. The sensitivity of $ETCO_2$ to predict the onset of a hypoxic event was 90.48% (95% CI: 68-98%) and specificity 69% (95% CI: 49-84%). Five patients received respiratory interventions from the healthcare team to improve respiration [Airway repositioning: (2), Verbal stimulation: (3)]. Thirty-seven patients had a history of concurrent drug or alcohol abuse and 24 had a concurrent psychiatric history. None of these patients had a major adverse event.

Conclusion: About half of the patients in this study exhibited respiratory depression. Many of these patients went on to have a hypoxic event, and most of the incidences of hypoxia were preceded by respiratory depression. Few of these events were recognized by their treating physicians. [West J Emerg Med. 2014;15(4):430–437.]

INTRODUCTION

When non-medical techniques for de-escalation (i.e. verbal de-escalation techniques, show of force, bargaining, and family recruitment) fail for the acutely agitated patient in the emergency department (ED), physical restraint and chemical sedation may be required. Pharmacological therapy is recommended to be used with physical restraint of the acutely agitated patient to reduce the risk of complications such as hyperthermia, lactic acidosis, and rhabdomyolysis.[1-3]

The administration of drugs for psychomotor agitation such as benzodiazepines and butryphenones, especially in combinations, may lead to hypoxia.[1-3] American College of Emergency Physicians clinical guidelines recommend vital sign assessment as well as pulse oximetry.[3] Routine management in our ED is to place all chemically restrained patients on continuous cardiac and pulse oximetry monitoring.

It is likely that patients receiving chemical sedation are also at risk for respiratory depression that may lead a hypoxic event. As an example, we know from procedural sedation literature that most of the patients who develop hypoxia have significant capnographic signs of respiratory depression well before their SpO_2 begins to drop.[4-6] Patients receiving chemical sedation are often sedated for long periods of time, and the synergistic effects of concomitant drug and or alcohol use may increase their risk of respiratory compromise.[7-12]

Further, many of these sedation studies illustrate a concerning issue, i.e. that practitioners don't recognize the clinical signs of respiratory depression in sedated patients until the patient develops hypoxia. In a randomized controlled trial of capnography use during adult ED sedation with propofol, clinicians monitoring patients for respiratory depression and hypoxia using capnography had a significantly lower rate of hypoxic events than did a group of physicians using standard monitoring only (blinded to capnography).[13] This illustrates the theoretical need for improved monitoring practice during chemical sedation, as these patients are often sedated for much longer periods of time, and may not have the same level of attention during a busy ED shift as a patient undergoing procedural sedation. Despite this, capnography is not currently recommended or routinely used for monitoring during chemical sedation.

This study evaluated capnography in addition to standard monitoring to determine the incidence of respiratory depression in a selected population of ED chemically-restrained patients. Since the drugs used in procedural sedation and in chemical restraint have similar respiratory effect profiles, we hypothesized that the incidence of unrecognized respiratory depression is similar as well.

OBJECTIVE

The goal of this study was to determine the incidence of respiratory depression in ED patients with violent behavior and psychomotor agitation who are chemically sedated.

MATERIALS AND METHODS

Study Design

This prospective, observational cohort study was conducted from January 2009 to February 2010. It received institutional review board approval. A waiver of consent was granted secondary to the minimally invasive nature of the study as well as the minimal risks, and the inability to obtain consent from patients beforehand due to their mental status. This study was funded by the ED.

Setting and selection of participants

This study was conducted at Einstein Medical Center, Philadelphia, PA, a Level I trauma center with an annual ED volume of 100,000 patients. Enrollment was done 24 hours a day, 7 days a week. Eligible patients were 18-60 years old or greater and deemed by the treating ED physician to need chemical sedation for violent behavior and psychomotor agitation. We excluded patients if they were pregnant, underage, had a history of dementia, were from a nursing home, had a history of allergies to the sedation agents, or had evidence of recent traumatic injuries.

Data collection and processing

Initial routine management of the violent patient with psychomotor agitation in our ED is to attempt to use non-medical techniques for de-escalation (i.e. verbal de-escalation techniques, show of force, bargaining, and family recruitment). When this fails, a combination of security and ED staff will attempt to physically control the patient until he can be sedated. Vital sign, SpO_2, and blood glucose assessment is done before chemical sedation except in the most extreme circumstances. Every attempt is made to get a history from EMS and or family; especially regarding psychiatric history and potential intoxicants. In our ED most of our most violent patients with psychomotor agitation are often acutely intoxicated and often have an underlying history of psychosis.

When an eligible patient was identified, a research associate would report to the bedside to begin data collection. Physical restraint and need for chemical sedation was left to the discretion of the treating physician. Standard protocol in our ED for physical restraint is in the supine position only, with the head of the bed at 30 degrees.

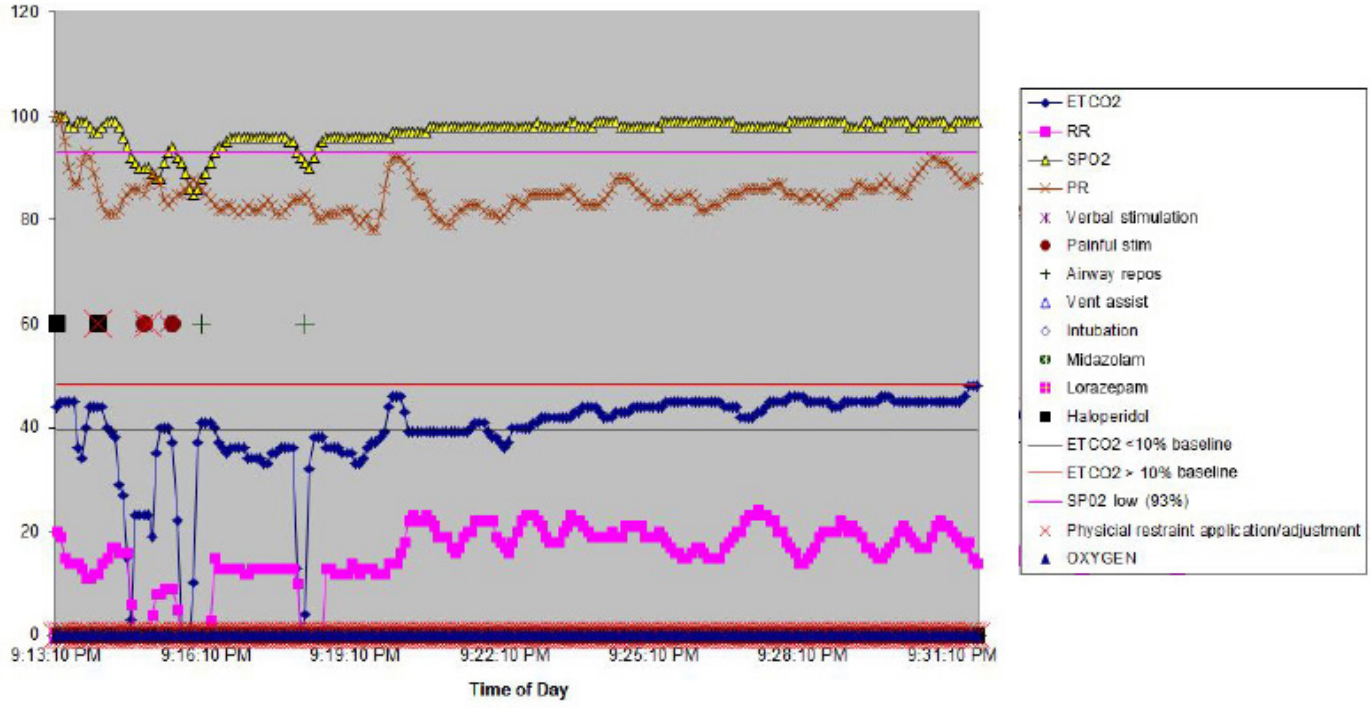
Chemical sedation was not standardized, and was left to physician discretion. However, the most common agents used at our institution are haloperidol and lorazepam. These drugs are both recommended for rapid tranquilization for severe psychomotor agitation with violent behavior.[2] Haloperidol is generally recommended as the drug of choice to sedate a violent patient, and rapid sedation is usually achieved using dosages of 2.5 to 10 mg at a time.[4] While IV use of Haloperidol is not FDA approved, use in this form is widespread, and is part of routine management in our ED.[2] Lorazepam is often used in our institution, as it works well in the violent patient who is intoxicated while efficacious

in acute psychosis[14] (dosed up to 2 mg IV) to clinical effect. Haloperidol is dosed no more than 5 mg IM or IV at a time, and subsequent doses titrated to clinical effect. The combination of lorazepam with haloperidol has been studied prospectively and has been shown to be superior to either drug alone.[8] The use of haloperidol (up to 5 mg) and lorezapam (up to 2 mg) IV may be given and dosages repeated every 30 minutes. This combination (which enjoys popularity as known as the "5 and 2") allows for synergistic effects with a minimization of major adverse events.

Research associates were responsible for all data collected. Research associates (all non-practicing physicians who had gone through extensive training in procedural sedation, monitoring techniques, Ramsay sedation score, and management for respiratory depression) placed the patient on the research monitor, and were at the bedside during ED monitoring. They collected patient demographic data (age, weight, medical history) from the ED chart. A nasal cannula capable of simultaneously delivering oxygen and measuring expired carbon dioxide was placed on all study patients. The portable monitor (Capnostream 20, Oridion Medical, Needham, MA) recorded SpO_2 and $ETCO_2$ (end-tidal CO_2) from the patient every 5 seconds with no set alarm for a specified SpO_2 or $ETCO_2$. These data were recorded and downloaded into an Excel spreadsheet for further analysis. The healthcare team had real time access to standard monitor with SpO_2, respiratory rate, heart rate, and blood pressure at all times. As capnography was not deemed part of routine practice outside of procedural sedation monitoring, the physicians were blinded to that data. The research associates only observed and recorded data; at no time did they communicate patient information or clinical status to the healthcare team. The only patient contact the research associates were allowed was to adjust the nasal cannula and the pulse oximeter probe if they became dislodged. The research associates recorded blood pressure and heart rate at baseline and every 5 minutes, unless there was an intervention, in which case they recorded vital signs every 60 seconds until the healthcare team judged that the patient's condition had improved. The research associates recorded any physician or nursing intervention to improve respiratory status, as well as any recognition without intervention "check" from a member of the healthcare team. Administration of medications and interventions were electronically time stamped into the monitor for further review. Major adverse events, including use of bag valve ventilation and endotracheal intubation, were recorded. Patients were observed for up to 90 minutes post-medication administration. After 90 minutes, data were no longer collected. Concurrent medications, positive alcohol and urine drug screens were recorded if available.

Data Analysis

After the patient encounter, all device data were transmitted to a database for analysis. We assigned each research subject a sequential number to preserve patient confidentiality. Electronic data from each sedation were downloaded from the monitor into a Microsoft Excel 2000 (Microsoft, Redmond, WA) database and were checked for any discrepancies with handwritten notations taken by the research associates. A printed time evaluation graph of the



$ETCO_2$, end-tidal CO_2; *RR*, repiratory rate; *$SPCO_2$*, skin partial pressure CO_2; *PR*, pulse rate; *SPO_2*, skin partial pressure O2

Figure 1. Sample graph from restraint via Capnostream 20.

Table 1. Patient characteristics with and without respiratory depression and hypoxia.

	Respiratory depression and hypoxia N=19	No respiratory depression, no hypoxia N=20
Median age (years)	30 (range: 18-57)	32 (range 18-60)
Gender (# of female)	31%	35%
Median weight (kg)	79 (range: 52-157)	78 (range: 57-142)
Median Ramsey scores*	2.6 (range: 1-6)	2.5 (range 1-6)

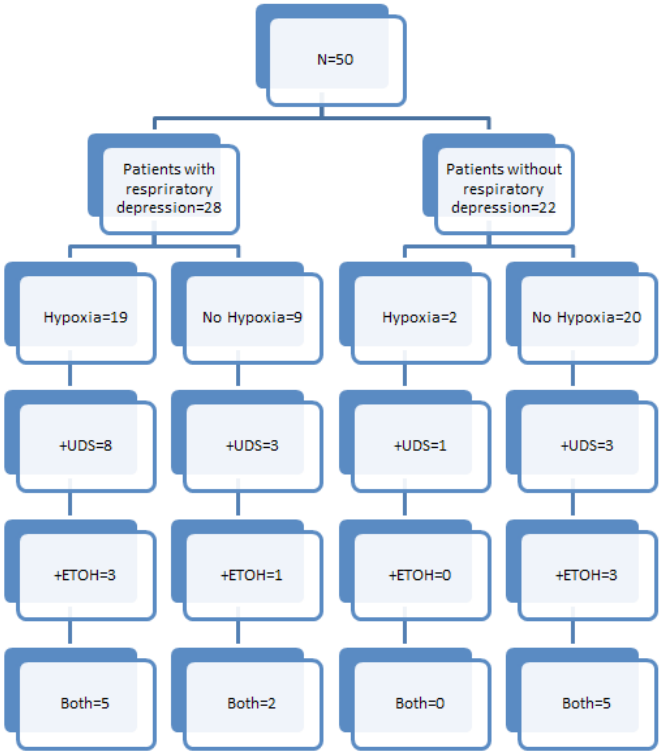
*taken once physician judged the patient to be sedated enough to no longer need initial doses of sedatives

duration the patient was chemically restrained was then produced (Figure 1), with the x axis showing time and the y axis depicting $ETCO_2$, SpO_2, respiratory rate, and heart rate. Electronic time stamps were plotted with specific signatures, such as medication administration, physician intervention(s), and adverse events (positive pressure ventilation, endotracheal intubation, or admission to the hospital for a sedation related event.)

Three investigators evaluated each graph to code the presence or absence of hypoxia and respiratory depression. All 3 needed to agree on the disposition of each graph. Hypoxia was defined a priori as a SpO_2 level of less than 93% for 15 seconds or greater. Respiratory depression was defined a priori as an $ETCO_2$ level of 50 mm Hg or greater, an absolute increase or decrease from baseline of 10% or greater, or a loss of waveform (for 15 seconds or greater).[16-19] There are 2 types of hypoventilation that are pharmacologically induced. Bradypneic hypoventilation (type 1) is characterized by an increased $ETCO_2$ and an increased $PaCO_2$. Respiratory rate is depressed proportionally greater than tidal volume, resulting in bradypnea, an increase in expiratory time, and an increase in $ETCO_2$, graphically represented by a high amplitude and wide capnogram. Bradypneic hypoventilation is commonly observed with opioids or ETOH. Bradypneic hypoventilation (decreased respiratory rate, high amplitude, and wide capnogram) can readily be distinguished from hyperventilation (increased respiratory rate, low amplitude, and narrow capnogram. This type of hypoventilation is associated with sedative hyponotics.[20]

We disqualified graphs if they had greater than 35% data loss, unless all 3 evaluators agreed that there was unequivocal evidence of hypoxia or respiratory depression. We then compared the data extrapolated from the graphs to the patient's observed file for final evaluation.

All data was evaluated via SPSS software (IBM, Chicago IL). Descriptive data is reported as means and medians with standard deviations and ranges as appropriate.



ETOH, alcohol; *UDS,* urine drug screening

Figure 2. Flow diagram of patients with and without respiratory depression and the association with hypoxia and presence or absence of intoxicants.

RESULTS

Over the 13-month enrollment period, 153 patients were screened and 59 patients enrolled. Eighty patients met exclusion criteria (5 allergic to study drug, 29 trauma patients, 2 pregnant, 9 underage, 7 over age) or did not receive chemical sedation (27). Fourteen patients were missed (research associates could not or did not get to the bedside to enroll), and we excluded 9 because of greater than 35% data loss, leaving 50 patients for analysis. Since this was purely a pilot, observational study, we did not perform a power calculation. Demographic and baseline data for this patient population is reported in Table 1.

The mean Ramsay sedation score was 2.7 (range 1-4). This was recorded after the treating physician deemed the patient appropriately sedated and additional sedatives were not acutely administered. Twenty-eight (28/50) patients developed respiratory depression at least once during their chemical sedation (56%, 95% CI 42-69%); the median number of events was 2 (range 1-6).

Of the 28 patients who had respiratory depression, 6/28 (21%, 95% CI 10-40%) received a benzodiazepine only, 22/28 (78%, 95% CI 60-90%) received both a benzodiazepine and an anti-psychotic. Of the 22 patients who did not develop hypoxia or respiratory depression, 6/22 (27% , 95% CI 14-

48%) received a benzodiazepine only, 16/22 (73%, 95% CI: 52-87%) received both. The mean lorazepam dose (total) was 0.05 mg/Kg; the mean haloperidol dose was 0.07 mg/Kg in both the respiratory depression/hypoxia group and the no respiratory depression/hypoxia group. There were no significant differences in the rate of respiratory depression dependent on if a subject received a benzodiazepine or a combination of drugs.

Twenty-one (21/50) patients had at least 1 hypoxic event during their chemical sedation (42%, 95% CI 29-55%). Of the 21 patients who had a hypoxic event, the median number of events was 2 (range 1-5). Nineteen (19/21) (90%, 95% CI 71-97%) of the patients that developed hypoxia had a corresponding $ETCO_2$ change. Fifteen (15/19) (79%, 95% CI 56-91%) patients who became hypoxic met criteria for respiratory depression before the onset of hypoxia. The median length of time between the onset of an $ETCO_2$ change to the onset of hypoxia was 1.39 minutes (range 15-332 sec).

Significant numbers of patients who were in this study had positive urine drug screens and ETOH levels. As this was an observational study, not all patients enrolled (5/28, 18% of patients who had respiratory depression; 7/22, 31% of patients who did not have respiratory depression) had urine drug screen and or an alcohol level ordered.

Figure 2 describes the relationships between the patients with and without respiratory depression, and patients with or without hypoxia. It goes on to illustrate patients in each group with the presence or absence of either/or ETOH or a positive urine drug screen. Of note, 16 out of 19 patients with respiratory depression that became hypoxic had a positive ETOH level, a positive urine drug screening, or both (85%, 95% CI 64-95%). Many patients who did not have respiratory depression or hypoxia tested positive for ETOH or illicit drugs (11 out of 20, 55%, 95% CI: 34-74%). As this was an observational study, not all patients (5/28, 18% of patients who had either/or hypoxia and respiratory depression; 7/22, 31% of patients who did not have either hypoxia or respiratory depression) who were enrolled in this study had urine drug screen and or an alcohol level ordered.

The sensitivity of capnographic evidence of respiratory depression as predictive of the onset of a hypoxic event was 90.48% (95% CI: 68-98%) and specificity 69% (95% CI: 49-84%). Five patients received interventions for clinical respiratory depression and hypoxia (Airway repositioning: [2], Verbal stimulation: [3]) Thirty-seven patients had a history of concurrent drug or alcohol abuse, and 24 had a concurrent psychiatric history. None of these patients needed positive pressure ventilation, endotracheal intubation, or admission to the hospital for a sedation related event.

DISCUSSION

Patients who are chemically restrained are given drugs that are respiratory depressants, are often physically restrained, and are often using intoxicants that may potentiate respiratory depression. In this preliminary study, we evaluated the incidence of hypoxia with or without respiratory depression in ED patients receiving chemical sedation (with or without physical restraint) for psychomotor agitation using standard monitoring and capnography. Almost half the patients developed hypoxia and respiratory depression. Many of these patients had multiple episodes of hypoxia and or respiratory depression, and few had any intervention. Healthcare providers in the ED should consider that patients with violent behavior and psychomotor agitation who are given chemical sedation and physical restraint may require continuous electronic vital sign monitoring, including real time SpO_2 and $ETCO_2$. We believe that strict monitoring practice of these patients is important; for while it is entirely likely that many patients can tolerate prolonged periods of respiratory depression and hypoxia, predicting which patient will go on to a serious adverse event is beyond the scope of this study.

What is the significance of capnographic evidence of respiratory depression in this population? Most of the patients in this study who developed hypoxia had a corresponding $ETCO_2$ change before the onset of hypoxia. This is consistent with previous studies of the use of capnography to detect respiratory depression during procedural sedation. The mean time between the onset of respiratory depression and the onset of hypoxia as measured via capnography may give a healthcare provider monitoring $ETCO_2$ ample time to intervene to prevent a hypoxic event. Previous work with capnography during ED procedural sedation has shown that clinicians can lower the rate of hypoxic events by using capnography concurrently with standard monitoring techniques. It is conceivable that the same would hold true during chemical sedation.

A few patients had a "false positive" result, i.e. they had respiratory depression without hypoxia 7/28 (25%, 95% CI 17-41%). The incidence of what is defined as "sub-clinical" respiratory depression (capnographic evidence of respiratory depression without hypoxia) has been illustrated in many procedural sedation studies.[16-21] The clinical relevance of this is not well understood. Two patients had false negative results, (i.e. developed hypoxia without capnographic evidence of respiratory depression). Despite the false negative results, the sensitivity of capnography to predict a hypoxic event in this study was over 90%, which is quite good for a screening test.

This is a preliminary study. A larger study designed to be a head-to-head trial of chemical sedation with blinded capnography versus chemical restraint, with the physicians having real time access to the monitor, is warranted. Capnography during chemical sedation may act as an "early warning" system for the healthcare team to provide an intervention to improve ventilation before the onset of a hypoxic event.

LIMITATIONS

A lack of standardization of sedation protocols may have affected the conclusions drawn from this study. Because many but not all patients had an alcohol or urine drug screen evaluated, it is impossible to derive the relationship between these tests and the incidence of hypoxia and respiratory

Table 2. Patients with hypoxia with and without respiratory depression.

Patient	Medications given	Urine drug screen result	ETOH level (mg/dL)	SpO_2 (lowest)	$ETCO_2$ >50 mmHg	$ETCO_2$ >10% change from baseline	Loss of Waveform	Intervention #
1	Lorazepam 2 mg, Haloperidol 5 mg	THC, opiate, PCP	N/A	93% (25 sec)	no	yes (85 sec)	no	2 (physical / verbal stimX2)
2	Lorazepam 2 mg Haloperidol 5 mg	Cocaine, THC	N/A	90% (145 sec)	no	no	no	2 (verbal stim/airway reposition)
3	Lorazepam 15 mg Haloperidol 5 mg	N/A	N/A	89% (185 sec)	no	yes (240 sec)	yes (25 sec)	0
4	Lorazepam 4 mg Haloperidol 5 mg	N/A	146	87% (125 sec)	no	yes (205 sec)	yes (45 sec)	0
5	Lorazepam 6 mg	THC	223	86% (75 sec)	no	yes (120 sec)	no	0
6	Lorazepam 4 mg	THC/Benzo	N/A	91% (35 sec)	no	yes (135 sec)	no	0
7	Lorazepam 2 mg Haloperidol 5 mg	THC/PCP	N/A	90% (240 sec)	no	yes (310 sec)	no	0
8	Lorazepam 2 mg Haloperidol 10 mg	THC/PCP	N/A	86% (65 sec)	no	yes (110 sec)	yes (20 sec)	0
9	Lorazepam 4 mg Haloperidol 5 mg	Cocaine	274	89% (25 sec)	yes (205 sec)	yes (250 sec)	yes (35 sec)	1 (physical/ verbal stim)
10	Lorazepam 2 mg Haloperidol 5 mg	N/A	81	92% (75 sec)	no	yes (110 sec)	yes (45 sec)	0
11	Lorazepam 6 mg Haloperidol 5 mg	N/A	N/A	90% (45 sec)	no	yes (95 sec)	no	0
12	Lorazepam 4 mg Haloperidol 5 mg	THC, Opiates	135	85% (345 sec)	yes (305 sec)	yes (315 sec)	yes (40 sec)	0
13	Lorazepam 6 mg	THC/PCP	229	90% (135 sec)	yes (45 sec)	yes (160 sec)	yes (15 sec)	0
14	Lorazepam 2 mg Haloperidol 5 mg	THC/PCP	N/A	91% (50 sec)	no	yes (55 sec)	no	0
15	Lorazepam 4 mg	Cocaine	N/A	89% (95 sec)	no	yes (125 sec)	no	0
16	Lorazepam 4 mg Haloperidol 5 mg	N/A	N/A	93% (35 sec)	no	no	no	0
17	Lorazepam 8 mg Haloperidol 5 mg	THC	117	87% (140 sec)	yes (145sec)	yes (150 sec)	yes (25 sec)	1 (physical/ verbal stim, airway reposition)
18	Lorazepam 2 mg Haloperidol 5 mg	THC/PCP	203	92% (65 sec)	no	yes (130 sec)	no	0
19	Lorazepam 4 mg	THC/PCP	156	91% (50 sec)	no	yes (75 sec)	no	1 (verbal stim)
20	Lorazepam 2 mg Haloperidol 10 mg	N/A	N/A	90% (55 sec)	no	yes (95 sec)	yes (15 sec)	0
21	Lorazepam 6 mg	N/A	N/A	87% (150 sec)	yes (205 sec)	yes (225 sec)	yes (30 sec)	0

STIM, stimulation; *PCP*, phencyclidine; *THC*, tetrahydrocannabinol; *ETOH*, alchohol; $ETCO_2$, end-tidal CO_2

depression in this study. Many but not all the patients were at some point physically restrained as well; this study was not designed to derive the relationship between physical restraints and respiratory depression. As this was an observational trial, drug dosing was not standardized. It is possible that with standardized dosing there may have been lower levels of respiratory depression and hypoxia. It is possible that suboptimal dosing of haloperidol with lorazepam may have contributed to the high rate of hypoxia and respiratory depression. However, we believe using these drugs in combination to be common practice in emergency medicine.

It is possible that the effect of having a research associate in the room may have biased our data, in that the healthcare team may have responded less or more due to their presence. If a strict protocol for data collection including patient weight had been implemented, more accurate data on the influence of BMI and drug dosing on respiratory depression and hypoxia would have been available.

Our rates of respiratory depression and hypoxia may not be representative of other similar institutions. Other institutions may use other drug regimens or more intensive monitoring practice, and thus their rates of respiratory depression and hypoxia may be lower (or higher) than ours. However, we feel based on our clinical experience that our ED experience with chemical sedation is fairly common among EDs.

A limitation of our conclusions is the lack of any adverse outcomes despite high levels of hypoxia and respiratory depression. A much larger study would have to be conducted to measure that; with current knowledge and technology we are not able to predict which patients will go on to have an adverse outcome. However, we believe that a prudent ED physician would consider that prolonged levels of hypoxia and respiratory depression in a patient with multiple intoxicants and significant chemical sedation is not quality care.

The cause for psychomotor agitation could not be determined in all cases. Because of privacy provisions, we were not able to evaluate previous patient records if the patient had a psychiatric history, thus any data received was gleaned from the treating healthcare team at the time of patient contact. This information may be inaccurate.

Some of these patients may have had some form of obstructive pulmonary disease, which may have predisposed them to hypoxia and or respiratory depression. Our "cut-offs" for hypoxia are only relevant for patients at or about sea level; if this study had been repeated at altitude, our tolerances may have changed. However strict hospital guidelines and policy were followed; none of the patients were placed in the prone position and all were seated at 30 degrees or more.

CONCLUSION

Almost half of the patients in this study exhibited respiratory depression; many went on to become hypoxic as well. Most of the incidences of hypoxia were preceded by respiratory depression. Capnography predicted the majority of hypoxic events in this observational study. Few of these events were recognized by their treating physicians. This preliminary study illustrates the need for further research that will help improve early recognition of patients who are chemically restrained who develop respiratory depression and or hypoxia.

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Characteristics of United States Emergency Departments that Routinely Perform Alcohol Risk Screening and Counseling for Patients Presenting with Drinking–related Complaints

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Introduction: Emergency department (ED) screening and counseling for alcohol misuse have been shown to reduce at-risk drinking. However, barriers to more widespread adoption of this service remain unclear.

Methods: We performed a secondary analysis of a nationwide survey of 277 EDs to determine the proportion of EDs that routinely perform alcohol screening and counseling among patients presenting with alcohol-related complaints and to identify potential institutional barriers and facilitators to routine screening and counseling. The survey was randomly mailed to 350 EDs sampled from the 2007 National Emergency Department Inventory (NEDI), with 80% of ED medical directors responding after receiving the mailing or follow-up fax/email. The survey asked about a variety of preventive services and ED directors' opinions regarding perceived barriers to offering preventive services in their EDs.

Results: Overall, only 27% of all EDs and 22% of Level I/II trauma center EDs reported routinely screening and counseling patients presenting with drinking-related complaints. Rates of routine screening and counseling were similar across geographic areas, crowding status, and urban-rural status. EDs that performed routine screening and counseling often offered other preventive services, such as tobacco cessation ($P<0.01$) and primary care linkage ($P=0.01$). EDs with directors who expressed concern about increased financial costs to the ED, inadequate follow-up, and diversion of nurse/physician time all had lower rates of screening and counseling and also more frequently reported lacking the perceived capacity to perform routine counseling and screening. Among EDs that did not routinely perform alcohol screening and counseling, more crowded than non-crowded ($P<0.01$) and more metro than rural ($P<0.01$) EDs reported lacking the capacity to perform routine screening and counseling. The capacity to perform routine screening also decreased as ED visit volume increased ($P=0.04$).

Conclusion: To increase routine alcohol screening and counseling for patients presenting with alcohol-related complaints, ED directors' perceived barriers related to an ED's capacity to perform screening, such as limited financial and staff resources, should be addressed, as should directors' concerns regarding the implementation of preventive health services in EDs. Uniform reimbursement methods should be used to increase ED compensation for performing this important and effective service. [West J Emerg Med. 2014;15(4):438–445.]

INTRODUCTION

Alcohol misuse and abuse represent a major cause of morbidity, mortality, and healthcare costs in the United States (U.S.).[1-3] Each year, there are approximately 2 million emergency department (ED) visits associated with alcohol.[4] Annual alcohol-related visits to EDs may account for as many as 28.7 visits for every 1,000 people in the U.S. population.[5] In one study in an urban setting, nearly one-quarter of all patients presenting to the ED were identified as dependent on alcohol through the use of brief screening tools.[6]

Emergency departments present a unique opportunity to address alcohol-related morbidity and mortality by identifying patients with at-risk drinking or alcohol dependence, performing a brief intervention, and referring appropriate patients to treatment. This process is referred to as SBIRT (screening and brief intervention, referral to treatment). Numerous studies have demonstrated the clinical efficacy of SBIRT for alcohol misuse. SBIRT has been shown to decrease ED utilization,[7] alcohol consumption by participants,[8-10] inpatient utilization,[11] Medicaid costs,[11] and arrest rates for driving under the influence (DUI),[12] while simultaneously increasing rates of entry into formal chemical dependency programs.[13] Since 2007, Level I and II trauma centers have been required by American College of Surgeons to screen for problem drinking, and Level I trauma centers must have mechanisms to provide intervention to appropriate patients.[14] The American College of Emergency Physicians issued a policy statement in 2005 to support the use of alcohol screening and interventions in U.S. EDs.[15]

Two previous studies have surveyed EDs to determine the extent of SBIRT use in U.S. EDs.[16,17] However, these studies have focused on Level I or Level I/II trauma centers, which are often also academic teaching hospitals. No efforts to date have documented the extent of SBIRT's use among all levels of EDs in the U.S., nor has any study attempted to identify specific characteristics of EDs that may make them more or less likely to routinely screen for alcohol misuse.

We aimed to fill the current knowledge gap by examining ED factors associated with the routine use of alcohol screening and counseling and by identifying potentially modifiable barriers that could be addressed to increase the adoption of screening and counseling in U.S. EDs. We performed a secondary analysis on data collected in 2008-9 in a national survey of ED directors regarding preventive health services in EDs. We hypothesized that crowded (defined by criteria used by Centers for Disease Control and Prevention [CDC] researchers),[18] publicly-owned, urban, and critical access hospitals (rural hospitals that are certified to receive Medicare cost-based reimbursement) would have higher rates of routine screening and counseling, since they are often safety-net hospitals most likely to see patients at high risk for alcohol-related complaints; however, since resources are generally limited in these settings, it has been unclear how the need for screening and scarcity of resources would be balanced. We also hypothesized that lower rates of screening and counseling would be reported by EDs whose directors cited barriers to the provision of preventive services in their EDs. Our research findings are particularly important for policy makers and ED directors seeking to implement or expand SBIRT in U.S. EDs, and for researchers who plan to perform ED SBIRT research, particularly in non-academic center EDs.

Table 1. Characteristics of 277 respondent emergency departments regarding routine alcohol screening.

Characteristic	n (%)
Teaching hospital	21 (8)
Region	
Northeast	35 (13)
Midwest	79 (29)
South	113 (41)
West	50 (18)
Crowded	127 (46)
Trauma center	53 (19)
Trauma level	
I	22 (8)
II	14 (5)
III	17 (6)
Urban influence code	
Metropolitan	159 (57)
Micropolitan	66 (24)
Rural	18 (7)
Frontier	34 (12)
Critical access hospital*	73 (26)
Volume	
Less than 10,000	87 (31)
10,000-19,999	46 (17)
20,000-39,999	84 (30)
40,000 and greater	60 (22)
Publicly owned hospital	79 (29)
Routinely performs alcohol screening†	75 (27)

*Critical access hospital: Medicare designation as being a "necessary provider" of health care services and location greater than 35 miles from nearest hospital
†for patients presenting with alcohol-related complaints

METHODS

Study Design

We performed a secondary analysis of data collected for a national survey of preventive services in U.S. EDs; the survey was conducted from September 2008 to April 2009. The local institutional review board approved all aspects of this study. The full methods of the survey have been previously described.[19]

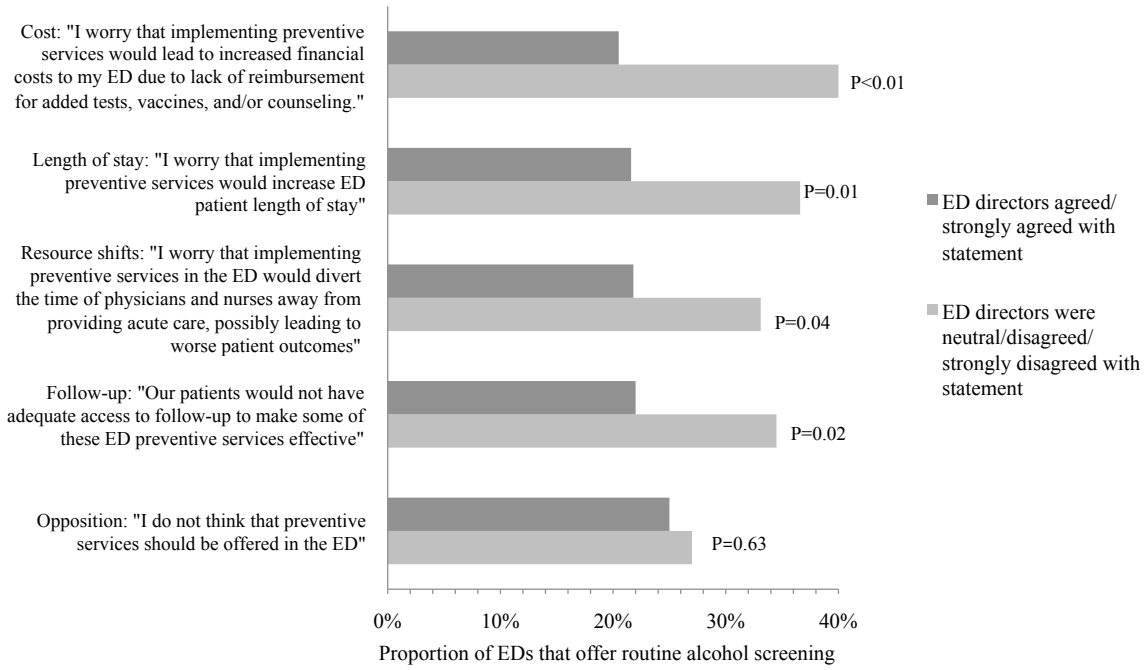

Figure 1. Perceived barriers to preventive services, according to availability of alcohol screening.

Study Population

Briefly, we randomly selected 350 EDs from the 2007 National Emergency Department Inventory (NEDI-USA; developed and maintained by the Emergency Medicine Network),[20] representing 7% of the 4,874 EDs in the inventory. The sample size was selected to attain a minimum sample of 5% of national EDs, assuming a 70% response rate. In total, 277 ED medical directors (80%) responded to the mail survey that was followed-up by email/fax, and there were no significant differences between responders and non-responders.[19]

Outcomes and Measurements

The cross-sectional analysis presented here examined potential factors associated with routine alcohol screening and counseling for patients presenting with drinking-related complaints in U.S. EDs; among EDs that did not routinely provide screening and counseling, we also examined factors associated with having the capacity to routinely perform screening and counseling. Our primary outcome of interest was the routine provision of alcohol screening and counseling for patients with drinking-related complaints and the secondary outcome was having the capacity to perform screening and counseling if not currently performed. We used a 2-part survey question to evaluate these outcomes: regarding "*alcohol risk screening, counseling, and referral for all patients with drinking-related complaints*," (1) "*is there a system in place that routinely performs this service in your ED?"* (primary outcome) and (2) "*if not, could you offer this service routinely with existing staff and funding?"* (secondary outcome). Independent variables of interest included teaching hospital status, region, trauma level, urban influence code, volume, public ownership, crowding, and the director's opinions regarding preventive services in EDs.

Urban-rural status (metropolitan, micropolitan, rural, frontier) was based on urban influence codes, which are a county-based measure of urban-rural status from the U.S. Department of Agriculture. We defined ED crowding by asking key surrogate questions for crowding, which have been used and validated by CDC researchers.[18] Specifically, we asked about the average time from triage sign-in to being placed in an ED treatment bed, the percentage of registered patients who left without being seen by a clinician, and the percentage of time spent in ambulance diversion status.

Data Analysis

We generated tabulations and descriptive statistics using Stata 11.0 (StataCorp, College Station, TX). Chi-Square (χ^2) tests were performed for discrete variables, with Fisher exact tests performed when sample or sub-sample sizes were small. We performed 2-sided t-tests for continuous variables. Two-sided p-values <0.05 were considered statistically significant.

RESULTS

Overall, 277 ED directors responded to the survey, representing a response rate of 80%. Respondents included ED directors from 46 states. A summary of respondent ED characteristics is presented in Table 1.

Characteristics of EDs performing and not performing routine alcohol screening and counseling are reported in Table 2. Seventy-five of the 277 respondents (27%, 95% confidence interval 22-32%) reported performing routine alcohol screening and counseling for patients presenting with

Table 2. Characteristics of emergency departments performing and not performing routine alcohol screening.

Characteristic	Performs routine alcohol screening	Does NOT perform routine alcohol screening	Total	p-value
	n (%)	n (%)	n	
Total	75 (27)	202 (73)	277	
Region				
Northeast	10 (29)	25 (71)	35	0.99
Midwest	21 (27)	58 (73)	79	
South	30 (27)	83 (74)	113	
West	14 (28)	36 (72)	50	
Crowded				
Yes	34 (27)	93 (73)	127	0.92
No	41 (27)	109 (73)	150	
Urban influence code				
Metropolitan	45 (28)	114 (72)	159	0.84
Micropolitan	18 (27)	48 (73)	66	
Rural	5 (28)	13 (72)	18	
Frontier	7 (21)	27 (79)	34	
Teaching hospital				
Teaching	7 (33)	14 (67)	21	0.50
Non-teaching	68 (27)	188 (73)	256	
Trauma level				
I or II	8 (2)	28 (78)	36	0.48
III or non-trauma center	67 (28)	174 (72)	241	
Trauma level				
I	3 (14)	19 (86)	22	0.43
II	5 (36)	9 (64)	14	
III	4 (24)	13 (77)	17	
Non-trauma center	63 (28)	161 (72)	224	
Offers tobacco cessation				
Yes	25 (45)	31 (55)	56	<0.01
No	50 (23)	171 (77)	221	
Offers linkage to PCP				
Yes	51 (34)	99 (66)	150	0.01
No	24 (19)	103 (81)	127	
Critical access hospital				
Yes	16 (22)	57 (78)	73	0.25
No	59 (29)	145 (71)	204	
Volume				
Less than 10,000	19 (22)	68 (78)	87	0.19
10,000-19,999	18 (39)	28 (61)	46	
20,000-39,999	21 (25)	63 (75)	84	
40,000 and greater	17 (28)	43 (72)	60	
Percentage of uninsured patients†				
<5%	1 (9)	10 (91)	11	0.61
5-14%	19 (25)	56 (75)	75	
15-24%	26 (29)	63 (71)	89	
25-34%	15 (25)	44 (75)	59	
>35%	12 (33)	24 (67)	36	
Publicly owned hospital				
Yes	25 (32)	54 (68)	79	0.25
No	49 (25)	148 (75)	197	
Social workers				
Yes	59 (28)	151 (72)	210	0.5
No	16 (24)	51 (76)	67	
Stratified:				
0 hr/wk	16 (24)	51 (76)	67	0.39
1-23 hr/wk	42 (26)	119 (74)	161	
24 hr/wk	17 (35)	32 (65)	49	

PCP, primary care provider
Percentages add across rows
†Director's estimate; n=270 for this variable only

alcohol-related complaints. Rates of screening and counseling were similar across geographic areas, crowding status, and urban-rural status. Among the 21 teaching hospitals, 7 (33%) performed routine screening and counseling versus 27% of non-teaching hospitals (P=0.5), and only 12 out of 53 (22%) Level I/II trauma centers performed routine screening and counseling. There was no statistical difference in screening rates of trauma centers vs. non-trauma centers, or among different levels of trauma care. EDs that offered tobacco cessation programs or primary care linkage reported significantly higher rates of routine alcohol screening and counseling.

Directors' concerns regarding preventive services were largely associated with not performing routine screening and counseling; EDs with directors who expressed concern about increased length of stay, increased financial costs to the ED, inadequate follow-up, and diversion of nurse/physician time all had lower rates of screening and counseling (Figure 1).

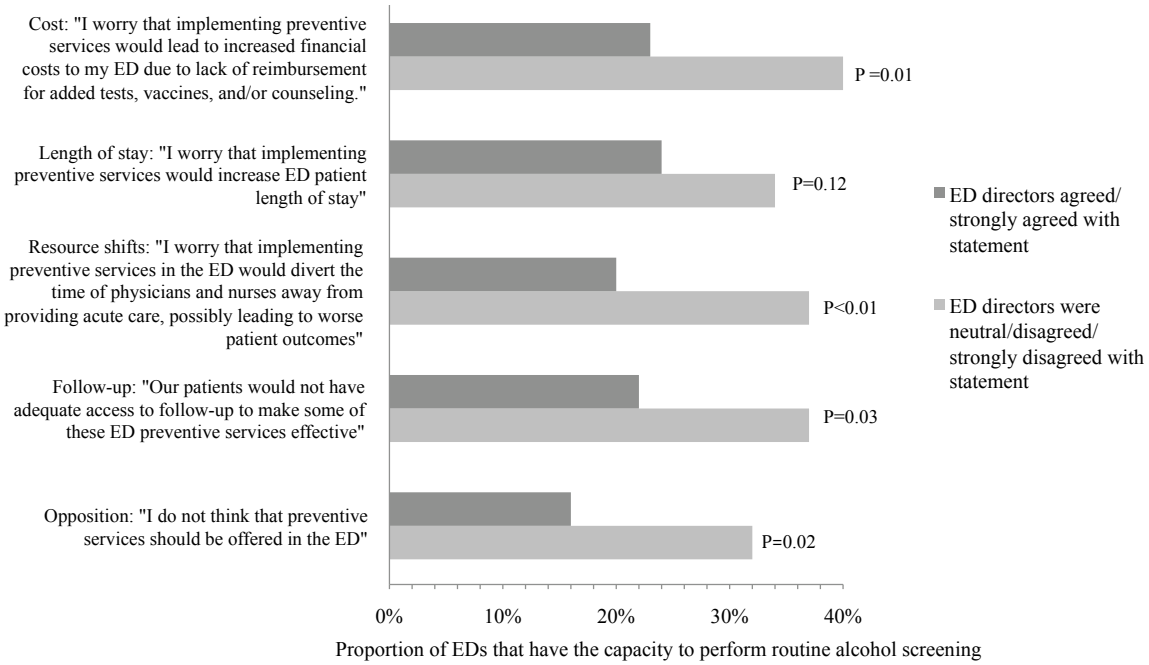

Figure 2. Perceived barriers to preventive services, according to capacity to perform routine screening among emergency departments (EDs) that do not routinely perform screening.

Among respondents who reported not performing routine alcohol screening and counseling, we compared the characteristics of EDs with and without the reported capacity to perform routine screening and counseling (Table 3). Among EDs not routinely performing alcohol screening and counseling, more crowded EDs than non-crowded EDs (P<0.01) reported lacking the capacity to perform routine screening and counseling, as did more metro EDs than rural ones (P<0.01). The capacity to perform routine screening also decreased as volume increased (P=0.04 for trend). More private hospitals than public hospitals reported lacking the capacity to perform routine screening and counseling. A larger proportion of critical access hospitals reported having the capacity to perform routine screening and counseling in comparison to non-critical access hospitals.

Additionally, many ED directors' concerns regarding preventive services were associated with lacking the perceived capacity to perform screening and counseling, including concerns about increased financial costs to the ED, inadequate follow-up, and diversion of nurse/physician time (Figure 2). Also, among EDs whose directors thought that preventive services should not be offered in EDs, 84% reported lacking the capacity to perform routine screening, in comparison to 68% of EDs whose directors did not report that belief (P=0.02).

DISCUSSION

Availability of Routine Alcohol Screening and Counseling

Twenty-seven percent (27%) of all EDs in our sample and only 22% of Level I/II trauma center EDs reported performing routine alcohol screening and counseling for patients presenting with alcohol-related complaints. We found that EDs that offered a range of preventive services were most likely to routinely perform alcohol screening and counseling for these patients.

We initially hypothesized that a larger proportion of urban, publicly owned, and crowded hospitals would report routine screening and counseling and this was indeed the case, except for publicly owned hospitals, where the relationship was not statistically significant. We also hypothesized that critical access hospitals would have higher rates of screening and counseling, but the inverse was true (these hospitals were less likely to perform screening). Finally, we hypothesized that lower rates of screening and counseling would be reported by EDs whose directors cited barriers to the provision of preventive services in their EDs. Our data support this hypothesis and also demonstrate that ED director opinions may be important for the perceived capacity to offer routine screening and counseling.

Of particular note, rates of routine screening and counseling were low among Level I/II trauma centers (22%), which are required by the American College of Surgeons (ACS) to perform routine alcohol screening for indicated patients. However, Level I/II trauma centers may be performing screening and counseling in inpatient wards or outpatient clinics, which could account for low rates of alcohol screening in their EDs. If this is indeed occurring, trauma centers may be missing a significant opportunity to screen patients who are not admitted. Only Level I trauma centers are required to have protocols to provide brief intervention to patients with alcohol-related complaints, while all Level I/II must be able to identify problem drinkers. Importantly, some trauma centers are certified by state agencies, not the ACS, and therefore may not adhere to the ACS screening and intervention requirements.

Table 3. Characteristics of emergency departments (EDs) that have and do not have the capacity to perform routine alcohol screening*, n=202.

Characteristic	Has capacity for alcohol screening	Lacks capacity for alcohol screening	Total	p-value
	n (%)	n (%)	n	
Total	55 (27)	147 (73)	202	
Region				
Northeast	4 (16)	21 (84)	25	0.07
Midwest	23 (40)	35 (60)	58	
South	18 (22)	65 (78)	83	
West	10 (28)	26 (72)	36	
Crowded				
Yes	16 (17)	77 (83)	93	<0.01
No	39 (36)	70 (64)	109	
Urban influence code				
Metropolitan	21 (18)	93 (82)	114	<0.01
Micropolitan	15 (31)	33 (69)	48	
Rural	8 (62)	5 (39)	13	
Frontier	11 (41)	16 (59)	27	
Teaching hospital				
Yes	5 (36)	9 (64)	14	0.54
No	50 (27)	138 (73)	188	
Trauma level I or II				
Yes	9 (32)	19 (68)	28	0.53
No	46 (26)	128 (74)	174	
Trauma level				
I	6 (32)	13 (68)	19	0.89
II	3 (33)	6 (67)	9	
III	3 (23)	10 (77)	13	
Non-trauma center	43 (27)	118 (73)	161	
Offers tobacco cessation				
Yes	12 (39)	19 (61)	31	0.12
No	43 (25)	128 (75)	171	
Capacity for tobacco cessation				
Yes	33 (58)	24 (42)	57	<0.01
No	22 (15)	123 (85)	145	
Offers linkage to PCP				
Yes	33 (33)	66 (67)	99	0.06
No	22 (21)	81 (79)	103	
Critical access hospital				
Yes	24 (42)	33 (58)	57	<0.01
No	31 (21)	114 (79)	145	
Volume				
Less than 10,000	27 (40)	41 (60)	68	0.04
10,000-19,999	7 (25)	21 (75)	28	
20,000-39,999	13 (21)	50 (79)	63	
40,000 and greater	8 (19)	35 (81)	43	
Percentage of uninsured patients‡				
<5%	5 (50)	5 (50)	10	0.29
5-14%	11 (20)	45 (80)	56	
15-24%	20 (32)	43 (68)	63	
25-34%	11 (25)	33 (75)	44	
>35%	6 (25)	18 (75)	24	
Publicly owned hospital				
Yes	21 (39)	33 (61)	54	0.03
No	34 (23)	114 (77)	148	
Social workers				
Yes	14 (28)	37 (73)	51	0.97
No	41 (27)	110 (73)	151	
Stratified:				
0 hr/wk	14 (28)	37 (73)	51	0.95
1-23 hr/wk	33 (28)	86 (72)	119	
24 hr/wk	8 (25)	24 (75)	32	

PCP, primary care provider
percentages add across rows
*Table 3 only includes EDs that do not routinely perform alcohol screening for patients presenting with drinking-related complaints
‡Director's estimate; n=197 for this variable only.

Our findings regarding the overall level of routine alcohol screening are similar to those of other studies that focused primarily on academic and urban EDs.[16,17] For example, Cunningham and colleagues[16] reported that 21% of Level I/II trauma centers used the CAGE instrument to screen for alcohol abuse in the ED; the authors also noted similar perceived barriers to performing routine screening (provider time and financial resources). Terrell et al[17] found that 39% of Level I trauma centers routinely used a screening instrument for alcohol abuse, and provided informal or formal counseling to roughly one-quarter of patients who screened positive.

Our current study adds to the existing literature by presenting a diverse, nationwide sample of EDs, which supplements the existing literature on ED-based alcohol screening in academic and urban hospitals. To our knowledge, there are no published studies examining national rates of screening, particularly in non-trauma center EDs. Since the vast majority of U.S. EDs are non-trauma centers, it is particularly important to understand alcohol screening practices in these settings.

Capacity to routinely perform alcohol screening and counseling

Among EDs that did not routinely offer screening, EDs that had directors with concerns about preventive services or that were crowded, urban, or privately owned more often perceived lacking the capacity (as defined by a lack of existing staff and funding) to perform routine screening, as defined by a lack of existing staff and funding. This implies that extra resources for routine alcohol screening and counseling (or better knowledge of existing resources) in these settings would be necessary to increase overall utilization of this service in these EDs.

Addressing potential barriers to routine screening and counseling for alcohol misuse in EDs could increase the number of EDs that use this important preventive health measure. For example, addressing ED director-identified potential barriers to implementing preventive services—such as increased length of stay, increased financial costs to the ED, lack of adequate follow up, and diversion of nurse/physician time—may facilitate the adoption of alcohol screening and counseling in more EDs. Our research suggests that uniform reimbursement for SBIRT services and performing these services in a way that does not prolong ED length of stay would be particularly promising avenues for increasing adoption of these services. Finally, prior research has demonstrated that SBIRT can reduce subsequent ED usage.[7] Therefore, routine screening could be considered as a way to decrease ED volume and crowding in the long term, which would address some of the directors' concerns regarding these types of interventions.

Future research directions

Further research is indicated to examine the role of ED directors' opinions in offering preventive services and to understand directors' and physicians' perceived benefits, barriers, and facilitators for ED-based alcohol screening. In particular, reasons for not offering alcohol screening and counseling despite having the existing staffing and funding to do so should also be investigated further. Research aimed at implementing alcohol screening and counseling without increasing ED length of stay or crowding should be explored. Further research is also indicated to understand whether patients presenting to trauma centers are receiving SBIRT as recommended by the American College of Surgeons, since trauma center EDs are offering these services at rates lower than the national average.

LIMITATIONS

There are some limitations to this study. First, the instrument used to collect data has not been previously validated with observation of EDs' actual practices. The original survey instrument was intended to assess general attitudes about preventive services and was not solely focused on alcohol screening. The survey did not assess specific reasons why alcohol screening was not performed in trauma centers, as required by ACS. It is possible that some EDs performed screening but not counseling or referral for patients with alcohol-related complaints, which would artificially lower our estimate of routine screening. While the survey asked ED medical directors if their ED had a system in place to perform "risk screening, counseling, and referral," we did not measure whether these services were actually delivered. Selection bias may have occurred, especially if EDs that did not offer preventive services represented a large proportion of non-responders. However, selection bias was likely averted with a high (80%) response rate, and the characteristics of our respondents were representative of EDs nationally (data not shown, full details have been published previously).[19] There may be additional variables not included in our analysis that could be confounding or modifying our results. Finally, our sample size limited our ability to perform subgroup analyses and colinearity of some of the variables prevented multivariate analysis. Despite these limitations, this study provides valuable information on the current rates of routine alcohol screening in a large variety of EDs and also reveals important potential barriers and facilitators for offering routine alcohol screening.

CONCLUSION

To improve the rate of routine alcohol screening and counseling among patients presenting with alcohol-related complaints in U.S. EDs, perceived barriers related to an ED's capacity to perform screening, such as limited financial and staff resources, should be addressed, as should directors' concerns regarding the implementation of preventive health services in EDs. In particular, our research suggests that enabling the uniform reimbursement of routine ED-based

alcohol screening and counseling and ensuring that these services do not prolong ED length of stay may increase adoption of this service. Future research is needed to better understand the role of specific facilitators and barriers in the use of routine alcohol screening, including the role of ED directors' concerns about routine screening, the role of directors' perceived capacity to perform routine screening, and the importance of reimbursement mechanisms for routine screening and counseling. Such knowledge could play a critical role in increasing the number of EDs that routinely screen and counsel indicated patients for alcohol misuse, ultimately leading to better identification of at-risk patients and referral to appropriate resources, such as substance abuse treatment.

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Application of a Proactive Risk Analysis to Emergency Department Sickle Cell Care

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Introduction: Patients with sickle cell disease (SCD) often seek care in emergency departments (EDs) for severe pain. However, there is evidence that they experience inaccurate assessment, suboptimal care, and inadequate follow-up referrals. The aim of this project was to 1) explore the feasibility of applying a failure modes, effects and criticality analysis (FMECA) in two EDs examining four processes of care (triage, analgesic management, high risk/high users, and referrals made) for patients with SCD, and 2) report the failures of these care processes in each ED.

Methods: A FMECA was conducted of ED SCD patient care at two hospitals. A multidisciplinary group examined each step of four processes. Providers identified failures in each step, and then characterized the frequency, impact, and safeguards, resulting in risk categorization.

Results: Many "high risk" failures existed in both institutions, including a lack of recognition of high-risk or high-user patients and a lack of emphasis on psychosocial referrals. Specific to SCD analgesic management, one setting inconsistently used existing analgesic policies, while the other setting did not have such policies.

Conclusion: FMECA facilitated the identification of failures of ED SCD care and has guided quality improvement activities. Interventions can focus on improvements in these specific areas targeting improvements in the delivery and organization of ED SCD care. Improvements should correspond with the forthcoming National Heart, Lung and Blood-sponsored guidelines for treatment of patients with sickle cell disease. [West J Emerg Med. 2014;15(4):446–458.]

INTRODUCTION

Sickle cell disease (SCD) is a painful, chronic, genetic condition that affects 90,000-100,000 individuals in the U.S.[1] and shortens life expectancy to around 40 years.[2-5] While there is wide variation in the use patterns of healthcare by SCD patients, particularly of emergency department (ED) care, there is also substantial evidence of generally poor quality of care for SCD patients in the ED.[6-8] The Emergency Department Sickle Cell Assessment of Needs and Strengths (ED-SCANS, http://sickleemergency.duke.edu/) was developed as a quality improvement (QI) framework for seven key clinical processes of SCD ED care. Patient and clinician characteristics make providing care to persons with SCD in the overcrowded ED a challenge.[6,9,10] The diminishing of attention to pain and pain management in the ED, partially due to crowding, often results in delays to analgesic medication administration.[11]

A FMECA, a prospective quality improvement and patient

safety approach, was applied and sought to identify and qualify risk contributors, often generic, to failed processes and systems. Through risk binning, that is attributing high to low risk characteristics to each process, as well as characterizing the frequency and existing safeguards of these potential adverse events, systems and processes can be assessed as to the consequences of failure and their likelihood as causative factors. The FMECA approach was developed by engineers and originally employed in high-risk industries, such as aeronautics, aerospace, and nuclear power, to identify potential system and process vulnerabilities.[12] It has been increasingly applied to complex healthcare processes, including intravenous drug administration, blood transfusion, and sterilization of surgical instruments.[13-23] In healthcare, a FMECA is conducted through multidisciplinary meetings with clinicians and staff who are involved with and knowledgeable about the system and processes under investigation with the goal of eliciting and generating a comprehensive description of all steps in a defined, specific clinical care process. Although time and resource intensive, a FMECA can provide a robust assessment of potential risks in the healthcare processes and systems and serve as the platform for significant process improvement and system redesign.[24]

We selected this approach over several other quality improvement approaches including value atream mapping (VSM) and root cause analysis (RCA). VSM seeks to identify those events which lead to "waste" of resources, especially time, i.e., process inefficiencies; our aim was not to evaluate the overall waste of resources.[25] RCA was not selected because it evaluates a system event after its occurrence and evaluates trends and assesses risks of underlying causal factors. Our goal was to evaluate specific processes of care in each ED, not in response to a specific event.

Caring for persons with SCD in the ED is complex from a medical, psychosocial, and health services utilization perspective. Pain associated with vaso-occlusive crises (VOC) remains the most common complaint of SCD patients seeking care in the ED.[26] Additional reasons for ED visits include other medical complications not limited to chronic anemia, iron overload from multiple transfusions, ischemic and hemorrhagic strokes, acute chest syndrome, pulmonary embolism, pneumonia, and renal failure.[3] VOC requires parenteral analgesics and is highly time sensitive due to the mortality risk of ischemic or infectious complications.[27,28] Current guidelines for the management of VOC from NHLBI and the American Pain Society recommend the following: (1) immediate assessment and differentiation of typical pain episodes from other complications of SCD; (2) rapid assessment and determination of pain medication requirements and pain control with opioids within 15-20 minutes of ED arrival; and (3) re-assessment of pain every 15-30 minutes.[29,30] These current guidelines are outdated, especially in this age of ED crowding, with unrealistic expectations of door to first dose of 30 minutes, and repeat doses reduced by one-quarter to one-half the initial dose. In an effort to provide more current, evidence based practice for treating SCD, the National Heart Lung and Blood Institute formed an Expert panel to develop evidence-based guidelines. This report will be published in 2014.

Clinicians, however, report significant barriers to following recommended guidelines in the ED and frustration with the care and management of SCD patients. Some perceive SCD patients to be "drug seeking" and many providers report a lack of understanding of opioid requirements for SCD and other chronic pain patients, especially those on chronic daily opioid therapy.[31] Clinicians are reluctant to order and administer appropriate high-dose opioids, resulting in delays and sub-therapeutic treatment of VOC episodes.[6,31] A further frustration of ED clinicians is the frequent use of the ED by a small fraction of patients with SCD, who may make 100 or more visits over several years.[6,32,33] The research team hypothesizes that the population of SCD patients with such intense ED use may well have other significant neurocognitive deficits and unmet psychosocial healthcare needs that lead to such dramatically high ED use. Ultimately, care of the patient with SCD in the ED is multifaceted and complex.

The aim of this project was to 1) explore the feasibility of applying a failure modes, effects and criticality analysis (FMECA) in two EDs examining four processes of care (triage, analgesic management, high risk/high users, and referrals made) for patients with SCD, and 2) report specific failures of these care processes in each ED.

METHODS

Study Design and Sample

We conducted a prospective FMECA at two urban EDs in the Southeastern United States, each affiliated with an academic medical center and with an emergency medicine residency training program. Site 1 had an adult ED patient volume of about 61,000 in 2011, with nearly 600 SCD visits annually. Site 2 had an adult patient volume of 73, 000 in 2011, with nearly 500 annual SCD visits.

We recruited FMECA participants because of their involvement with and knowledge of the care of SCD patients in the ED. Participants at each site included representatives of ED physician and nursing leadership, ED physicians and nurses, an ED pharmacologist, ED and hospital social workers. Select members of the Sickle Cell Clinic team (hematologists, nurses, one physician assistant, nurse practitioner, social worker, and educator) also participated. One patient with SCD who received care at each site was also recruited to contribute. Members received a $75 gift card for participation. Two in-person FMECA sessions were held at each of the two sites. The project was approved by the institutional review boards at both study sites and participants provided written consent.

Procedures

Quality Improvement Framework: Emergency Department

Sickle Cell Assessment of Needs and Strengths (ED-SCANS)

Four of the seven processes recommended by the ED-SCANS were selected for analysis during the FMECA. The ED-SCANS is a decision support tool developed as a quality improvement framework to address the complex healthcare needs of SCD patients in the ED; it is comprised of seven algorithms (http://sickleemergency.duke.edu/).[10] The ED-SCANS can be used to guide the clinical management of individual SCD patients in the ED and develop best practice protocols to support their care in that setting. Four algorithms -- (1) triage; (2) analgesic management; (3) identification of the high risk/user; and (4) need for referrals to a physician or for psycho-social support if discharged home -- were the focus of desired QI activities and this FMECA. Due to the complexity of conducting a FMECA to analyze four processes, we determined that processes relevant to the other three ED-SCANS algorithms (diagnostic evaluation, disposition, and need for an analgesic prescription if discharged home) would not be assessed. Future work would be necessary to analyze these processes. A brief description of each of the four algorithms is outlined below:

1. Triage: Assessment of vital signs and chief complaints suggestive of something other than pain related to a VOC and assignment of a triage priority score.
2. Analgesic management: Individualized pain management, or generic departmental pain management protocols, or weight-based or patient-controlled analgesia (PCA) opioid dosing regimens
3. Assessment of the high ED user/high risk patient: Defined as patients with more than 3 ED visits or hospitalizations/year, SCD patients who do not have a primary care provider (PCP), or have other difficulties obtaining appointments, and SCD patients who are pregnant; and
4. Referrals: Identification and coordination of medical and psycho-social referrals made in the ED for discharged patients.

Session 1: Process Mapping.

In the first FMECA session at each site, the research team explicitly identified the process boundaries of ED SCD care for each of the four processes (triage, analgesic management, identification of the high- risk or high-user patients, and referral). Participants were encouraged to describe their own involvement, tasks, and experiences during the process of caring for an SCD patient and to comment on routinely used "workarounds" or "shortcuts" rather than recite hospital protocols and policies.[13,34-37] After completion of Session 1, the research teams translated the description of each of the four SCD processes into site-specific process maps for each decision (Microsoft Visio 2010; Microsoft Corporation, Redmond, WA). The researchers then used the process maps to create a site-specific FMECA risk assessment chart for each decision, a document that listed all ED SCD care process steps, using Excel software (Microsoft Excel 2010; Microsoft Corporation, Redmond, WA).

Session 2: Risk assessment.

During the second FMECA session at each site, participants were given each of the four site-specific process maps. These maps were used to populate the 'process step" column of the FMECA risk assessment charts developed for each process (triage, analgesic management, high risk/higher user, and referrals) at each site. To complete the risk assessment charts, participants systematically reviewed each process step for each process map, and identified, for each step, weak points or failures and their causes (failure mode causes). Next, FMECA participants, as a group, estimated the frequency of each identified potential failure and the likely consequences for the patient of each identified potential failure.

Finally, to qualify the most critical systematic and process failures, the research team applied a method, developed by the US Department of Energy and adapted for healthcare, in which each potential failure is categorized by a "risk bin," depending on its frequency and consequence scores.[36] The process of risk binning permits the prioritization (from highest to lowest by significance and frequency) of failures for selection for targets of QI initiatives and efforts. Following the second session, researchers met with individual participants, as needed, to fill in any perceived gaps in the risk chart.

In Session 2, frequency of a potential failure was measured as remote (F1), uncommon (F2), common (F3), or frequent (F4). Consequences to the patient of each identified potential failure were measured as none (C1), some (C2), serious (C3), or significant or certain (C4). Criticality risk bins were categorized as low, medium or high (Table 1). A failure with a high frequency score (F4) and a high consequence score (C4), for example, was ranked as a "high" criticality failure, whereas a failure that occurred at a high frequency rate (F4) but had little consequence (C1) was scored as a "low" criticality failure.[38] Safeguards for the processes were explored and rated as (S1) if a formal policy or procedure was in place to prevent the failure, (S2) if the process was a standard of practice with no policy in place, and (S3) if there was nothing. For example, a policy existed at Site 1 that allowed the triage nurse to obtain an analgesic order from a physician in the event of delayed placement in a treatment space. This was rated as (S1), to address the risk of delays to analgesic administration, despite the existence of a policy and procedure, in the event of crowding.

Data Analysis

All sessions were digitally recorded and transcribed, and the research team also took detailed field notes. After the first and second sessions, FMECA participants were asked, independently, to review their site-specific process maps and risk charts and to offer revisions or corrections and researchers met with individual participants, as needed, to fill in any gaps. We then examined the final four process maps and FMECA risk assessment charts from each site to identify similar and different risks across both study sites.

Table 1. Risk matrix for frequency and consequence of a failure.

Frequency	Consequence			
	CP1 none	CP2 some	CP3 serious	CP4 significant
F1 remote	Low	Low	Low	Medium
F2 uncommon	Low	Low	Medium	Medium
F3 common	Low	Medium	Medium	High
F4 frequent	Low	Medium	High	High

Table used with permission and adapted from G Coles, B Fuller, K Nordquist, et al. Three Kinds of Proactive Risk Analyses for Health Care. *Joint Commission Journal on Quality and Patient Safety*. 2010; 36:365-375, Appendix A.

Table 2. Participants by site in a risk assessment analysis related to patients with sickle cell disease (SCD).

Provider Type/site	Number of participants	
	Site 1	Site 2
Hematologist	1	1
Emergency Physician	4	2
Emergency department (ED) nurse	6	3
Nurse practitioner	3	0
Physician assistant	0	1
Pharmacist	1	0
ED administrator	2	2
Educator	3	0
Social worker	2	1
SCD Patient	1	1
Total	23	11

RESULTS

The FMECA included a total of 23 participants. Participant characteristics for each site are described in Table 2. Each FMECA session lasted approximately three hours. A process map and risk assessment chart was developed for each of the four processes. Because the process maps were developed to inform the risk assessment chart, only results from the risk assessment charts are presented and discussed. An expert facilitator led the FMECAs, and high-level support from physician and nursing leadership to encourage participation was a key component. Despite the complexities of describing SCD ED care at two different sites, the application of FMECA was feasible and participants reported high satisfaction with having an opportunity to identify failures and vulnerabilities in the high-risk processes that lead to breakdowns in SCD ED care. The FMECA required more time to complete than originally planned. Results specific to each of the four care processes are discussed below.

Triage and Analgesic Management

Both sites identified multiple, similar complex failures in triage and analgesic administration, despite significant differences in their protocols. For example, at both sites triage nurses assessed vital signs and chief complaints and attempted to determine if an open ED bed was available. If a bed was not available patients were placed in the waiting room. This process step was identified as high risk because it occurred frequently due to ED crowding at both sites, and because of erroneous triage assessment, and resulted in a delay in SCD patients receiving analgesics, the potential of undetected serious complications, and an inability to perform recommended re-assessments. However, Site 1 offered the triage nurse an option of requesting and obtaining an order for a first and repeat dose of sub-cutaneous opioid for any SCD patient with an existing treatment plan, when an ED bed was unavailable. However, it was widely acknowledged that triage nurses infrequently used this option. Site 2 did not have a similar option.

While several policies were in place at Site 1 to facilitate analgesic management, widespread lack of implementation and adherence was identified as a key failure. Obtaining timely intravenous access was a high-frequency, high-risk process at both sites, which contributed to significant delays in receiving analgesics. Site 1 used individualized analgesic dosing protocols available in the electronic medical record, and weight-based dosing was used when individual protocols were not available. Site 2 had a generic analgesic protocol available for management of ED SCD patients, but it, reportedly, was often not used. Site 1 also used a patient-controlled analgesia (PCA) protocol that required re-assessments of pain every 10 minutes with orders for re-administration of additional doses through the PCA. However, the protocol was usually not followed because of its complexity. Re-assessment and re-dosing for unrelieved pain were identified as high-risk areas at both sites. Difficult intravenous access was another barrier to providing rapid administration of analgesics at both sites. While resources such as ultrasound were available at both sites, they were frequently not used. Process steps, potential failures, consequences, safeguards, and risk bins for analgesic administration at both sites are presented in Tables 3 and 4, as examples.

High ED Use and High Risk Patients

Quality care processes to identify ED patients with high ED use or those at high risk did not exist at either site. For example, while participants at both sites acknowledged significant frustration with a small number of patients who were high ED users, neither site had any formal process in place to identify this subset of ED SCD patients in "real time," nor any formal process for reviewing these cases and identifying solutions.

Referrals

The ED-SCANS recommends a brief psychosocial assessment to identify unmet needs of patients who might benefit from follow-up services after discharge to the community (http://sickleemergency.duke.edu/sites/default/files/ED-Scans_Adult-Algorithms.pdf). Neither site had any process in place for conducting a psychosocial assessment, even for patients with frequent ED visits or those at high risk of severe disease. Although Site 1 had both a SCD program social worker and ED social workers who could assist with psychosocial assessments and referrals, there were no process guidelines in place to use these resources. Site 2 had no identified ED staff to assist in performing psychosocial assessments or making referrals.

DISCUSSION

This study involved the performance of a complex FMECA of all steps involved in four processes of ED care for patients with SCD, based on a SCD QI framework, the ED-SCANS. We found multiple processes were reflective of high-risk areas. We carefully followed the process of assigning frequency and criticality. The large number of high-risk areas is reflective of how complicated and in need of improvement the care processes are. Caring for persons with SCD in the ED is not just about pain.

In general, key findings at Site 1 were the following: (1) poor adherence to current analgesic protocols, and (2) failure to maximize the use of existing resources. In general at Site 2, the FMECA identified (1) a lack of structured SCD ED care processes and protocols, and (2) lack of resources to provide optimal SCD ED care. Patient input at each session was invaluable. As existing policies and processes were discussed, patients often validated the lengthy delays to analgesic administration and that these processes were not used. For example, at Site 1 triage nurses are allowed to administer an analgesic in the waiting room if a delay is unavailable. Patients verified that they were unaware of this option, and not offered analgesics at triage.

Reports from both sites indicate that findings from the FMECA are being used to guide ongoing QI efforts. Members of the FMECA teams at both sites continue to meet monthly. Collaborative efforts between the two sites are continuing through monthly teleconference calls during which progress on the identified high-risk areas are discussed.

Typically, a FMECA is paired with other QI methods. For example, a rapid cycle, process improvement method, the plan-do-study-act (PDSA), is being used by both sites to review the FMECA findings, enact the redesign and process improvement, study the results, and implement additional process improvements to successfully implement process changes.[39,40] Individual members of the teams at both sites have used the results of the FMECA to focus their work on the two identified high-risk areas: (1) revision of analgesic management policies and related clinician education. and (2) implementation of processes to obtain psychosocial assessments and referrals. At Site 1, the PCA protocol was revised to facilitate a more achievable time interval between administration of repeat analgesic doses. When no changes in real-time processes were noted, the team reviewed the risk binning results again and determined that the route of administration was a barrier. The protocol was modified and the route of administration for initial doses was changed from PCA to intravenous bolus doses. Initial results following this change have been favorable. Re-education of staff on the subcutaneous protocol has also been implemented. At Site 2, the emphasis has been on the development of individualized opioid pain management protocols and development of a SCD-specific protocol. Review of randomly selected medical records at each site has shown decreases in times from arrival to placement and from arrival to first dose of opioid analgesia.

Education was identified as a barrier to process re-designs implementation. A one-day workshop on SCD was offered in 2012, and a two-day workshop was offered in 2013, to members at both study sites; FMECA team members from both sites attended. A SCD Champion Program was also created at both sites, modelled after the pain resource nurse (PRN) program established to provide education to nurses about SCD and pain management.[41] PRNs participate in unit-based QI activities, provide unit-based education to their peers, and attend ongoing multi-disciplinary SCD Champion quarterly education and operational meetings. SCD Champion nurses at both study sites participate in these activities and are identified as resource nurses to physicians and nurses in their respective departments, and a means of sustaining the progress being made.

The second focus for each QI team was the identification of unmet psychosocial needs and follow-up care for patients with SCD, especially for persons at high risk or with high ED use. At Site 1, the QI team implemented a process that automatically "pages" an ED social worker, upon arrival of every adult with SCD. The social worker conducts a brief, targeted, psychosocial screening interview to identify unmet psychosocial needs. Prior to the last quarter of the project, no patients received referrals to psychological or behavioral services. Now, all patients are evaluated by the social worker during the hours a social worker is available, which includes 24/7 on weekends and approximately 14 hours/day during the week. At Site 2, the team is devising means to engage a consistent process that will allow for psychosocial referrals. At both sites, high-risk patients and high ED users are being better identified.

LIMITATIONS

Since this study was conducted in only two institutions, the key failures in the process of ED SCD assessment, treatment, and referral, as well as the causes, frequencies, and consequences, may differ from other institutions. Rather than being designed to identify all failures in the systems

Table 3. Site 1 analgesic risk analysis.

Step ID	Process Step	Failure Mode	Failure Mode Causes	Frequency Score	Consequences	Consequence Score	Safeguard	Safeguard Score	Risk/Bin
1	Obtain analgesic order								
	Medical doctor (MD) available to initiate protocol	MD not readily available	Providers may also order oral or intra-muscular; some patients may not want sub-cutaneous (SC)	F4	Delay in initiating pain protocol; pain worsens	C3	Policy states which MD to approach for initial order.	S1	High
2	Obtain supplies to administer dose								
	Intravenous (IV) access	Delay in getting access	Anatomy; system issues (patient load acuity); patient preference	F4	Delay in initiating pain protocol; pain worsens; delay in getting; lack of continuing to give SC or bolus doses	C3	Intake nurse; ultrasound capable nurses; residents to place external jugular; other nurses with skills in IV	S2	High
	Ultrasound (US) nurse available	US RN not available	Ultrasound trained nurse not always on duty; ultrasound trained nurse busy with another patient; ultrasound machine may not be available; other patient may be waiting for ultrasound IV.	F4	Same as above	C3	Residents/attending can put in an external jugular (EJ) catheter and ultrasound guided IV's, can continue to give SC doses	S2	High
	Patient continuous analgesia (PCA) pump available	Not available	Pumps stored back of pediatric ED, during high volume PCAs are more difficult to find; not enough stock; key not available	F4	Same as above	C3	During day time, someone will go down and get a pump; but bio engineering does not always have a pump available	S3	High

RN, registered nurse

Table 3. Continued.

Step ID	Process Step	Failure Mode	Failure Mode Causes	Frequency Score	Consequences	Consequence Score	Safeguard	Safeguard Score	Risk/Bin
	If applicable: resident nurse (RN) trained to access port	Not all RN's trained to access port	Difficulty, unable to draw blood or can draw but not infuse	F2	Same as above	C3	Peripheral IV; flush with heparin; reposition pt.	S1	Medium
3	PCA analgesic administration								
	Obtain MD PCA loading dose and order	Not ordered, or not ordered per protocol	MD trainees typically taught IV bolus methods only, not familiar with use of PCA in SCD; residents not initiating PCA order; lack of knowledge that loading dose can be given as many as 4 bolus doses every 10 minutes; non-emergency medicine residents unfamiliar with ED SCD PCA order form; wrong PCA form completed; wrong dose ordered; attending MD does not review PCA order before nurse implementation	F2	Delays in care	C3	Electronic medical record of clinic notes and ED notes with prescribed doses are readily available	S1	Medium
	PCA doses re-administered q 10 minutes x4	Not followed	Nurse availability for frequent re-dosing; opioid administration requires a 2-RN check; delay because must locate & obtain PCA key & another RN may have it; boluses not being given consistently per PCA order	F4: being given but not every 10 minutes as per protocol	Poor pain control; decreased pt. satisfaction, quality of care; staff frustration; poor pt. - clinician interactions	C3	May be receiving PCA demand and continuous dosing	S1	High
	Re-assess pain each hour; PCA protocol: reassess medication use every 2 hours	Not followed	Nurse availability for frequent re-evaluation; increased acuity or patient load prevents	F3	No change in analgesic management based on pain score and RASS (sedation) score prompt; increasing pain; longer length of stay	C3	Electronic flag with PCA usage	S1	Medium
	If inadequate pain relief, administer rescue doses x2 and adjust continuous and PCA doses	Not followed	Not routine practice	F4	Inadequate pain management	C3	Order set is clear and stipulates rescue dosing & adjusted PCA doses	S1	High

PCA, patient continuous analgesia; *MD*, medical doctor; *IV*, intravenous; *ED*, emergency department; *RASS,* Richmond Agitation Sedation Scale; *SCD*, Sickle Cell Disease

Table 4. Site 2 analgesic risk analysis.

Step ID	Process Step	Failure Mode	Failure Mode Causes	Freq Score	Consequences	Consequence Score	Safeguard	Safeguard Score	Risk/bin
1	Treatment bay, IV and O2 established								
2	Obtain analgesic order								
	MD available for analgesic order	MD not readily available	Busy caring for other patients; may be in an ED room; if MD is not caring for the patient or has not examined the patient; hesitancy to write analgesic order	F3	Delay in initiating pain medication;	C3	Nurse "hunts" to find an MD; nurse advocates for MD to write an order	S3	Medium
	Acute pain protocol ordered?	Not readily used by ED MDs	Lack of familiarity with acute pain protocol by "off service" trainees; MDs have fear of using protocol because of high dose of hydromorphone and frequency (also can give ondansetron + diphenhydramine);	F4	Patient has inadequately treated pain, untimely treatment; not adequately re-dosed.	C3	Smaller than recommended or split doses are ordered; MD asks nurse to recheck pt for pain; patient is encouraged to notify if pain not resolved; inadequate pain medication dose administered	S1	High
	Patient reassessed every 15 minutes if on acute pain protocol	Never achieved	Re-dosing every 15 minutes is practically impossible; nurse tied up with other patients; Can only prepare one dose at a time. Need to go to (1) pyxis, (2) pull medication, (3) draw up medication, (4) administer medication, (5) document administration and (6) monitor patient. This takes more than 15 minutes with each dose.	F4	Patient has inadequately treated pain, untimely treatment; not adequately re-dosed.	C3	Part of a protocol	S1	High

MD, medical doctor; *IV*, intravenous; *ED*, emergency department; *SCD*, Sickle Cell Disease

Table 4. Continued.

Step ID	Process Step	Failure Mode	Failure Mode Causes	Freq Score	Consequences	Consequence Score	Safeguard	Safeguard Score	Risk/bin
	Patient reassessed every 15 minutes if patient NOT on acute pain protocol	Not part of the protocol; not hospital policy	Nursing caring for multiple patients; no opportunity for another dose in 15 minutes (see above).	F4	Patient has inadequately treated pain, untimely treatment; not adequately re-dosed.	C3	Patient asks for more pain medication.	S2	High
	IF no acute pain protocol, find individualized pain medication dose in modified release (MR)	No single location in MR to look up most recent dose; individualized dose may be in clinic note or inpatient note; not clearly identified in MR	Lack of time to search through MR for the last dose in the most recent ED visit. Even if ED visit located, dose may not be the most appropriate dose	F4	Patient has inadequately treated pain, untimely treatment; not adequately re-dosed.	C3	Ask the patient	S2	High
3	Administer analgesic								
	IV access available	Unable to quickly establish IV access	Patient has difficult underlying vascular morphology/physiology Safeguards available, often not used	F2	Patient has inadequately treated pain, untimely treatment; not adequately re-dosed.	C3	Lots of providers with a lot of skill; ultrasound guided; alternative delivery modes; IJ line	S2	Medium
	Definition of IV “push”	No standardized definition of IV “push”; variation in methods used. NOTE: IV “push” = administration over 1-2 minutes; NO piggy-backing of medication.	Reluctance of staff to give IV “push”; patients want the medications to be given “push”. Lack of knowledge and experience of staff; concerns about side effects of IV “push” (e.g., respiratory depression or hypotension).	F4	Patient has inadequately treated pain, untimely treatment; not adequately re-dosed.	C3	Patient has to keep asking for more pain medication.	S3	High

IV, intravenous; *ED*, emergency department; *IJ*, internal jugular

Table 4. Continued.

Step ID	Process Step	Failure Mode	Failure Mode Causes	Freq Score	Consequences	Consequence Score	Safeguard	Safeguard Score	Risk/bin
	Pain medication dosing	Inadequate, non-customized dosing	Lack of knowledge and experience of pain medication doses in SCD patients; clinicians reluctant to give high doses of opioids; MDs order "split" doses or just smaller dose; MDs fear of substance- seeking pts; fear of side effects of high dose pain medications	F4	Patient has inadequately treated pain, untimely treatment; not adequately re-dosed.	C3	Patient asks for more pain medication.	S2	High
	No immediate IV access	Cannot achieve rapid IV access	Protocol is to try 2-3 times to get peripheral, then, seek additional help. Do not use sub-cutaneous route.	F4	Patient has inadequately treated pain, untimely treatment; not adequately re-dosed.	C3	Lots of providers with a lot of skill; ultrasound guided; alternative delivery modes; IJ line	S2	High
4	Order for analgesic given and dose administered								
	Re-assessment of pain	Patient not reassessed in a timely manner	Nursing staff caring for other patients; no automatic alert or reminder available to nursing	F4	Patient has inadequately treated pain, untimely treatment; not adequately re-dosed	C3	Patient asks for more pain medication	S3	High

IV, intravenous; *MD*, medical doctor; *IJ*, internal jugular; *SCD*, Sickle Cell Disease

and processes of ED SCD care, the aim of this study was to demonstrate the application, by healthcare clinicians and staff, of a proactive, risk assessment methodology – FMECA – to the acute, time-sensitive ED SCD process of care, endorsed by the ED-SCANS in order to identify potential failures in SCD processes of care. The FMECA permitted a ranking of the identified failures by greatest risk which, in turn, facilitated the selection of ED-specific targets for development and implementation of interventions.

The FMECA approach has some inherent limitations. It does not include all staff or clinicians involved in ED SCD care and therefore relies on convenience sampling. In this study, more clinicians and staff participated at Site 1 than at Site 2. Having additional participants may have added different perspectives and identified additional steps, failures, and causes. Also, it is possible that participants may not have identified all of the failures or may have inaccurately gauged the frequency or consequence of those identified. To address these issues, FMECA moderators asked probing questions during the sessions to increase discussion, but it is likely that the group did not entirely capture all problems.[42]

An additional limitation relates to the FMECA assessment of the failure's consequence score. Evidence has shown that participants can be, on the one hand, overly optimistic, in that they underestimate potential consequences of a process failure due to the hazard being perceived as considerably frequent, although no severe consequences have actually occurred. On the other hand, they may be overly pessimistic: although they have never experienced or heard about a failure occurring, they cannot exclude that the failure will ever occur. As detailed in a 2008 critique of risk matrices,[43] the quantitative value of risk analysis is limited by the mathematical assumptions of the embedded judgments of frequency and severity rating, in this context, the frequency and severity of barriers to optimal care for patients with SCD. In healthcare, risk contributors are not necessarily "randomly selected pairs of hazards" and in fact represent a number of possible outcomes, based on observed clinical occurrences (consequences). However, our intent at adapting risk analysis to improve the care of SCD patients is qualitative at this point in time, not quantitative, and represents a qualitative assessment of multiple risks that cause a healthcare process to fail.[44] This is a dynamic process, and allowed for the input of multiple providers who can better suggest as a whole the barriers that may be in place. Furthermore, this methodology includes the use of a safeguard or safety intervention, which could be reasonably expected to impact the frequency and severity of risk contributors. The quantitative impact of the barriers and the success of the safeguards can only be determined by analysis of data which is currently underway.

CONCLUSION

This study demonstrates the feasibility of conducting a complex FMECA of each aspect of four clinical processes of SCD ED care at two hospitals. Results from the FMECA identified specific process failures and have been instrumental in determining the focus of QI activities at each site. While a FMECA is an excellent tool for identifying potential weaknesses or failures in complex processes, implementation of process and quality improvement techniques to address the identified failures and vulnerabilities in the ED SCD process of care is also critical. Units and facilities that undertake FMECAs can use the results to guide QI activities to redesign, test, and improve specific processes of care to the benefit of both patients and those who care for them.

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Adherence to Head Computed Tomography Guidelines for Mild Traumatic Brain Injury

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Introduction: Traumatic brain injury (TBI) is a significant health concern. While 70-90% of TBI cases are considered mild, decision-making regarding imaging can be difficult. This survey aimed to assess whether clinicians' decision-making was consistent with the most recent American College of Emergency Physicians (ACEP) clinical recommendations regarding indications for a non-contrast head computed tomography (CT) in patients with mild TBI.

Methods: We surveyed 2 academic emergency medicine departments. Six realistic clinical vignettes were created. The survey software randomly varied 2 factors: age (30, 59, or 61 years old) and presence or absence of visible trauma above the clavicles. A single important question was asked: "Would you perform a non-contrast head CT on this patient?"

Results: Physician decision-making was consistent with the guidelines in only 62.8% of total vignettes. By age group (30, 59, and 61), decision-making was consistent with the guidelines in 66.7%, 47.4%, and 72.7% of cases, respectively. This was a statistically-significant difference when comparing the 59- and 61-year-old age groups. In the setting of presence/absence of trauma above the clavicles, respondents were consistent with the guidelines in 57.1% of cases. Decision-making consistent with the guidelines was significantly better in the absence of trauma above the clavicles.

Conclusion: Respondents poorly differentiated the "older" patients from one another, suggesting that respondents either inappropriately apply the guidelines or are unaware of the recommendations in this setting. No particular cause for inconsistency could be determined, and respondents similarly under-scanned and over-scanned in incorrect vignettes. Improved dissemination of the ACEP clinical policy and recommendations is a potential solution to this problem. [West J Emerg Med. 2014;15(4):459–464.]

INTRODUCTION

Traumatic brain injury (TBI) is a significant health concern and accounts for approximately 1.2 million emergency department (ED) visits yearly, translating to about 1% of total ED visits annually.[1,2] Of these TBI cases, 70-90% are considered mild and, although most are mild, decision-making regarding imaging can be difficult.[3-6] Ionizing radiation from computed tomography (CT) imaging is not without risk, and recent literature has demonstrated an increased risk of both leukemias and brain tumors in children.[7] While the negative health effects of ionizing radiation in adults is believed to be milder, judicious and cost-reductive use of CT imaging in an era of rising healthcare costs—without sacrificing patient care—is important.

In 2008, the American College of Emergency Physicians (ACEP) revised and disseminated their most recent clinical policy regarding recommendations for a non-contrast head CT in the setting of mild TBI.[8] In this revised policy, the authors identified Level A, Level B, and Level C recommendations. In the setting of mild TBI—defined as

non-penetrating trauma presentation within 24 hours in patients at least 16 years old with a Glasgow Coma Scale (GCS) of 14 or 15—10 Level A recommendations were made including: headache, vomiting, age older than 60 years, drug/alcohol intoxication, deficits in short-term memory, physical evidence of trauma above the clavicles, post-traumatic seizure, GCS<15, focal neurologic deficits, or coagulopathy. Patients who had experienced either loss of consciousness (LOC) or post-traumatic amnesia and 1 of the 10 previously-mentioned findings were recommended to receive a non-contrast head CT according to Level A recommendations.[8]

No determination has been made as to whether or not these most recent ACEP guidelines are routinely applied appropriately and, if they are not, what factors lead to a varied practice inconsistent with these guidelines. To assess this hypothesis, a survey was undertaken of 2 separate emergency medicine (EM) departments. We hypothesized that EPs are aware of the most recent ACEP clinical policy recommendations regarding indications for a non-contrast head CT in patients with mild TBI and that they appropriately apply these recommendations.

We created a set of realistic clinical vignettes, with a supplemental categorization survey, that describes a typical patient encounter in the ED. Each vignette describes a typical ED patient with mild TBI and then asks the respondent to make a single decision regarding whether or not to obtain a non-contrast head CT.

METHODS

For this survey study, we created 6 realistic clinical vignettes, followed by a supplemental categorization survey, which described a common patient encounter in the ED. Voluntary participants were directed to a web-based online survey. The survey program (DataMomentum [Ithaca, NY]) then presented, in a random order, 1 of the 6 head CT scenarios. Each vignette described a typical ED patient with mild TBI and then asked the respondent to make a single decision regarding whether or not to obtain a non-contrast head CT. In addition, all respondents were then asked to complete the same additional 8 supplemental categorization questions—none of which gathered any identifiable information. Each survey responder received only 1 random vignette total.

Two separate academic EM department chairs were sent a single invitation email. This email briefly explained the goal of the study and contained a link to an online web-based survey. If agreeable, the department chairmen were requested to forward the email once to their respective intra-departmental list-serve of physicians, including both residents and faculty. This process was repeated a second time 14 days later. Voluntary participants were directed to a web-based online survey.

The survey program then presented, in a random order, 1 of the 6 head CT scenarios. The survey software randomly varied 2 factors: age (30, 59, or 61 years old) and presence or absence of visible trauma above the clavicles. A representative sample of the vignette appears in Figure. These variations provided 6 different realistic clinical vignettes with a single independent variable in each. Ultimately, this survey asked a single important question: "Would you perform a non-contrast head CT on this patient?"

Responses were recorded—without identifiable information—by a web-based online service. The online survey remained open and collected responses for 6 weeks from the time of initial email to the department chairmen. We obtained IRB exemption from the local institutional review committees at both these respective institutions.

We tabulated and analyzed result data with MedCalc®, version 12.3.0.0 (MedCalc Software, Ostend, Belgium).

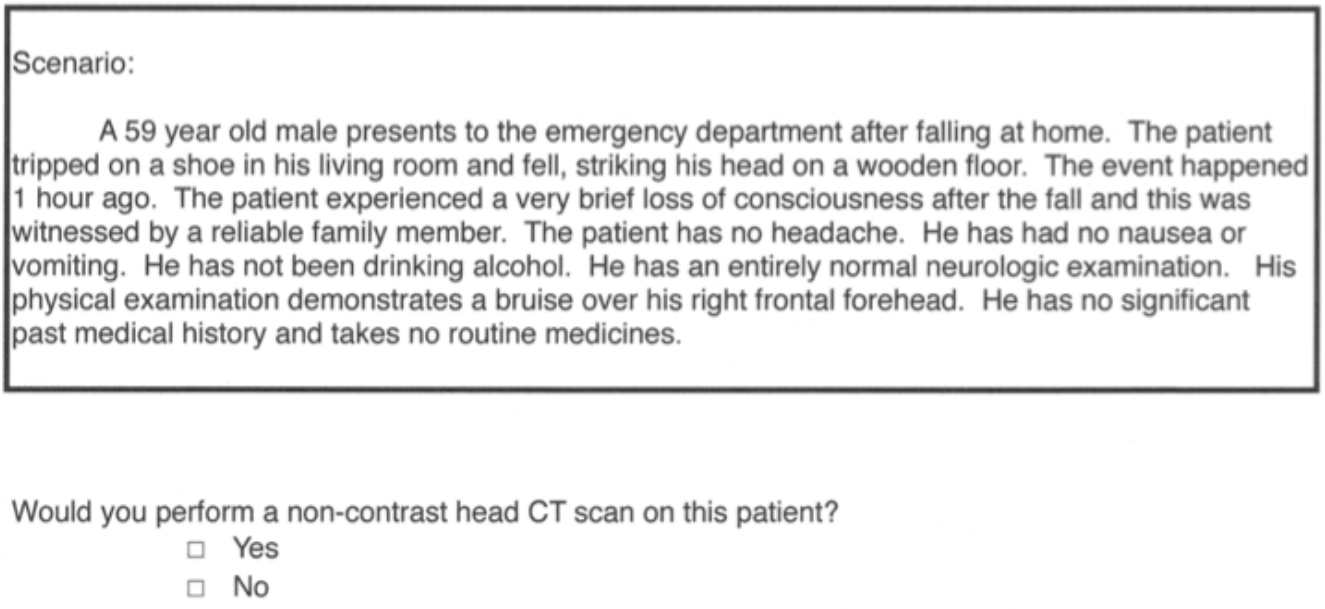

Figure. Representative vignette sample in a survey of emergency physician adherence to head computed tomography (CT) guidelines.

We assessed decision-making results, both consistent and inconsistent with the ACEP guidelines, in regards to both age (30, 59, and 61 years) and presence or absence of trauma above the clavicles.

RESULTS

"The introductory email and web-based survey link were forwarded by the department chairmen of 2 separate academic EM programs to their respective faculty and residents." Of the 241 total potential survey respondents at these institutions, 121 responded (50.2%).

Of those who did respond, 94.2% (114/121) completed the voluntary 8-question supplemental categorization survey. Respondents categorized their practice as a combination of "Some adults/Some pediatrics" in 79.8%, "Adults only" in 14.9%, and "Pediatrics only" in 5.3%. Ninety-nine of 114 respondents (86.8%) identified themselves as EM residency trained. There was no statistical difference between appropriate application of the guidelines in respondents who did and did not train in EM residency programs (62.6% versus 60.0%). Respondents also identified their practice setting as "Academic" in 99/114 (86.8%) of surveys. "Community" (8.8%) or "Other" (4.4%) was identified as the practice setting in the remainder of surveys completed. One hundred of 114 (87.7%) respondents identified their ED as a "Level I" trauma center, while 7.0% (8/114) and 5.3% (6/114) identified their practice location as a "Level II" trauma center or "Not a trauma center," respectively. Finally, 91.2% (104/114) of categorization surveys responded "yes" when asked if they had a "dedicated CT scanner located in your emergency department."

Physician decision-making in the setting of mild TBI was consistent with the most recent ACEP recommendations in only 62.8% (76/121) of total vignettes. By age group (30, 59, and 61), responses were consistent with the guidelines in 66.7% (26/39), 47.4% (18/38), and 72.7% (32/44) of cases, respectively. When comparing results by age group, there was a statistically-significant difference between the results comparing the 59- and 61-year-old age groups (p=0.034). There was no statistical significance when comparing the results of the 30- versus 59-year-old age groups (p=0.139) or when comparing the 30- versus 61-year-old age groups (p=0.723).

In the setting of presence/absence of trauma above the clavicles at ages 30 and 59, respondents appropriately applied the guidelines in 57.1% (44/77) of cases. Calculations regarding presence or absence of supraclavicular trauma were not performed in the 61-year-old group because all patients over 60 years are recommended to receive a non-contrast head CT in this setting according to guidelines. In the presence of trauma above the clavicles, responses were consistent with the most recent ACEP recommendations in only 43.2% (16/37) of vignettes. In the absence of trauma, the guidelines were appropriately applied in 70% (28/40) of cases. These results were statistically significant (p=0.032) when comparing the presence versus absence of supraclavicular trauma. Appropriate application of the guidelines was better (70.0% versus 43.2%) in the absence of trauma above the clavicles.

DISCUSSION

Clinical guidelines exist to offer the best evidence-based diagnostic or therapeutic recommendations in clinical scenarios where evidence exists. These recommendations are traditionally categorized as Level A, B, or C recommendations according to the strength of evidence on that topic. When strong evidence exists, guidelines give Level A recommendations. When either poor or conflicting data exist—or there is an absence of data on the topic—these recommendations are labeled as Level C recommendations. Evidence with moderate clinical certainty falls into the Level B recommendations. In instances where there is a paucity of data on a topic, clinical guidelines will usually make recommendations based upon "expert consensus."

Guideline recommendations serve to increase the quality of care, introduce and educate practitioners on best-evidence practice, increase the uniformity of care, and reduce cost.[9,10] They have also been shown to minimize increases in practice variation.[9] Interestingly, though, guideline recommendations have a wide adherence range from 20% to nearly 100%.[11] Since practice recommendations themselves, do not automatically change clinician practice, the reasons for variation also need to be explored. For example, the stakeholder's impact—meaning the reputation of the professional college or professional network producing it—has been reported to be important in the adoption of these best-evidence practices.[10] For this reason, we also sought to determine reasons behind clinician decision-making that varied from the recommendations.

In 2008, ACEP revised and disseminated their most recent clinical policy regarding recommendations for a non-contrast head CT in the setting of mild TBI.[8] In this revised policy, the authors identified Level A, Level B, and Level C recommendations. In the setting of mild TBI—defined as non-penetrating head trauma presentation within 24 hours in patients at least 16 years old with a GCS of 14 or 15—10 Level A recommendations were made including: headache, vomiting, age older than 60 years, drug/alcohol intoxication, deficits in short-term memory, physical evidence of trauma above the clavicles, post-traumatic seizure, GCS<15, focal neurologic deficits, or coagulopathy. Patients who had experienced either loss of consciousness (LOC) or post-traumatic amnesia AND 1 of the 10 previously-mentioned findings were recommended to receive a non-contrast head CT according to Level A recommendations.[8]

After performing a literature review, we were unable to identify any studies that addressed the application of the ACEP clinical guidelines in the setting of mild TBI. In reviewing the Level A recommendations, we believe that patient age and the presence of supraclavicular evidence of

trauma are the 2 best objective data points to evaluate how emergency providers might determine whether or not to image these patients with a non-contrast head CT. These indicators can be easily and objectively assessed by the clinician and are the least ambiguous of the 10 previously-mentioned findings. Indicators such as headache, vomiting, drug/alcohol intoxication, and coagulopathy were felt to be subjective in nature. The vignette patient ages of 30, 59, and 61 years were chosen purposefully in an effort to better differentiate the responders' awareness of the important age of 60 years in the clinical policy recommendations. Our hypothesis was that EPs are aware of the guidelines and their decision-making is consistent with the most recent ACEP guidelines in the setting of mild TBI.

Overall, physician decision-making was consistent with the guidelines in only 62.8% (76/121) of total vignettes. When analyzed by patient age—30, 59, and 61 years—the clinical guidelines were applied appropriately in 66.7% (26/39), 47.4% (18/38), and 72.7% (32/44) of cases, respectively. When these age groups were compared, there was no significance when comparing the results of the 30- versus 59-year-old groups (p=0.139) or the 30- versus 61-year-old groups (p=0.723), suggesting that respondents correctly identify the 30-year-old patient as a lower risk age group. Conversely, when comparing the results of the 59- versus 61-year-old groups, there was a significant difference (p=0.034). This inconsistent application of the most recent ACEP guidelines suggests 1 of 2 things—either these respondents inappropriately apply the guidelines, whether purposefully or not, or are unaware of the ACEP clinical guidelines. Furthermore, this argues that survey responders poorly differentiate the 59-year-old from the 61-year-old patient. Our results suggest that practitioners see these 2 age groups as a single "older" patient and their application of the guidelines to some members of this "older" group are inconsistent with the most recent ACEP clinical guidelines. Our hypothesis was that EM physicians are aware of the guidelines and appropriately apply the guidelines in mild TBI. This may only be the case in approximately 60% of patient encounters. Both instances argue that better dissemination and diffusion of the guidelines—whether in hard copy or electronic version—are indicated.

In the setting of the presence or absence of trauma above the clavicles, the guidelines were appropriately applied in only 57.1% (44/77) of cases. With the appropriate application of the guidelines significantly higher in the absence, compared to the presence, of trauma (70.0% versus 43.2%, p=0.032), this might suggest that practitioners appropriately apply the guidelines better when there is no evidence of trauma above the clavicles. Again, a potential solution to this problem is improved dissemination of the ACEP clinical policy.

Since survey respondents inappropriately applied the guidelines in 37.2% (45/121) of vignettes, we sought to figure out why this is the case. For this purpose, we included a voluntary supplemental categorization study that included no identifiable information. This was completed by 94.2% of these survey responders. Of survey responders, 94.7% (108/114) described their practice as either "Some Adults/Some Pediatrics" or as "Adults Only," suggesting that the survey responders were an appropriate survey population and have experience with treating adults. The vignettes included only patients in the "Adult" range. Only 5.3% (6/121) of respondents have only pediatric patient experience.

This categorization study also evaluated whether responders were EM residency trained. Ninety-nine of 114 (86.8%) respondents were EM residency trained and there was no statistical difference between vignette responses consistent with the most recent ACEP clinical policy between respondents who did and did not train in EM residency programs (62.6% versus 60.0%). Similarly, 86.8% (99/114) of responders described their practice as "Academic" while the remainder described their practice setting as either "Community" or "Other." The responders who were not EM residency trained were not the same population as the "Community" or "Other" population, meaning these were not the same 15/114 survey responders. With the categorization data collected, our survey study is unable to determine whether community-based physicians apply the guidelines differently than academic-based physicians and this was not a goal of our study. Finally, 91.2% (104/114) of categorization surveys responded "yes" when asked if they had a "dedicated CT scanner located in your emergency department." This question was asked to determine whether distance to a CT scanner potentially affected a responder's answer. Ultimately, no particular cause for this variation in practice pattern could be identified.

A final topic of interest was in regards to over- versus under-scanning individuals with a potential need for a head CT. Ionizing radiation has significant risks and a recent study by Pearce et al[7] has demonstrated an increase in relative risk of both leukemia and brain tumors in children receiving CT scans. While the negative health effects of ionizing radiation in adults is believed to be milder, judicious and cost-reductive use of CT imaging in an era of rising healthcare costs—without sacrificing patient care—is important. It would be an interesting finding if responders tended to over-scan and were inconsistent with the ACEP clinical policy guidelines. According to our collected survey data, though, respondents did not consistently over-scan. There was no significant difference. In cases where the guidelines were applied inappropriately, over-scanning occurred in 30.0% (12/40) of cases and under-scanning occurred in 40.7% (33/81) of cases. This data suggests that respondents over-scanned and under-scanned in a similar percentage of incorrect vignettes. They did not consistently over-scan the vignette patients.

LIMITATIONS

Limitations to our survey study include the small size of the study and the predominantly academic practice population of the survey responders. Clinicians in the community may

practice differently compared to academic practitioners. Academic EM residency programs include designated journal club discussions and may remain more up-to-date on current topics. Conversely, though, EM residency programs also include residents with less experience compared to seasoned community clinicians. For this reason, the effect of a larger community-based clinician population is unpredictable.

Another limitation to our study was the inability to determine if survey responders were aware of the guidelines. Our aim was to evaluate the surveyors' application of the most recent ACEP guidelines without their knowledge, so as to minimize bias. We did not seek to "alert" them that we were evaluating the ACEP mild-TBI clinical guidelines. One inherent limit to this, though, is that it is difficult to differentiate whether they inconsistently apply the guidelines or have minimal or no knowledge of the guidelines' recommendations. Our study inherently hypothesized that the ACEP mild-TBI guidelines were both reproducible and reasonable and represented "best practice evidence" in regards to mild TBI. Poor compliance with the recommendations could simply be the failure of practitioners to apply the best evidence-based care. Conversely, though, non-compliance could be secondary to an intrinsic limitation in the applicability of the guidelines (i.e., they are difficult to apply) or poor penetrance of the ACEP guidelines' recommendations. We sought to minimize intrinsic limitation by minimizing ambiguity in our clinical vignettes. Low penetrance of the ACEP guidelines, though, could also lead to the poor guideline application results found in our study and would further strengthen the argument of needed improvement in clinical guideline dissemination and diffusion. We were unable to determine whether the survey responders simply inappropriately applied the guidelines or did not know about the guidelines. Additionally, while other studies, such as the New Orleans Criteria and Canadian Head CT Rule, are incorporated into the ACEP clinical recommendations, some responders may have chosen to only apply the age cut-off of the Canadian Head CT Rule (age≥65).[12,13]

Lastly, like all survey studies, there are the limitations that exist between vignettes and actual practice. Practitioners may practice in the way their vignette responses indicated, but we are unable to confirm whether their actual practice is consistent. A number of other factors such as anecdotal experience, medico-legal concern, and other confounders may influence their real world practice.

CONCLUSION

In the setting of mild TBI, physician decision-making was consistent with the most recent ACEP guidelines in only 62.8% (76/121) of total vignettes. Age and the presence/absence of supraclavicular trauma were the 2 objective Level A recommendations evaluated in our survey study. Respondents poorly differentiated the "older" patients from one another, suggesting that respondents either inappropriately apply the guidelines or are unaware of the guideline recommendations in this setting. Also, surveyor responses were more consistent with the ACEP guidelines in the absence of supraclavicular trauma compared to the presence of trauma above the clavicles. No particular reasons for responses inconsistent with the ACEP guidelines could be determined, and respondents similarly under-scanned and over-scanned in incorrect vignettes. One potential solution to this issue is improved dissemination—whether in hard copy or electronic version—of the most recent ACEP clinical policy on imaging in the setting of mild TBI.

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Yield and Clinical Predictors of Thoracic Spine Injury from Chest Computed Tomography for Blunt Trauma

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Introduction: Cost and radiation risk have prompted intense examination of trauma patient imaging. A proposed decision instrument (DI) for the use of chest computed tomography (CT), (CCT) in blunt trauma patients includes thoracic spine (TS) tenderness, altered mental status (AMS) and distracting painful injury (DPI) as potential predictor variables. TS CT is a separate, costly study whose value is currently ill-defined. The objective of this study is to determine test characteristics of these predictor variables alone, and in combination, to derive a TS injury DI.

Methods: Prospective cohort study of blunt trauma patients age > 14 in a Level I Trauma Center who had either CCT or TS CT.

Results: Of 1,798 blunt trauma patients, 1,174 (65.3%) had CCT, and 46 (2.6%) had a TS CT at physician discretion. CCT identified 58 TS injuries in 1,220 patients (4.8%). For 1,032 patients without AMS, 18/35 had TS tenderness, for sensitivity of 51.4%, specificity 84.7%, positive (PPV) and negative predictive values (NPV) of 10.5% and 98.0%. Positive likelihood ratio (+LR) was 3.35, with negative (-LR) 0.57. Among the 58 TS injuries, 23 had AMS for sensitivity of 39.7%, with other test characteristics of 85.8%, 12.2%, 96.6%, with +LR 2.79 and -LR 0.70. Thirty-eight of 58 had DPI, for sensitivity 65.5%, with other test characteristics 65.7%, 8.7%, and 97.4%, with +LR 1.91 and -LR 0.52. Combining 3 predictor variables into a proposed DI found 56/58 injuries for test characteristics of 96.6% (95% CI 88.1-99.6%), 49.1% (46.1-52.0%), 8.6% (6.6-11.1%) and 99.7% (CI 98.7-100%), with +LR 1.90 (1.76-2.04) and -LR 0.07 (0.02-0.28). If validated, the DI would exclude 572/1,220 CCT patients from separate TS CT (46.9%, CI 44.1-49.7%), and 141/511 (27.6%, CI 23.8-31.7%) patients who actually had TS CT in our cohort. Medicare payment at our center for sagittal reconstructions of TS CT is $280 for professional plus technical charges ($3,312 per study). The DI, if validated, would save $39,000 –$160,000 in TS imaging payments.

Conclusion: TS CT is low yield and costly. Patients who are alert, have no TS tenderness and no DPI have a very low likelihood of TS injury (NPV 99.7% 95% CI lower limit 98.7%) with –LR=0.07, 95% CI upper limit 0.28). Avoiding TS CT may save considerable charges and payments. [West J Emerg Med. 2014;15(4):465–470.]

INTRODUCTION

Increased focus on cost-effective trauma evaluation has driven the development of clinical decision rules for high volume and high risk injuries, including cervical spine,[1,2] blunt head,[3] and chest[4,5] trauma, as well as high volume extremity injury.[6,7] Chest computed tomography (CCT) evaluation for blunt trauma varies widely. Thoracic spine (TS) injury, though uncommon, can lead to spinal cord injury and paralysis, and would be considered a no-miss condition. Twenty percent of patients with 1 spinal column injury are also found to have a second, non-contiguous fracture, and these are associated with high velocity mechanisms.[8] Therefore, it would be prudent to develop a decision instrument (DI) to identify all TS fractures, while not increasing cost with dedicated sagittal reconstructions of the TS from CCT.

Previous work has concluded that tenderness alone is insufficient to identify more than 50% of TS and lumbar-sacral spine (LS) fractures, and almost 25% that are clinically significant.[9] Therefore, a DI would need to include other predictive factors to capture the vast majority of injuries.[9]

Mancini and Burchard[10] found that chest/abdomen/pelvis CT identified all 35 patients with TS or LS fracture, and 98% of their sites of injury (78/80). However, their paper did not disclose the decision process that led to body cavity or selective spine imaging. Therefore, the current study would expand on previous work by creating a DI to govern the imaging decision, and describe the sensitivity of the body cavity CT vs. the criterion reference spine CT. In addition, we report the clinical significance of spine injuries missed by body cavity CT alone.

Sagittal reconstruction of the TS generates substantial technical ($3,070) and professional ($242) charges in our trauma center, and might be necessary with suspicion for TS injury. A previous study found that 6.6% of spine injuries were missed on chest or abdomino-pelvic CT, but discovered on dedicated spine CT.[10] This author questioned whether this "false negative" subset of spine injuries was clinically important. A valid DI might guide omission of dedicated spine imaging if patients were determined sufficiently low risk for injury, or for clinically important injury, and might save charges, costs, and time.

Recently, a DI for all thoracic injuries was derived and is being validated, which includes 12 predictor variables: rapid deceleration, distracting painful injury (DPI), intoxication, altered mental status (AMS), chest pain, tenderness of the sternum, other chest wall, thoracic spine or scapula, and abnormal ultrasound of the chest, pericardium, or abdomen.

This retrospective analysis of prospectively collected trauma patient data sought to determine if a relevant subset of 3 of these predictive factors, DPI, AMS or TS tenderness would predict TS injury. If so, this would form the basis of a prospective validation study. This is the largest study of clinical features that led to identification of TS injury, and the first to propose a DI to guide clinical decision making.

We sought to determine test characteristics of these 3 predictor variables alone, and in combination, to postulate a TS-injury DI. To our knowledge, this is the first attempt to derive such a rule for this injury.

METHODS

We have previously described the derivation and inter-rater reliability assessment of our selective chest imaging DI. For 2 of our 3 predictive factors, AMS and DPI, Kappa values were >0.5 indicating good inter-rater reliability, while T-spine tenderness was not assessed.[12]

We conducted this single-center, prospective cohort derivation study at a high-volume (3,600 trauma activations

Table 1. Characteristics of 1,798 patients presenting with blunt chest trauma.

Sex	Male	1107	61.6%
Age	15-19	198	11.0%
	21-29	403	22.4%
	30-39	243	13.5%
	40-49	235	13.1%
	50-64	353	19.6%
	65+	366	20.4%
Mechanism	Motor vehicle collision	780	43.4%
	Two-wheeled vehicle*	187	10.4%
	Pedestrian†	143	8.0%
	Bicycle‡	126	7.0%
	Fall from standing	209	11.6%
	Other fall	149	8.3%
	Struck by blunt object	46	2.6%
	Struck by fists or kicked	51	2.8%
	Sports§	30	1.7%
	Other	15	0.8%
Intoxication‖	Yes	258	14.3
	No	1,531	85.2
	Unknown	9	0.5

*Two-wheeled vehicle: Includes motorized scooters, but not skateboards or rollerblades.

†Pedestrian: Pedestrian struck by motorized moving vehicle.

‡Bicycle: Fall from bicycle or crash into object on bicycle.

§Sports: Any injury that occurred while playing sports, including skateboards and rollerblades.

‖Intoxication: History of intoxication or recent ingestion, any positive alcohol level in blood or breath, urine toxicology screen positive for nine categories of drugs, physical evidence suggesting intoxication (see methods), or behavior consistent with intoxication and unexplained by medical or psychiatric illness.

per year) urban United States American College of Surgeons-verified Level I Trauma Center over 13 months from November 2011 to December 2012. These patients were a subset of 2 larger studies to validate and derive decision instruments for chest radiograph and CCT.

We enrolled patients with the following inclusion criteria: 1) age >14 years, 2) blunt trauma within 24 hours of emergency department (ED) presentation, and 3) receiving CCT with or without TS sagittal reconstruction or dedicated TS CT alone in the ED, as part of their evaluation for blunt trauma, per trauma captain clinical judgment.

Our research assistants enrolled subjects daily from 8AM to 12 midnight and collected demographic and mechanism data. We left the decision for chest or spine imaging to the discretion of treating trauma surgeon (PGY 4 or 5, trauma/critical care fellow, or surgical attending). After CCT was ordered, and prior to viewing images or report, the treating emergency physician (EP) completed a 1-page data sheet where they indicated presence or absence of AMS, DPI, and TS tenderness, the 3 components of our proposed DI. The DI was determined to be valid in each patient if none of the 3 predictive factors were present and the patient did not have a TS injury on any imaging (including cervical and abdominal CT). Conversely, the DI was ruled valid if a patient with TS injury had at least 1 of the 3 predictive factors.

TS tenderness was elicited by log-rolling the patient off the spine board with maintenance of cervical spine (CS) immobilization and progressively pushing on the TS from the border of the cervical collar to the sacrum, repeatedly asking the patient "does this hurt here." Any positive response from the patient was considered "tenderness" regardless of degree.

We defined DPI as any condition thought by clinician to be producing sufficient pain to distract the patient from a second injury, including long bone fractures, visceral injuries requiring surgical consultation, large laceration, degloving or crush injury, large burns, or any other injury producing acute functional impairment.

We defined AMS as a patient who was not alert or not able to appropriately respond to "yes" or "no" questions, for example Glasgow Coma Scale $\leq$14, disorientation to person, place, time or event, or delayed or inappropriate response to external stimuli. Insurmountable language barrier at the time initial evaluation was also considered in this category.

We defined "intoxication" as history of intoxication or recent ingestion provided by patient or observer, any positive alcohol level in blood or breath, urine toxicology screen positive for 9 categories of drugs, physical evidence suggesting intoxication (odor of alcohol, slurred speech, ataxia, dysmetria or other cerebellar findings), or behavior consistent with intoxication and unexplained by medical or psychiatric illness.

CT was performed predominately with a Siemens 256-slice scanner immediately adjacent to the ED. Sagittal reconstructions were done using the same data acquired for CCT and did not involve additional radiation or scan time. Post-processing time was approximately 3 minutes.

Outcome Determination

We used official reports by board-certified radiologists, blind to subject enrollment, to determine the presence or absence of acute TS injury, including vertebral body, spinous or transverse process fractures. We included TS injury identified on CT of the chest, abdomen, or CS, even if sagittal reconstructions of the TS were not done.

Regarding clinical significance of identified TS injuries, we defined major clinical significance as patients who received surgical stabilization, minor clinical significance as those who received inpatient pain management, inpatient observation >24 hours, or were treated as an outpatient with a TLSO (thoraco-lumbar-spine orthotic) brace. Injuries of no clinical importance received none of these interventions.

Per the recommendations of Worster and Bledsoe,[13] we conformed to methods of retrospective chart reviews in 10 of 12 areas: our abstractors were trained before data collection, inclusion and exclusion criteria were defined, and categorization of injury and clinical significance were determined in advance. We used standard data abstraction forms, monitored research abstractors for accuracy by double checking data entry for each patient, the clinical predictors underwent inter-observer reliability testing, and we described our convenience sampling method. Regarding missing data, we excluded such patients and did not use data imputation, and the study was institutional review board (IRB) approved. However, we did not blind the data abstractors to the study hypothesis, nor did we perform inter-observer reliability testing between them.

We de-identified and recorded data in a manner that precluded individual patient identification. IRB approval with a waiver of informed consent was obtained.

Statistical Analysis

We managed study data using Research Electronic Data Capture (RedCAP) tools hosted by the blinded for review. We performed statistical tests using STATA version 12.1 (StataCorp, College Station, TX). We summarized and reported demographic data in aggregate form and calculated screening performance characteristics (sensitivity, specificity, positive predictive value, negative predictive value, and positive and negative likelihood ratios) using standard formulae.

RESULTS

We studied 1,798 total blunt trauma patients with demographics, mechanism of injury, and intoxication status shown in Table 1. Of these, 1,174 (65.3%) had CCT and 46 (2.6%) had a dedicated TS CT without CCT. These 2 CT modalities identified 58 TS injuries in 1,220 total imaged patients (4.8%). Of the 1,174 who had CCT, 465 (39.6%) had TS sagittal reconstructions, and 709 did not. Of all 511 patients who had one or the other form of TS CT, 465 had a

Table 2. Thoracic spine tenderness as a predictive factor among patients with normal mental status (n=1032)

Computed tomography for spinal fracture	Thoracic spine tenderness	
	Yes	No
Positive	18	17
Negative	153	844
Total	171	861

Table 3. Altered mental status as a predictive factor for T spine injury. (n=1220).

Computed tomography for spinal fracture	Altered mental status	
	Yes	No
Positive	23	35
Negative	165	997
Total	188	1032

Table 4. Distracting painful injury as a predictive factor for T spine injury. (n=1220).

Computed tomography for spinal fracture	Distracting painful injury	
	Yes	No
Positive	38	20
Negative	398	764
Total	436	784

Table 5. Performance of the proposed decision instrument incorporating all 3 predictive factors (T spine tenderness, altered mental status, and distracting painful injury) to identify T spine injury, (n=1220).

Computed tomography for spinal fracture	Decision instrument	
	Yes	No
Positive	56	2
Negative	592	570
Total	648	572

CCT from which TS sagittal images were reconstructed, and 46 had a dedicated TS CT without chest CT.

The performance of the 3 components of the DI was as follows: For 1,032 patients with normal mental status, 18 had TS tenderness among 35 injuries, for sensitivity of 51.4%, specificity 84.7%, positive and negative predictive values (PPV, NPV) of 10.5% and 98.0%, respectively. Positive likelihood ratio (+LR) was 3.35, while negative (-LR) was 0.57 (Table 2).

Among the 58 TS injuries, 23 had AMS for sensitivity of 39.7% with other test characteristics of 85.8%, 12.2%, 96.6%, with +LR 2.79 and -LR 0.70 (Table 3).

Thirty-eight of 58 patients had DPI for sensitivity of 65.5% with other test characteristics of 65.7%, 8.7%, and 97.4%, with +LR 1.91 and -LR 0.52. (Table 4).

Combining all 3 predictor variables into a proposed DI captured 56/58 injuries for test characteristics of sensitivity of 96.6% (95% CI 88.1-99.6%), specificity 49.1% (46.1-52.0%), PPV 8.6% (6.6-11.1%) and NPV 99.7% (CI 98.7-100%), with +LR 1.90 (1.76-2.04) and -LR 0.07 (0.02-0.28) (Table 5).

The DI, if validated, relies on all 3 predictive factors being absent to potentially forego TS imaging. Conversely, if any of the 3 predictive factors are present, then TS imaging would be indicated.

Such a DI, if validated, would exclude 572/1,220 CCT patients from additional TS imaging (46.9%, CI 44.1-49.7%) and 141/511 (27.6%, CI 23.8-31.7%) patients who actually had specific TS imaging in our cohort. Technical charge for each TS sagittal reconstruction at our center was $3,070, and professional charge for radiologist interpretation was $242, for combined charge of $3,312 per study. Medicare reimbursement at our center for sagittal reconstructions of TS CT is $280 per study (professional $53 plus facilities $227). If validated in an external cohort, the proposed DI would therefore save $39,000 –$160,000 in TS imaging reimbursement.

We found 58 total TS injuries, 41 of which were diagnosed on the 53 patients who had CCT (12 false negative, sensitivity 77.4%), while 17 were diagnosed by other CTs (6 on TS alone, 5 on CS alone, 5 on both TS + abdominal CT, and 1 on abdominal CT alone). Five of 58 (8.6%) had no dedicated TS CT performed (TS injury found on other CT).

Two patients with TS injuries failed to be identified by our proposed DI. The first was a 52-year-old man who fell from 20 feet from a ladder onto his buttock and complained of low back pain. He was alert, not intoxicated, and had no other injury than a T12 burst fracture identified. He had lumbar but not thoracic spine tenderness on exam. There was no retropulsion of bone into the spinal canal or neurological deficit. He was fitted with a TLSO back brace and did not require surgery. He was therefore categorized as minor clinical significance.

The second patient with TS injury missed by the proposed DI was a 51-year-old helmeted non-intoxicated and alert man riding a motorcycle that collided with a bicycle. He complained of forehead pain with a 3 x 3 cm hematoma and a 3 cm lip laceration. He had no CS or TS tenderness. The radiologist identified a "subtle non-displaced" T1 transverse process fracture which was thought inconsequential by the spine consultant. He was therefore categorized as no clinical significance.

There were 11 TS injuries identified on sagittal reconstruction CT that were not reported on the patient's CCT. Two were categorized as major (underwent spine surgery), 5 were minor (pain control and inpatient observation), and 6 were not clinically important. Hence, 2/11 (18%) TS injuries identified only on dedicated sagittal reconstruction CT were of obvious import, while 45% needed pain control. Of the entire cohort, 2/58 (3.5%) TS injuries were major and identified only on dedicated imaging. This proportion was 2/46 (4.3%) using the denominator of dedicated TS CT without CCT, 2/1220 (0.2%) for any chest or spine imaging, and 2/1798 (0.1%) for all patients enrolled.

DISCUSSION

Gross[11] in 2008 found a 6.6% false negative rate for chest and abdominal CT in identifying T and LS spine injuries and questioned their clinical import. Similarly, our study found that 11/58, or 19.0% of our TS injuries were found only on dedicated spine CT (6 on TS and 5 on CS CT), but 7 of these 11 had some clinical import (2 major, 5 minor). Therefore, 7/58 injuries of some importance (12.1%) required dedicated spine imaging for identification, higher than the previous study. However, only 2/58 required surgery.

It appears as if the cost of these dedicated sagittal reconstructions of spine CT is increasing. While Gross quoted $2,450 incremental cost for the reconstruction in 2008,[11] our center charged $3,070 in 2013. Although these are different centers, this amounts to a 25% increase in 5 years. With the advent of the Affordable Care Act in 2014, pressure on prices and their connection to quality care are coming under more intense scrutiny.[11]

Inaba et al[9] opined in 2011 that a combination of both clinical examination and CT screening based on mechanism will likely be required to ensure adequate sensitivity with an acceptable specificity for the diagnosis of clinically significant injuries of the thoracic-lumbar (TL) spine. However, our data suggests that clinical criteria alone may be reliable to identify TS injuries if our DI is subsequently validated.

Finally, the prevalence of TS injuries in our cohort was small (58/1,798, 3.2%) if we assume that patients who did not have CCT or dedicated TS imaging indeed had no injury. Therefore, the NPV without this proposed DI would be 96.8% (1740 true negatives/1,798 total subjects). If this DI is shown to be valid, the NPV would increase to 99.7% (570 true negatives/572 patients who had a positive DI, which missed 2 injuries). This suggests that chest and TS imaging to identify a low prevalence of TS injury may not be cost-effective. In our cohort, we performed dedicated TS CT on 1,220 patients at a charge of $3,312 per patient and found 56/58 injuries. That equates to $72,154 in charges per identified TS injury. With increasing pressure to control healthcare costs, this may not be justified or sustainable.

LIMITATIONS

This study reports patients from a single site and cohort of physicians. Though the sample of patients enrolled is moderate, the identified injuries are small. We used convenience sampling and some subjective adjudication of injury severity.

We used predictive factors, which were a subset of a larger group of predictors of chest injury in general. If we had set out to develop a specific TS injury DI, we might have considered other mechanistic factors that would predict injury, including lateral impact on driver's side, ejected from vehicle, lap belt without shoulder belt, or head-on collision. Since there are no further clinical predictors (only mechanistic ones), it is reasonable to use this study as a derivation set to be externally validated. Had TS injury been the singular focus of this study, other factors may have been found to be important. Therefore, if validation of the DI fails, then other predictive factors may need to be considered.

We did not CT all patients we enrolled, which opens the possibility of further missed injuries, reducing the sensitivity of the DI. However, the prevalence of chest plus TS CT in this trauma center was 68%, the highest of 5 trauma centers enrolling patients for the overall chest CT DI. Therefore, it is less likely that we would have missed a significant number of TS injuries with this liberal CT culture, by not imaging all patients.

We did not enroll patients on the night shift, where intoxication may be more prevalent. However, since one of our predictive criteria was altered mental status, the predictive value of this factor should remain constant. Had we enrolled patients 24 hours per day, this likely would have increased our sample size of T spine injuries.

Since our study included patients with T spine injuries on either CCT or dedicated T spine reconstructions, but many patients did not have the latter, it is possible that we missed some T spine injuries. This may reduce the sensitivity and predictive value of our proposed DI.

CONCLUSION

Sagittal reconstructions of TS from CCT imaging are of low yield and generate significant charges. Patients are highly unlikely to have TS injury if they are alert, without TS tenderness or DPI (-LR 0.07, 95% CI upper limit 0.28, NPV 99.7% 95% CI lower limit 98.7%). Excluding them from such reconstructive imaging may save considerable charges and payments.

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Comparison of Three Prehospital Cervical Spine Protocols for Missed Injuries

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Introduction: We wanted to compare 3 existing emergency medical services (EMS) immobilization protocols: the Prehospital Trauma Life Support (PHTLS, mechanism-based); the Domeier protocol (parallels the National Emergency X-Radiography Utilization Study [NEXUS] criteria); and the Hankins' criteria (immobilization for patients <12 or >65 years, those with altered consciousness, focal neurologic deficit, distracting injury, or midline or paraspinal tenderness).To determine the proportion of patients who would require cervical immobilization per protocol and the number of missed cervical spine injuries, had each protocol been followed with 100% compliance.

Methods: This was a cross-sectional study of patients ≥18 years transported by EMS post-traumatic mechanism to an inner city emergency department. Demographic and clinical/historical data obtained by physicians were recorded prior to radiologic imaging. Medical record review ascertained cervical spine injuries. Both physicians and EMS were blinded to the objective of the study.

Results: Of 498 participants, 58% were male and mean age was 48 years. The following participants would have required cervical spine immobilization based on the respective protocol: PHTLS, 95.4% (95% CI: 93.1-96.9%); Domeier, 68.7% (95% CI: 64.5-72.6%); Hankins, 81.5% (95% CI: 77.9-84.7%). There were 18 cervical spine injuries: 12 vertebral fractures, 2 subluxations/dislocations and 4 spinal cord injuries. Compliance with each of the 3 protocols would have led to appropriate cervical spine immobilization of all injured patients. In practice, 2 injuries were missed when the PHTLS criteria were mis-applied.

Conclusion: Although physician-determined presence of cervical spine immobilization criteria cannot be generalized to the findings obtained by EMS personnel, our findings suggest that the mechanism-based PHTLS criteria may result in unnecessary cervical spine immobilization without apparent benefit to injured patients. PHTLS criteria may also be more difficult to implement due to the subjective interpretation of the severity of the mechanism, leading to non-compliance and missed injury. [West J Emerg Med. 2014;15(4):471–479.]

INTRODUCTION

Cervical spine injury occurs in 2-6% of all blunt trauma cases, with higher rates in patients with severe closed head injury.[1-7] Even though the incidence of these injuries is low, the morbidity and mortality associated with them can be devastating; and without appropriate immobilization, 10- 25% of all patients with spine injuries will deteriorate.[8] Consequently, traditional emergency medical services (EMS) practice is to assume a potential cervical

spine injury in any trauma patient with an appropriate *mechanism of injury*.[9,10] Because a concern during the initial management of patients with potential cervical spine injuries is that neurological function may be further impaired by pathological motion of the injured vertebrae, full spinal immobilization of these patients consists of a cervical collar, a rigid fiberglass or plastic backboard, and stabilization of the head.[11]

Recently, mechanism-based immobilization practices have come under question since the immobilization process can lead to morbidity. Extrication and transfer of patients from the scene is prolonged, and immobilization itself can cause pain, respiratory compromise and decreased capillary blood flow to sacral and occipital soft tissue.[12-18] Thus, the goal of current EMS cervical spine immobilization protocols is to appropriately immobilize patients at high risk of cervical spine injury while avoiding immobilization in those who are at low risk. Several protocols currently exist for EMS providers, a common one being the conventional, mechanism-based Prehospital Trauma Life Support (PHTLS) protocol. The PHTLS program was developed by the National Association of Emergency Medical Technicians in cooperation with the American College of Surgeons Committee on Trauma to promote a national standard for prehospital trauma care.[19] Although the PHTLS protocol has been used since 1979, it does require immobilization for a large proportion of trauma patients, given that it is mechanism-based, as opposed to signs and symptoms based.

Due to concerns about excessive immobilization requirements via the PHTLS protocol by our EMS providers and inconsistent immobilization of trauma patients post-EMS transfer to our emergency department (ED), we set out to systematically investigate our local EMS practices. We focused on trauma patients presented to the ED only, and not to the trauma service, as the latter patients were uniformly immobilized by prehospital providers. We compared 3 EMS immobilization protocols -- the PHTLS (focuses on mechanism of injury); the Domeier protocol (parallels the National Emergency X-Radiography Utilization Study [NEXUS] criteria); and the refined Hankins clinical criteria (requires immobilization for those <12 or >65 years, with altered consciousness, focal neurologic deficit, distracting injury, and midline or paraspinal tenderness) -- to local EMS practices, to determine the number of patients who would require cervical immobilization.[19-22] Our secondary objective was to determine the percentage of missed cervical spine injuries, had each protocol been followed with 100% compliance.

MATERIALS AND METHODS

Design

This was a cross-sectional study of local EMS practices in cervical spine immobilization in trauma patients. All trauma patients transported to the ED by EMS were prospectively screened for inclusion by trained research assistants who completed a standardized data form on all eligible patients. The form included all the variables from 3 cervical spine immobilization protocols: the PHTLS (currently in use by EMS agencies working under our medical direction), the Domeier and the Hankins protocols.[19-22] Data forms were completed by the treating physicians, who were blinded to the objective of this investigation. Our primary objective was to determine the proportion of patients who required cervical spine immobilization, based on each protocol's criteria. Our secondary objective was to determine the percentage of missed cervical spine injuries, had each protocol been followed with 100% compliance. Our institutional review board (IRB)did not require written informed consent, as no interventions were undertaken and all data forms were recoded immediately after medical record review with a unique patient identifier instead of patient names. This study was approved by our IRB, which waived the requirement for written informed consent.

Setting

The study was conducted from March to November 2010 at an urban, Level 1 trauma center with an annual ED census of 62,000 visits during the study period. Cooper University Hospital has a 2-tiered EMS system providing basic and advanced life support services. There is no standardized statewide list of criteria mandating prehospital immobilization; immobilization practices are determined by the individual EMS agencies and their medical directors.

Patients

During the study period, trained research associated assessed all patients transported to the ED by EMS for a traumatic mechanism of injury. Patients were included in this cohort if they were 18 years or older and experienced a blunt trauma that was not isolated to an extremity (e.g. crush injury to the forearm or isolated ankle sprain would be excluded). Patients that met our internal Trauma Alert activation criteria (Appendix) were immediately evaluated by the Trauma Team and were excluded from the study. We excluded these patients because insufficient immobilization of these referred patients was not a concern. All patients deemed to require a trauma evaluation were automatically placed in immobilization by the prehospital providers, so noncompliance with the PHTLS protocol did not occur. Instead, we wished to assess compliance with cervical spine immobilization criteria in a more varied population where compliance was already a concern, namely patients who presented to the ED. ED patients were screened from 9 AM – 10 PM, which corresponded to our peak ED volume periods. Enrollment occurred 7 days a week.

Protocol

Upon arrival to the ED, patients were screened and enrolled by research assistants who obtained demographic information and recorded who (EMS versus ED personnel) placed the

cervical collar. Data was prospectively collected using a standardized data collection form. Demographic data, including patient age, sex, and mechanism of injury, was obtained from EMS personnel or from the patient by the trained research assistants. Additional data regarding mechanism of injury, presence of intoxication, level of consciousness and physical examination findings, reflecting variables in the PHTLS, Domeier and Hankins cervical spine immobilization criteria, was also collected.[19-22] This data collection was completed by the treating physicians who were blinded to the objectives of this investigation and was recorded shortly after the history and physical examination and prior to radiologic imaging.

Medical record review was completed by one of the investigators who was blinded to the clinical characteristics (presence/absence of cervical spine immobilization and presenting signs and symptoms) of enrolled patients. The investigator reviewed medical records for results of radiographic imaging, including cervical spine series, computed tomography and magnetic resonance imaging. Completion of radiographic imaging was solely at the discretion of the treating physician. All radiographic studies were interpreted by radiologists who did not have access to our data. However, complete blinding of radiologists was not possible, due to clinical interaction between treating physicians and radiology staff. The presence or absence of cervical spine injuries was based on the final interpretation of all imaging studies. Cervical spine injuries were categorized as vertebral fractures, subluxations/dislocations and spinal cord injuries. Clinically important cervical spine injury was defined as any fracture, dislocation, or ligamentous instability requiring internal fixation or treatment with a halo, brace, or rigid collar.

Outcomes

The primary outcome measure was to determine the proportion of patients who would require cervical immobilization based on each protocol. The secondary outcome measure was to determine the number of missed cervical spine injuries given 100% compliance, which may validate the use of these protocols in the prehospital setting based on the number of missed injuries and number of unnecessary cervical immobilizations without any benefit to injured patients.

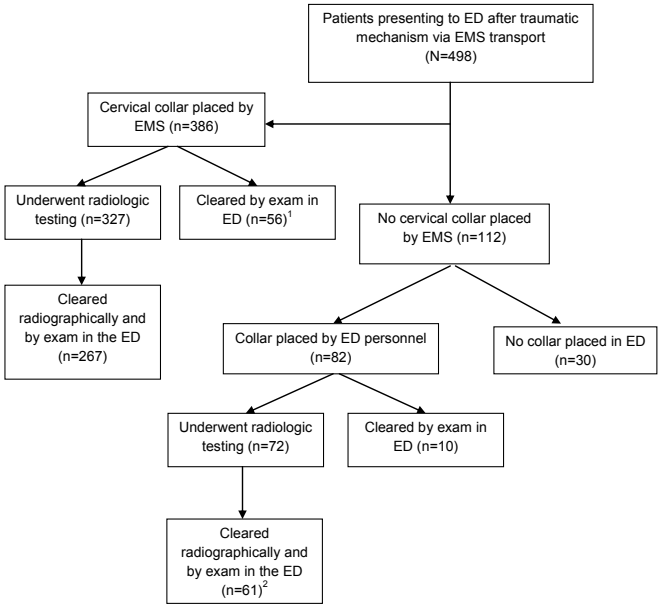
Data Analysis

We reported measurements using descriptive statistics, with means and standard deviations (SD) presented for continuous variables that were normally distributed. For nonparametric data, medians and interquartile ranges (IQR) are presented. We calculated the proportion of patients who required cervical spine immobilization, based on each protocol's criteria. These proportions are presented with 95% confidence intervals (95% CI). The percentage of missed cervical spine injuries, had each protocol been followed with 100% compliance, is also presented. We conducted the analysis using SPSS 15.0 (SPSS Inc, Chicago, IL). Sample size was determined using a baseline estimate of 70% compliance with immobilization protocols. To achieve a 95% CI within 10%, 400 subjects were needed. Additionally, we wished to enroll enough subjects to achieve at least 10 cervical spine injuries. Based on prior studies, where cervical spine injury rates were between 2-4%, we needed a minimum of 500 subjects to achieve this goal. Thus, we endeavored to enroll 500 subjects.

RESULTS

During the study period, 5,158 patients were transported to the ED by EMS. Of these, 1,340 experienced a blunt traumatic mechanism, with 371 patients with trauma isolated to a distal extremity, 259 patients <18 years of age and 189 patients evaluated only by the trauma team. This resulted in 521 eligible patients, of whom 498 were enrolled and 23 were missed, due to an enrollment attempt after radiologic imaging had been viewed by the treating physician. The majority (78%) of patients underwent cervical spine immobilization by EMS. The mean age of patients was 47.8 (19.5) years, over half of patients were male, and 85% had a complaint of pain. Median pain score was 7.0 (IQR: 4.0, 9.0) and median Glasgow coma scale score was 15 (IQR: 15, 15). Clinical and radiologic clearance of these patients, as well as the initiation of cervical spine immobilization of EMS patients by ED personnel, is outlined in the Figure.

We present criteria used for the PHTLS protocol and compliance with these criteria in Table 1. The majority of



[1]Three Patients removed their cervical collars against medical advice.
[2]One patient removed cervical collar against medical advice.
Figure. Immobilization practices of emergency medical services (EMS) and emergency department (ED) personnel.

Table 1. Implementation of Current Prehospital Trauma Life Support (PHTLS) Criteria.

PHTLS Immobilization Criteria	Criteria noted by treating physician (N=498)	C spine collar placed by EMS	Total compliance by EMS and ED (N=498)
	n (%)	n (compliance%)	n (compliance%)
Anatomic deformity of spine	2 (<1)	2/2 (100)	2 (100)
Inability to communicate	40 (8.0)	26/40 (65.0)	38 (95)
Mechanism produced violent impact to head	292 (58.6)	221/292 (75.7)	281 (96.2)
Mechanism produced violent impact to neck	223 (44.8)	186/223 (83.4)	220 (98.7)
Mechanism produced violent impact to torso	153 (30.7)	132/153 (86.3)	151 (98.7)
Mechanism produced violent impact to pelvis	123 (24.7)	107/123 (87.0)	119 (96.8)
Patient sustained a fall	193 (38.8)	130/193 (67.4)	175 (90.7)
Patient ejected or fall from motorized vehicle	38 (7.6)	31/38 (81.5)	37 (97.4)
Victim of shallow water diving accident	2 (<1)	1/2 (50)	1 (50)
Sudden acceleration, deceleration or lateral bending forces	253 (50.8)	214/253 (84.6)	245 (96.8)
At least one PHTLS criteria present	475 (95.4)	367/475 (77.3)	447 (94.1)

EMS, emergency medical services; *ED,* emergency department; *C spine*, cervical spine

Table 2. Implementation of Domeier Criteria.

Domeier Criteria	Criteria noted by treating physician (N=498)	C spine collar placed by EMS	Total compliance by EMS and ED (N=498)
	n (%)	n (compliance%)	n (compliance%)
Focal neurologic deficit present	16 (3.2)	14/16 (87.5)	15 (93.8)
Midline spinal tenderness present	152 (30.5)	128/152 (84.2)	152 (100)
Altered level of consciousness	98 (19.7)	71/98 (72.5)	97 (99.0)
Intoxicated	81 (16.3)	56/81 (69.1)	80 (98.8)
Distracting injury present	149 (29.9)	123/149 (82.6)	141 (94.6)
At least one Domeier criteria present	342 (68.7)	273/342 (79.8)	333 (97.4)

EMS, emergency medical services; *ED,* emergency department; *C spine*, cervical spine

Table 3. Implementation of Refined Hankins Clinical Criteria.

Hankins Criteria	Criteria noted by treating physician (N=498)	C spine collar placed by EMS	Total compliance by EMS and ED (N=498)
	n (%)	n (compliance%)	n (compliance%)
Extremes of age:<12 or >65 years*	94 (18.9)	70/94 (74.5)	89 (94.7)
Altered level of consciousness	98 (19.7)	71/98 (72.5)	97 (99.0)
Focal neurologic deficit present	16 (3.2)	14/16 (87.5)	15 (93.8)
Distracting injury present	149 (29.9)	123/149 (82.6)	141 (94.6)
Midline spinal/paraspinal tenderness present	292 (58.6)	242/292 (82.9)	289 (99.0)
At least one Hankins criteria present	406 (81.5)	324/406 (79.8)	392 (96.6)

* Only >65 years was used for this investigation, as all enrolled patients were 18 years or older
EMS, emergency medical services; *ED,* emergency department; *C spine*, cervical spine

Table 4. Use of cervical immobilization in patients based on Current Prehospital Trauma Life Support (PHTLS) immobilization criteria.

Number of criteria present/positive	Cervical collar not placed by EMS	Cervical Collar placed by EMS	Total
No current criteria present/positive	4 (17%)	19 (83%)	23 (100%)
At least one PHTLS criteria present/positive	108 (23%)	367 (77%)	475 (100%)
Total	112	386	498

EMS, emergency medical services

patients experienced sudden acceleration, deceleration or lateral bending forces, a fall, or a violent impact to the head or neck. At least one PHTLS criterion was noted in 95.4% of patients by the treating physician. Tables 2 and 3 present the Domeier and refined Hankins criteria, respectively. Treating physicians noted at least one Domeier criterion in 68.7% of patients and at least one Hankins criterion in 81.5% of patients.

Tables 4-6 demonstrate the compliance with the PHTLS, Domeier and Hankins cervical spine immobilization protocols, respectively. The following proportions of patients would have required cervical spine immobilization based on the respective protocols: PHTLS, 95.4% (95% CI: 93.1-96.9%); Domeier, 68.7% (95% CI: 64.5-72.6%); Hankins, 81.5% (95% CI: 77.9-84.7%).

Even though the current PHTLS criteria required the largest proportion of patients to undergo cervical spine immobilization, the actual compliance rates with the PHTLS protocol did not differ from the compliance with the other 2 non-implemented protocols: PHTLS 77.3% (95% CI:73.3-80.8%); Domeier, 79.8% (95% CI:75.2-83.8%); Hankins, 79.8% (95% CI:75.6-83.4%).

Cervical spine injuries were determined via medical record review of radiologic imaging. Of the 386 patients who underwent cervical spine immobilization by EMS, 327 underwent radiologic imaging. Of these, there were 11 vertebral fractures, 2 subluxation/dislocation injuries and 3 spinal cord injuries. Two patients had multiple injuries in this group, and all sustained a clinically important cervical spine injury, defined as any fracture, dislocation, or ligamentous instability requiring internal fixation or treatment with a halo, brace, or rigid collar. In the additional 82 patients who had a cervical collar placed in the ED, 72 of them underwent radiologic imaging. There was one vertebral fracture and one spinal cord injury in this subgroup. Both of these injuries were clinically important, as defined above. If the PHTLS cervical spine immobilization criteria had been followed by all EMS personnel and every patient with at least one positive finding had been immobilized, all 16 patients with injuries would have been immobilized appropriately 0% (95% CI: 0-23%). Complete compliance with either the Domeier or the Hankins protocols would also have resulted in appropriate cervical spine immobilization of all 16 injured patients.

DISCUSSION

In this investigation, we attempted to demonstrate the rate and appropriateness of prehospital immobilization based on the protocols and missed injuries, as well as EMS consistency with 3 cervical spine immobilization protocols using the treating physicians' assessments of patients' signs and symptoms as the gold standard for cervical spine immobilization at ED presentation. We chose these particular protocols as they have been implemented by many EMS agencies, though they may not be used for the EMS agencies transporting patients to our ED. Using these parameters, we demonstrated that EMS consistency with the current PHTLS protocol is 77%. Had all patients been appropriately immobilized based on at least one positive PHTLS criterion, 475 (95.4%) of enrolled patients would

Table 5. Use of cervical immobilization in patients based on Domeier immobilization criteria.

Number of criteria present/positive	Cervical collar not placed by EMS	Cervical Collar placed by EMS	Total
No current criteria present/positive	44 (28%)	113 (72%)	157 (100%)
At least one Domeier criteria present/positive	68 (20%)	273 (80%)	341 (100%)
Total	112	386	498

EMS, emergency medical services

Table 6. Use of cervical immobilization in patients based on Refined Hankins immobilization criteria.

Number of criteria present/positive	Cervical collar not placed by EMS	Cervical Collar placed by EMS	Total
No current criteria present/positive	30 (33%)	62 (67%)	92 (100%)
At least one Hankins criteria present/positive	82 (20%)	324 (80%)	406 (100%)
Total	112	386	498

EMS, emergency medical services

have required cervical spine immobilization. Factors with the lowest level of consistency included shallow water diving accident (50%), inability to communicate (65%) and fall (67%). In comparison, the percentage of patients requiring immobilization was only 69% using the Domeier criteria and 82% using the Hankins criteria. For the Domeier criteria, the lowest levels of compliance were in patients who were intoxicated (69%) and those who had an altered level of consciousness (73%). For the Hankins protocol, the lowest levels of compliance were in patients at extremes of age (75%) and, again, those with an altered level of consciousness (73%). These latter findings are not surprising, since the criteria in the Domeier and Hankins protocols with the lowest levels of compliance were solely based on clinical findings and not mechanism of injury.

The original standards for prehospital transport supported spine immobilization for patients with symptoms possibly stemming from spine injury.[23] The practice of prehospital immobilization shifted from clinical indicators toward mechanism of injury due to significant failures in EDs to correctly identify patients at risk of spinal injury.[24] This led to routine immobilization and imaging practices of trauma patients, which continued well into the early 1990s. As recently as 1989, 96% of the 125 North American hospitals with experience in acute trauma routinely obtained cervical radiographs as a protocol study on all patients who suffered major trauma.[25] This comprehensive inclusion of trauma patients for cervical spine imaging is also reflected in the mechanism-based PHTLS cervical spine immobilization protocol, where, in our study sample, 95% of our patients should have been immobilized. Mirvis et al. questioned this practice and suggested that asymptomatic, neurologically intact patients may not need further imaging. In a sample of 408 patients with a history of major blunt trauma, 138 were mentally alert patients without symptoms referable to cervical spine injury. The investigators demonstrated the very low yield of imaging a non-displaced transverse process fracture of C7. Yet the combined cost of computed tomography and radiography per patient was $427, with total costs over $59,000.[25]

Others also questioned the utility of cervical spine radiography in alert, non-intoxicated and asymptomatic trauma patients and continued to demonstrate low yields of clinically relevant injuries while imaging costs escalated.[26-28] The NEXUS criteria and the Canadian C-Spine Rule are the culmination of these earlier investigations. The NEXUS low-risk criteria consists of clinical criteria that identify trauma patients with a very low probability of clinically significant cervical spine injury.[29] The Canadian C-Spine Rule includes both clinical indicators and mechanism of injury to assess need for radiography.[30] While both of these criteria are solely intended for the determination of the need for cervical spine imaging, they have also been used to develop prehospital cervical spine immobilization protocols, such as the Hankins and especially the Domeier protocols.

The impetus for using cervical spine immobilization protocols based on clinical criteria is to reduce the frequency of unnecessary immobilization. Our results demonstrate that the requirement for cervical spine immobilization in our patient population was less using the Domeier (68.7%) and Hankins (81.5%) protocols, as compared to the PHTLS protocol (95.4%). This is particularly noteworthy since we also demonstrated that complete compliance with any of the 3 protocols would have resulted in appropriate immobilization of all 16 patients who had cervical spine and cord injuries. Why should the reduction of unnecessary immobilization in trauma patients be a priority for healthcare providers? Appropriate and effective immobilization requires time for proper patient positioning and application of immobilization devices, which extends EMS field time and delays transport to definitive care.[22, 31-33] The immobilization process may also cause discomfort to patients. Pain caused by the initial

trauma may be exacerbated by immobilization devices or they may lead to new pain reports in previously asymptomatic patients.[22,31,34,35] If physicians are unable to differentiate the source of the presenting pain (trauma versus immobilization), this may lead to unnecessary radiographic studies, prolong the ED evaluation and further decrease overall ED throughput.[12,31,36,37] Other complications due to supine immobilization include airway and respiratory compromise, increased risk of aspiration, sacral and occipital soft tissue damage, and skin ulcer formation.[15-18,35,38,39] A move away from mechanism-based protocols and greater reliance on clinical indicators, as found in the Domeier and Hankins protocols, may also benefit the EMS system. Decreased use of immobilization equipment will result in reduced costs for disposable items, such as cervical collars, and replacement equipment for reusable items.[31,37] Also, because EMS providers are at risk from injuries due to repeated lifting of immobilized patients, reducing this risk will support existing workforces and lessen financial compensation for work-related injuries.[39] Finally, decreased run times from limiting unnecessary immobilization will lead to faster transport times and increased availability of EMS personnel for new calls.[22,31-33]

LIMITATIONS

There are several limitations to this investigation. First, this was a convenience sample of patients who were transported to our ED during the hours of 9 AM-10 PM. We likely missed patients who arrived during the overnight hours. However, given that our institution is the only Level 1 trauma center in the southern New Jersey area, we think that our sample is representative of our ED trauma patients. What this sample may not adequately represent is EMS immobilization practices of night shift personnel, which may change based on a different presenting population (e.g., greater proportion of intoxicated patients). A second limitation is that this study was only conducted at one center and we excluded patients who were immediately cared for by the trauma service. Thus, our findings may not be representative of other EMS systems or patient populations. This single-center study design was intentional because our secondary intent was to examine our EMS responders' compliance with the current cervical spine immobilization protocol in trauma patients presenting to the ED. Our exclusion of patients presenting to the trauma service was intentional, as these patients are always immobilized. A third limitation is that the criteria for cervical spine immobilization were completed by the treating physician, which may have been biased. EMS personnel who are able to witness the motor vehicle collision or who are involved in the extrication of a patient may have had more information about the mechanism of injury than the treating physicians had. This bias, however, would likely have led to an *under-reporting* of criteria by the treating physicians, leading to an *underestimate* of the number of patients who should have undergone cervical spine immobilization. Alternatively, treating physicians could have obtained information about the injury from multiple sources, including the patient, EMS and witnesses at the scene. It is possible that over the course of medical evaluation and management in the ED, treating physicians may have obtained *more information*, leading to the reporting of a *greater number* of cervical spine immobilization criteria as compared to what was obtained by EMS personnel. This would have led to a higher estimate of patients who should have undergone cervical spine immobilization. We attempted to limit this effect by having our research assistants approach the treating physicians immediately after the initial patient encounter. To better address these discrepancies, future studies should have both EMS personnel and the treating physicians complete the immobilization criteria for each patient. If there are discrepancies between the two, particularly if EMS notes fewer criteria than the treating physicians, then further investigation should be undertaken to determine if the criteria are being accurately recorded or if on-scene time constraints and limited history-taking may be at fault. At this time, the available literature suggests that the agreement between EMS and emergency physician assessments for individual immobilization criteria (paralleling the Domeier and NEXUS criteria) ranges from good (K=0.81) to poor (K=0.35).[9] However, when final immobilization determinations were made, EMS performed well. In only 7.7% of assessments, the emergency physician assessment indicated immobilization when the EMS did not.[9] This value is almost half of our best performance with our 3 protocols, suggesting that there is a great deal of room for improvement at our institution. Finally, not every patient who had positive criteria for the current PHTLS protocol or the Domeier or Hankins protocols underwent imaging. Thus, we do not know the true rate of cervical spine injury. However, in patients who did undergo imaging, our overall incidence of cervical spinal and cord injury was 4%, which is consistent with prior studies.[1-7] Comparing the sensitivity of these decision rules was not our intent; our primary objective was to examine the compliance by EMS with its current cervical spine immobilization policy. For future investigations, a larger sample size from multiple sites should be implemented to increase the total number of cervical spinal injuries. This will further aid in determining the true sensitivity of these decision rules.

CONCLUSION

In summary, of the 3 protocols we investigated the mechanism-based PHTLS protocol required immobilization of the greatest percentage of patients. Yet compliance with the PHTLS protocol did not differ from compliance with the 2 other investigated protocols that were not implemented during this investigation. Although physician-determined presence of

cervical spine immobilization criteria cannot be generalized to the findings obtained by EMS personnel, our findings suggest that compliance with mechanism-based criteria may result in unnecessary cervical spine immobilization in trauma patients transported to the ED. Furthermore, due to inadequate compliance with the PHTLS protocol, 2 patients (12.5%) with clinically relevant injuries were missed. PHTLS criteria may be more difficult to implement due to the subjective interpretation of the severity of the mechanism, leading to non-compliance and missed injury. Further study is needed to determine if EMS compliance with protocols based on clinical indicators, such as the Domeier or the Hankins protocols, would be improved over current PHTLS compliance. Finally, a larger sample size will be needed to test the sensitivity of any replacement cervical spine immobilization protocol in correctly identifying patients at high risk of cervical spine and cord injuries.

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Successful Conviction of Intoxicated Drivers at a Level I Trauma Center

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Introduction: Conviction rates for drivers driving under the influence (DUI) and in motor vehicle collisions (MVC) presenting to trauma centers are based primarily on data from the 1990s. Our goal was to identify DUI conviction rates of intoxicated drivers in MVCs presenting to a trauma center and to identify factors associated with the failure to obtain a DUI conviction.

Methods: Retrospective study of adults (>18 years) presenting to a trauma center emergency department (ED) in 2007. Eligible subjects were drivers involved in a MVC with an ED blood alcohol level (BAL) ≥ 80mg/dL. Subjects were matched to their Department of Motor Vehicle (DMV) records to identify DUI convictions from the collision, the legal blood alcohol concentration (BAC), and arresting officer's impression of the driver's sobriety. We entered potential variables predictive of failure to obtain a DUI conviction into a regression model.

Results: The 241 included subjects had a mean age of 34.1 ± 12.8 years, and 185 (77%) were male. Successful DUI convictions occurred in 142/241 (58.9%, 95% CI 52.4, 65.2%) subjects. In a regression model, Injury Severity Score > 15 (odds ratio = 2.70 (95% CI 1.06, 6.85)) and a lower ED BAL from 80 to 200mg/dL (odds ratio = 5.03 (95% CI 1.69, 14.9) were independently associated with a failure to obtain a DUI conviction.

Conclusion: Slightly more than half of drivers who present to an ED after a MVC receive a DUI conviction. The most severely injured subjects and those with lower BALs are least likely to be convicted of a DUI. [West J Emerg Med. 2014;15(4):480–485.]

INTRODUCTION

Driving while under the influence (DUI) is illegal in all 50 states in the United States. Although DUI- related deaths have decreased, it remains a significant cause of preventable morbidity and mortality.[1] Thus, various efforts to further decrease the negative impacts resulting from intoxicated drivers continue.[2,3]

Evidence primarily from the 1990s indicated that a substantial proportion of intoxicated drivers involved in motor vehicle collisions (MVC) and transported to emergency departments (ED) were not successfully prosecuted.[4-15] In these 12 studies DUI charges ranged from 3 – 41%, and convictions among those charged ranged from 0 – 63%. Remarkably, 8 studies reported DUI conviction rates < 20%.[7,9-11,14,15] A prior study demonstrated a DUI conviction rate of only 4% for those hospitalized after a MVC, while statewide the DUI conviction rate was 85% of non-injured drivers cited for DUI during the same time period.[10] A Canadian study including data from 1995 to 2003 suggests a conviction rate of only 15% for injured, impaired drivers.[16] Thus, failure to

obtain a DUI conviction in hospitalized patients appears to primarily be an issue of law enforcement failing to provide a DUI citation. These studies clearly demonstrated the need for increased diligence among law enforcement and medical providers in identifying and prosecuting intoxicated drivers presenting to EDs after MVCs.

Prosecuting DUI offenders decreases the risk of future alcohol-related MVCs.[2,17,18] More specifically, ED patients presenting after MVCs while driving intoxicated are at risk for future DUIs.[7] Therefore, increasing the number of prosecutions of intoxicated drivers who were evaluated and treated in the ED potentially decreases future DUI-related morbidity and mortality.

Despite multiple prior studies identifying poor DUI conviction rates and a call to increase prosecution of intoxicated, injured drivers treated in EDs, no recent evidence exists that suggests successful prosecution rates have increased. It is unclear if the identification of this problem and the subsequent awareness to close this gap has resulted in increased rates of DUI prosecution in ED patients who were drivers in MVCs. The goals of this study are to identify more recent DUI conviction rates of intoxicated drivers in MVCs presenting to the ED for medical care and to identify factors associated with the failure to obtain a DUI conviction in these patients.

METHODS

Study Design

This was a retrospective study of adult subjects (>18 years of age) who presented to the study site ED from January 1, 2007 through December 31, 2007. The study was approved by the study site's institutional review board.

Setting

We conducted the study at an urban, university based, Level I trauma center. The hospital cares for more than 3,000 adult trauma admissions per year and provides Level I trauma services for a region of 6 million people covering 65,000 square miles.

Selection of Participants

Subject eligibility included those drivers over the age of 18 involved in MVCs and presenting to the participating ED for care and undergoing a trauma activation (appendix). Study period was January 1, 2007 – December 31, 2007. Subjects were considered drivers if coded as such by the treating physicians, either based on subject report or emergency medical services records. Blood alcohol levels (BAL) are obtained as part of the standard ED evaluation of trauma team-activated subjects. We included all eligible subjects with an initial ED BAL ≥ 80mg/dL in the study. Subjects were excluded if they died during their ED evaluation or subsequent hospitalization. We also excluded subjects if no BAL was obtained in the ED.

Data Collection and Processing

We reviewed the medical records to identify all drivers with BALs ≥ 80mg/dL. Clinical data collected included age, gender, date of MVC, Glasgow Coma Scale (GCS) score, ED intubation, death, hospital admission, and Injury Severity Score (ISS). If any of these data were missing from the trauma registry, we reviewed the electronic health record to gather the missing data. All clinical data were collected without abstractor knowledge of the outcome of interest. Subjects were then matched to their Department of Motor Vehicle (DMV) records to identify any convictions associated with the MVCs for the subject's index visit. This linkage occurred without the DMV knowledge of any clinical variables beyond name, date of birth and date of MVC. This search occurred at least 2 years after the ED visit to ensure more than enough time for adjudication through the legal system.[16] In addition, we also collected from the DMV records the evidential blood alcohol concentration (BAC) for the DUI citation or conviction, if it was obtained, along with the investigating officers' impressions of sobriety.

Outcome Measures

The outcome of interest was conviction for an intoxicated driving offense. This included convictions for any of the various state and federal DUI laws, most commonly, the following California Penal Code (PC) or Vehicle Code (VC) violation sections: PC § 191.5 (California gross vehicular manslaughter involving alcohol and/or drugs), PC § 192.3 or PC § 192.C3 (vehicular manslaughter with or without negligence involving alcohol and/or drugs), VC § 23103 as specified in VC § 23105.5 (California "Wet" or alcohol-involved reckless driving), VC § 23140 (youth driving with an alcohol concentration of 0.05% or more, by weight, of alcohol in his or her blood), VC § 23152 (driving under influence of alcohol, drugs, or both), and VC § 23153 (driving under influence of alcohol, drugs, or both causing bodily injury to another – a felony conviction). DUI convictions with a violation date associated with the date of ED visit following the MVC were considered successful alcohol-related prosecutions.

Data Analysis

We described data with simple descriptive statistics. Continuous data are presented as the mean ± one standard deviation. We created a multivariate logistic regression model to identify variables independently associated with no DUI conviction. Ten percent of charts were reviewed to confirm data quality. We measured data reliability using the kappa statistic. Finally, we performed a sensitivity analysis to assess the impact of subjects not identified in the DMV records. We conducted all statistical analysis with STATA for Windows, Rel. 10.0 2007 (STATA Corp College Station, TX, USA).

RESULTS

We identified 285 eligible subjects as being drivers in

Table 1. Characteristics of study patients (n=241) involved in motor vehicle collisions and with elevated blood alcohol levels.

			(95% CI)
Mean age	34.2 ± 12.7 years		
Male gender	185	77%	(71, 82%)
Initial Glasgow Coma Scale=15	179	74%	(68, 80%)
Hospital admission	133	55%	(49, 62%)
Emergency department intubation	26	12%	(8, 17%)
Injury severity score > 15	32	13%	(9, 18%)
Blood alcohol level 80-200 mg/dL	109	45%	(39, 52%)
Blood alcohol level 200-300 mg/dL	107	44%	(38, 51%)
Blood alcohol level >300 mg/dL	25	10%	(7, 15%)

MVCs and having an elevated BAL ≥ 80mg/dL. We excluded 44 (15%) subjects from further analysis due to the absence of a DMV match. The 241 subjects making up the study cohort had a mean age of 34.2 ± 12.7 years and 185 (77%) were male. The median ED BAL was 204 mg/dL (interquartile range 146, 258 mg/dL). Additional subject characteristics are in Table 1. During the study period (2007), the successful prosecution of drivers receiving a DUI-related citation in California was 79%.

Successful DUI-related convictions occurred in 142/241 (58.9%, 95% CI 52.4, 65.2%) study subjects. In these 142 subjects, the mean ED BAL (223mg/dL, range 80 – 490 mg/dL) was significantly higher than the law enforcement-obtained evidentiary blood alcohol concentration (BAC) levels (171mg/dL, range 40 – 360 mg/dL), difference in means 52mg/dL (95% CI 47, 57mg/dL), p<0.0001. In only 7 (5%, 95% CI 2, 10%) cases were subjects' ED BAL lower than the legal evidentiary BAC level. The ED BAL was more likely to be greater than 50mg/dL higher than the law enforcement BAC in those patients with an ISS > 15 (10/12, 83%, 95% CI 52, 98%) than those with an ISS < 15 (68/130, 52%, 95% CI 43, 61%).

The results of the multiple logistic model are presented in Table 2. The Hosmer-Lemeshow test demonstrated good fit of the model (p=0.87). Both ISS and lower ED blood alcohol levels were associated with failure to obtain a DUI conviction.

Investigating officer's sobriety impression was available for 205 (85%) subjects. In these 205 subjects with an ED BAL >80mg/dL, the arresting officer's impression as indicated on the DMV driver record was "Had-been-drinking (HBD) - ability impaired" 165 (80%, 95% CI 74, 86%), "HBD – ability not impaired" 8 (3.9%, 95% CI 1.7, 7.5%), "HBD- unknown impairment" 9 (4.4%, 95% CI 2.0, 8.1%), and "had-not-been-drinking" 23 (11%, 95% CI 7.2, 16%). Despite having a median ED BAL = 135mg/dL (interquartile range 115, 217mg/dL), none of the 23 subjects considered as "had-not-been-drinking" by the investigating officer received a DUI conviction. Seventeen (74%) of these had ED BALs < 200mg/dL. Only three (13%) of these 23 subjects were intubated, and 20 (87%) had GCS scores ≥ 14.

Table 2. Multivariate regression model to predict failure to obtain a driving under the influence conviction.

	Odds Ratio (95% CI)	p-value
Age	1.01 (0.99, 1.03)	0.31
Male gender	0.78 (0.41, 1.48)	0.44
Emergency department blood alcohol level 80-200	5.03 (1.69, 14.9)	0.004
Emergency department blood alcohol level 200-300	1.93 (0.64, 5.82)	0.24
Hospital admission	1.27 (0.71, 2.30)	0.42
Injury severity score > 15	2.70 (1.06, 6.85)	0.048

Forty-four (15%) subjects were unable to be matched to DMV records. The mean age of these subjects was 30.8 ± 12.5 years and 34 (85%) were male. Twelve (27%) were admitted and only two (5%) had an ISS > 15. We performed a sensitivity analysis, considering these patients to not be successfully prosecuted. Under this assumption, successful DUI-related convictions would have occurred in 142/285 (49.8%, 95% CI 43.9, 55.8%).

DISCUSSION

DUI remains a problem despite considerable effort to prevent these incidents. This study demonstrates a substantial increase in the successful prosecution of intoxicated drivers involved in MVCs and cared for in an ED from prior published data. The protection from DUI prosecution offered by ED care, however, still exists, and despite the increase from the abysmal rates in the 1990s considerable room for improvement still exists.

We suggest that a goal for successful prosecution rates of intoxicated drivers evaluated in the ED mirror successful DUI prosecution rates of those given citations within the state. In this study the convictions rate was 59%, far lower than the state conviction rate of 79% of those cited during the same time period.[19] We evaluated several variables for their independent association with failure to obtain a DUI prosecution. Determining such variables allows for identification of those cases most likely to not be successfully prosecuted and to develop strategies aimed at increasing prosecution rates in these subjects.

The most severely injured subjects (ISS >15) were less likely to obtain a DUI conviction. This is not surprising as the most injured patients require numerous diagnostic tests and procedures. These activities often remove patients from the ED and delay or prevent police access. Prior evidence supports the failure to obtain conviction rates in the most injured patients.[13,15] Sympathy for the significantly injured driver has also been conjectured as an explanation for low prosecution rates. This reason may have influenced law enforcement 20 years ago; however, in the current environment, it likely plays a very minimal role.[7]

We also identified subjects with lower ED BALs as being less likely to receive a DUI or DUI-related conviction. This likely reflects those subjects appearing least intoxicated or who were evaluated by the officer such a significant time after the MVC that the subject had metabolized a substantial portion of their BAL. Officer evaluation of subject drinking included 11% documented as "had not been drinking" and 4% as "HBD - not impaired." Prior work has also confirmed lower BALs and officer impression of subject drinking being associated with not receiving a DUI conviction.[12]

Future work should focus on better identification by officers of this lower BAL patient population (BAL < 200mg/dL) as they are well above the BAL for impairment and are at greatest risk for not being successfully prosecuted. One solution would be mandatory reporting by the ED physician/nurse providing care. This issue has been previously suggested and eloquently argued.[4,5,7,9,11,13] Currently, substantial variation in mandatory reporting laws exists across the U.S. Perhaps most supportive of the concept of mandatory reporting of intoxicated drivers is a 1990 survey of 1,041 emergency physicians, of whom 78% supported the practice.[20] A 2003 survey, however, suggested emergency physicians are more comfortable reporting intoxicated drivers to their state DMV rather than to law enforcement and more comfortable reporting those with higher BALs. [21] It must be noted, however, that in conflict with much of its membership, the American College of Emergency Physicians (ACEP) opposes both mandatory and permissive reporting. In a 2011 policy statement, ACEP "opposes legislation providing permissive or mandatory reporting of the results of patient toxicological screening, including but not limited to blood alcohol concentration levels, by physicians to law enforcement officials because such reporting fundamentally conflicts with the appropriate role of physicians in the physician-patient relationship."[22]

The ED BALs were generally higher than the arrest BAC levels, which likely reflect the delay in the arresting officer obtaining the evidentiary BAC level from the subject. In a normal traffic stop that results in a DUI citation, the officer is generally able to more quickly obtain an evidentiary alcohol level from either a breathalyzer reading or blood sample, which reflects the BAC closer to the time of driving. The ED BAL reflects the alcohol level at the time of ED blood draw (usually during initial ED evaluation). In cases where the subject is transported to the ED, the evidentiary alcohol level is drawn at the time the officer is able to evaluate the patient. This is often delayed by the medical care being provided and the time for the officer to get to the hospital from the MVC site. The more injured patients (ISS > 15) were most likely to have the greatest discrepancy between the ED BAL and the law enforcement BAC. Improved coordination between the ED staff and police officer may limit the delay in obtaining a legal BAC level.

Prior studies focused primarily on patients admitted to the hospital after presenting to an ED. This limitation introduces selection bias impacting the results and conclusions of these studies. Since the most injured patients are at lower risk to obtain a DUI conviction, prior studies likely underestimated the true rate of successful prosecution (patients with lesser injuries who were directly discharged home from the ED would not have been included in the study but likely were prosecuted at higher rates). The current study included all patients presenting to the ED following a trauma activation, and conviction rates in this study were highest in those discharged from the ED.

The current study has a higher conviction rate compared to all but one of the studies from the 1990s (Table 3). Several factors likely resulted in this increase. Certainly, there is more awareness by both law enforcement and healthcare providers. In addition, the study site has more supportive policies. During the study period, the study site had an official policy for registered nurses in the ED to draw blood for legal purposes if asked by the investigating officer. In addition, legal BAC kits were stored in the ED. Thus, we would

Table 3. Prior published studies on driving under the influence conviction rates in the United States.

Author	State	Time period*	Conviction for driving under the influence	95% confidence interval
Maull [5]	Tennessee	1979-82	0/53	0% (0, 5%)
Colquitt [4]	Connecticut	1981-85	0/53	0% (0, 5%)
Evett [10]	Virginia	1989-90	9/245	4% (2, 7%)
Barillo [6]	Pennsylvania	1990-91	205/511	40% (36, 44%)
Runge [15]	North Carolina	1990-91	32/187	17% (12, 23%)
McLaughlin [13]	Michigan	1990-91	29/49	59% (44,73%)
Fantus [11]	Illinois	1991	0/61	0% (0, 5%)
Rehm [14]	New Jersey	1991	11/78	14% (7, 24%)
Krause [12]	Michigan	1991-97	35/69	51% (38, 63%)
Cydulka [9]	Ohio	1993-95	15/70	21% (13, 33%)
Biffl [7]	Rhode Island	1997-98	10/113	9% (4, 16%)
Chang [8]	Pennsylvania	1997-98	135/213	63% (57, 70%)

*Time period is the time during which the patients presented to the emergency department.

consider the study site to be supportive towards officers and helpful in their DUI investigations. We would suggest EDs adopt a formal policy for their staff to assist officers in their investigation and obtaining an evidentiary BAC level. The study site, however, does not contact the police to inform them of the presence of an intoxicated driver.

LIMITATIONS

The study has certain limitations. It is a retrospective analysis of the trauma registry for eligible patients. Some eligible patients may not have been identified if a BAL was not obtained in the ED. However, this is unlikely since the policy and practice at the study site, at the time, was to obtain BALs on these patients. Data are from 2007; it is possible that convictions rates have subsequently changed.

We were unable to match 15% of the original pool of study-eligible subjects with DMV driver license records either indicating that the subjects had no California driving record or provided a non-matchable, or false name or birth date. The rate of prosecution in these subjects is unknown but is likely lower than the rest of the subjects because they evaded detection or were more easily missed within the DUI adjudication process given their non-matching identifiers in the state system's records. Had none of these subjects been successfully prosecuted, the rate of successful prosecution would fall from 59% to 50%.

Finally, the study was performed at a single site that had a protocol to facilitate assistance for legal blood draws in the ED. The results may not be generalizable to all facilities, especially facilities that may not have such a commitment to assist law enforcement.

CONCLUSION

Slightly more than half of drivers who present to an ED after a MVC receive a DUI conviction which is an increase from older evidence. The most severely injured subjects and those with lower BALs are least likely to be convicted of a DUI. The need for further improvement in prosecution rates of these subjects continues.

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Analysis of Medication Errors in Simulated Pediatric Resuscitation by Residents

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Introduction: The objective of our study was to estimate the incidence of prescribing medication errors specifically made by a trainee and identify factors associated with these errors during the simulated resuscitation of a critically ill child.

Methods: The results of the simulated resuscitation are described. We analyzed data from the simulated resuscitation for the occurrence of a prescribing medication error. We compared univariate analysis of each variable to medication error rate and performed a separate multiple logistic regression analysis on the significant univariate variables to assess the association between the selected variables.

Results: We reviewed 49 simulated resuscitations. The final medication error rate for the simulation was 26.5% (95% CI 13.7% - 39.3%). On univariate analysis, statistically significant findings for decreased prescribing medication error rates included senior residents in charge, presence of a pharmacist, sleeping greater than 8 hours prior to the simulation, and a visual analog scale score showing more confidence in caring for critically ill children. Multiple logistic regression analysis using the above significant variables showed only the presence of a pharmacist to remain significantly associated with decreased medication error, odds ratio of 0.09 (95% CI 0.01 - 0.64).

Conclusion: Our results indicate that the presence of a clinical pharmacist during the resuscitation of a critically ill child reduces the medication errors made by resident physician trainees. [West J Emerg Med. 2014;15(4):486–490.]

INTRODUCTION

Medication errors are a common cause of iatrogenic events in children. There are 3 types of medication errors: namely those in medication prescribing, dispensing, and administering.[1] In the emergency department (ED), up to 10% of medication errors result from prescribing errors.[2] Of these errors, medication error rates were found to be significantly associated with severely ill patients or when ordered by a trainee.[2] To our knowledge, there are no studies to date specifically describing the incidence or factors associated with medication errors during the resuscitation of a child by a resident trainee. At our institution, resident physicians are required to lead in the simulated resuscitation of a critically ill child, and efforts are made to simulate a real case scenario. The objective of our study was to estimate the incidence of prescribing medication errors specifically made by a trainee and identify factors associated with these errors during the simulated resuscitation of a critically ill child.

METHODS

We performed a prospective observational study using data obtained during an immersive simulated resuscitation of a critically ill child with first and third year pediatric residents from July 1, 2010 to November 30, 2011. Pediatric residents at our institution are required to lead in an immersive simulated resuscitation of a critically ill child during their pediatric emergency medicine rotation. The sessions occurred

in our simulation center using high technology manikins with capabilities of making physiologic responses to interventions.

An immersive simulation attempts to replicate real experiences with a team of participants that allow learners to address different aspects of resuscitation, including knowledge, decision-making, and teamwork. A pediatric working simulation group consisting of pediatric hospitalists, intensivists, emergency physicians, nurses, respiratory therapists, and pharmacists developed case scenarios based on actual patient encounters in the ED, inpatient unit, intensive care unit or during a transport of a critically ill child. Cases included a shaken infant with a traumatic head injury, a submersion injury requiring intubation, a teenager with septic shock, a child with status asthmaticus, and an automobile verse pedestrian accident with hypovolemic shock.

Each resident filled out a questionnaire prior to the simulation to determine background information related to the trainee's experience, level of training, and confidence in resuscitation of a critically ill child. Confidence was determined by having the resident place a line on a 100mm visual analog scale (VAS) with no confidence on the low end. Questionnaires also included details on the previous number of real case resuscitations and the amount of sleep the night prior to the simulation.

All the scenarios required medications to be prescribed during the resuscitation, but not all scenarios required the same medications. In an attempt to simulate real case scenarios in the ED, inpatient hospital unit or on transport, all cases included the participation of a nurse and respiratory therapists. At our institution, the presence of a clinical pharmacist is dependent on the time of day, so the participation of a clinical pharmacist was based on availability. This allowed us to evaluate the significance of having a pharmacist on overall medication error rates.

The supervising attending physician assigned cases randomly to each resident without knowledge by any of the participants. During the simulation, the supervising attending physician observed from the control room and made appropriate physiologic changes based on medications prescribed and interventions performed by the resident physician. Simulations were recorded and reviewed during the debriefing period for immediate feedback with all the participants. Videos were also stored on disc for a period of 2 weeks for review.

The study investigators reviewed the videotaped sessions regularly. Data collected from review of the videotapes included presence of a clinical pharmacist, cognitive aids used by the resident during the simulation, and details of the medications ordered. A medication was defined as prescribed when the resident verbally ordered the drug during the simulation. Each medication and dose prescribed by the resident physician was entered into the data collection form. Based on the stated weight, the dose per kilogram ordered was compared to the standard dosing for the final determination of a prescribing medication error. We combined data from the questionnaire and data collection form for analysis.

A final prescribing medication error was defined as a drug ordered that varied by at least 20% from the recommended dose, which also included not knowing the dose of the medication ordered. Error was also defined as drugs ordered by an incorrect route or an ordered drug that was not indicated for the patient's condition.[8] The Harriet Lane handbook (18th ed) and the PALS handbook (1st ed) were used as reference for standard recommended drug dosing.

Two of the study investigators reviewed the first 2 months of videotapes and completed the data collection forms together. The remaining videotapes and data collection forms were reviewed and completed by one study investigator. The second study investigator reviewed 10 percent of the data forms to determine inter rater reliability for a prescribing medication error.

We analyzed data using STATA 12.0 (Stata Corporation, College Station, Texas). Descriptive statistics of the data are reported. We compared univariate analysis of each variable to medication error rate, followed by a separate multiple logistic regression analysis on the significant univariate variables to assess the association between the selected variables. P value <0.05 was considered significant. We calculated a kappa statistic for inter rater reliability for the determination of a final prescribing medication error. In consultation with the institutional review committee of our institution, the study was exempt.

RESULTS

A total of 57 residents participated in the study; data or videotapes were incomplete or missing for 8. In the remaining 49 complete data sets, 26 (53.1%) of the subjects were interns. The questionnaire revealed that 33 (67.3%) of the residents had previous resuscitation experience. Sixteen (32.7%) had slept greater than 8 hours the night prior to the day of the simulation.

Review of the simulation revealed that a cognitive aid was used by 13 (26.5%) of the 49 participants. Cognitive aids included the use of a reference or code sheet, handheld device, small pocket book, and/or calculators. More interns (30.8%) compared to seniors (21.7%) used cognitive aids, but was not found to be statistically significant, p=0.47. Pharmacists were present during 23 (46.9%) of the simulated case scenarios. They were present during 14 (53.8%) of the 26 intern simulations and 9 (39.1%) of the 23 senior simulations, p=0.30.

There was a potential medication error rate of 40.8% (95% CI 26.6% - 55.1%) identified with the initial prescribed medication by the participant. Sixty-five percent were associated with error in dosing, 40% with an unknown dose, and 5% with an inappropriate medication ordered. Thirteen of the 20 (65%) initial prescribed medication errors were corrected prior to delivery to the manikin resulting in a final medication error rate of 26.5% (95% CI 13.7% - 39.3%). Pharmacists (71.4%) corrected majority of the prescribing

Table 1. Statistically significant findings for final decreased medication error rates.

Variable	Error with variable	Error without variable	p value
Level of training	13.0% (95% CI -1.8 – 27.5)	38.5% (95% CI 18.9 – 58.0)	0.04*
Sleeping > 8 hours	6.2% (95% CI - 6.3- 18.8)	36.3% (95% CI 19.2 – 53.5)	0.01*
Previous experience	24.2% (95% CI 9.0 – 39.5)	31.3% (95% CI 7.2 – 55.3)	0.60
Confidence	37.7 mm (95% CI 14.5 - 33.9)	24.2mm (95% CI 30.5 - 44.9)	0.04*
Pharmacist	13.0% (95% CI - 1.8 – 27.5)	38.5% (95% CI 18.9 – 58.0)	0.04*
Cognitive aid	23.1% (95% CI - 1.4 – 47.5)	27.8% (95% CI 12.6 – 43.0)	0.74

*significance <0.05

Table 2. Analysis showing protective effect of having a pharmacist present.

Variable	OR (95% CI)	p value
Pharmacist presence	0.09 (0.01 - 0.64)	0.02*
Year of resident	0.74 (0.07 - 7.66)	0.80
Hours slept	0.75 (0.45 - 1.26)	0.28
Visual analog scale	0.94 (0.88 - 1.01)	0.10

*significance <0.05
OR, odds ratio

errors, followed by a respiratory therapist (14.3%) and a nurse (14.3%). Pharmacists were never the source of a medication error, but there were 3 cases of a final medication error that occurred which were not caught during pharmacist presence. Our kappa statistic for the determination of prescribing medication error was 1.0, showing perfect agreement.

On univariate analysis, statistically significant findings for final decreased medication error rates included senior residents in charge, presence of a pharmacist, sleeping greater than 8 hours prior to the simulation, and a VAS score showing more confidence in caring for critically ill children (Table 1). Multiple logistic regression analysis using the above significant variables showed only pharmacist presence during resuscitation remained significantly associated with decreased medication error, odds ratio (OR) of 0.09 (95% CI 0.01 - 0.64) showing a protective effect (Table 2).

DISCUSSION

Medication error is a preventable cause of morbidity and mortality that has come to the forefront of medical practice. Variables associated with making medication errors are illness severity and the training level of the provider.[2] Prescribing errors with incorrect dosing are the most common type of errors made by physicians.[2,8-10] The ED has inherent features that place the pediatric patient at higher risk for experiencing adverse drug events. It is a high stress environment where acutely ill patients present to physicians who have no prior relationship and limited data on patient history. Critical decisions are made in an environment where multitasking and constant distractions are the norm. The pediatric ED has all the baseline distractions of an ED combined with required weight-based dose requirements of administered medications. The Joint Commission suggests efforts to reduce pediatric medication error include standard dose calculation forms for critically ill children, continued education and communication between staff, as well as access to a clinical pharmacist with expertise in pediatric care.[11]

Pharmacy presence in the ED has a significant impact on medication errors.[6,12-14] More medication errors are reported with the presence of a pharmacist in the ED and the recommendations given by pharmacist have a high acceptance rate.[15,16] One study completed in a rural ED showed a 66% difference in errors made before and after the implementation of an on-site clinical pharmacist.[17] A Veterans Administration study showed the cost avoidance realized of pharmacist presence in the ED to be $1.6 million per year based on interventions with a high probability to cause harm.[15] Consultative activities led to the highest number of error interceptions, 25% of which are described as serious or life threatening.[13] A recent study during trauma resuscitations found medication errors were 13 times more likely to occur when pharmacist were absent.[18] These gains have been demonstrated to be significant and lasting, leading to decreases in delayed medications and missed medications after the addition of a clinical pharmacist.[19]

Simulation has been used as a successful learning tool in many different hospital departments. Whether computer based, in situ or high fidelity, simulation shows demonstrable improvement within different disciplines related to patient care.[20] Nurses, physician and physician trainees, as well as pharmacist, all show improvement in self-reported confidence, technical skills, as well as reductions in medication errors after participation in such exercises.[21-23] These results hold true in the highly specialized setting of the pediatric ED. The incidence of medication errors in the pediatric ED has been shown to be as high as 10-15%.[24,25] A recent study shows such errors can be positively influenced after participating in simulated resuscitations.[20]

Our study chose to look at the prescribing medication errors made during high fidelity simulated pediatric emergency resuscitation. We showed a 25% difference in the

incidence of medication errors in the presence of a clinical pharmacist, and only the presence of pharmacist remained statistically significant after logistic regression analysis. These data are consistent with previous studies in the ED setting that demonstrate an improvement in medication errors with the addition of a pharmacist to the clinical team.

LIMITATIONS

Limitations of this study include a relatively small sample size and the lack of randomization. We obtained the study sample from a convenience sample of pediatric resident training physicians who are required to participate in a simulated resuscitation. As this was an observational study of simulated scenarios based on real-life cases, we were not able to randomize factors such as the presence of a clinical pharmacist. Additionally there were different resuscitation scenarios that required a variable number of medications that was not standardized. Although our results did not show a significant difference in the use of a cognitive aid, we do encourage the use of cognitive aids for patient safety best practice. Other factors may be significant but could not be detected in a sample of this size. The setting of this study was in a high fidelity simulation center, and though the manikins used mimicked physiologic changes seen in real patients they are not an exact substitute for the ED setting.

CONCLUSION

Our results show on univariate analysis that pharmacist presence, senior resident, > 8hrs of sleep and confidence are significantly associated with decreased medication error. Logistic regression showed pharmacist presence during resuscitation remained significantly associated with decreased medication error, OR of 0.09 showing a protective effect. Our study supports that having a pharmacist focus on medication dosing during resuscitations decreases medication errors made by trainees.

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Clinical Management of Skin and Soft Tissue Infections in the U.S. Emergency Departments

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Introduction: Community-associated methicillin resistant *Staphylococcus aureus* (CA-MRSA) has emerged as the most common cause of skin and soft-tissue infections (SSTI) in the United States. A nearly three-fold increase in SSTI visit rates had been documented in the nation's emergency departments (ED). The objective of this study was to determine characteristics associated with ED performance of incision and drainage (I+D) and use of adjuvant antibiotics in the management of skin and soft tissue infections (SSTI).

Methods: Cross-sectional study of the National Hospital Ambulatory Medical Care Survey, a nationally representative database of ED visits from 2007-09. Demographics, rates of I+D, and adjuvant antibiotic therapy were described. We used multivariable regression to identify factors independently associated with use of I+D and adjuvant antibiotics.

Results: An estimated 6.8 million (95% CI: 5.9-7.8) ED visits for SSTI were derived from 1,806 sampled visits; 17% were for children <18 years of age and most visits were in the South (49%). I+D was performed in 27% (95% CI 24-31) of visits, and was less common in subjects <18 years compared to adults 19-49 years (p<0.001), and more common in the South. Antibiotics were prescribed for 85% of SSTI; there was no relationship to performance of I+D (p=0.72). MRSA-active agents were more frequently prescribed after I+D compared to non-drained lesions (70% versus 56%, p<0.001). After multivariable adjustment, I+D was associated with presentation in the South (OR 2.36; 95% CI 1.52-3.65 compared with Northeast), followed by West (OR 2.13; 1.31-3.45), and Midwest (OR 1.96; 1.96-3.22).

Conclusion: Clinical management of most SSTIs in the U.S. involves adjuvant antibiotics, regardless of I+D. Although not necessarily indicated, CA-MRSA effective therapy is being used for drained SSTI. [West J Emerg Med. 2014;15(4):491–498.]

INTRODUCTION

Background

Community-associated methicillin resistant *Staphylococcus aureus* (CA-MRSA) has emerged as the most common cause of skin and soft-tissue infections (SSTI) in the United States, especially in purulent skin abscess. In many areas of the country, MRSA prevalence is as high as 75-80% among cultured SSTI.[1–7] This epidemic has disproportionately

affected patients presenting to the emergency department (ED), where a nearly three-fold increase in SSTI visit rates had been documented in adults and children, and increases in both skin abscesses and cellulitis have been observed.[8–10] Although the rise in SSTIs due to MRSA has led to an increase in hospitalizations and, in some cases, invasive disease, the majority of skin infections are managed in ambulatory settings, including the ED.[8,9]

Importance

The rise in SSTIs and CA-MRSA has led to significant changes in clinical ED practice. First, the determination of the presence of an abscess, as opposed to a cellulitis, is an increasingly frequent diagnostic challenge faced by emergency physicians (EP). As a result, many EPs are using formal or bedside ultrasonography for diagnostic evaluation of SSTI.[11–13] Also, due to the increasing number of patients presenting with purulent abscess, incision and drainage (I+D) procedures are more frequently indicated. I+D can be especially time consuming in children, as procedural sedation is often required, which also carries inherent risk to the patient.[14,15] Therapeutic decisions regarding use of antibiotic therapy are also changing. Soon after the emergence of CA-MRSA, use of agents "active" against this organism, such as clindamycin and trimethoprim-sulfamethoxazole (TMP-SMX) has increased, while ß-lactam antibiotics, which provide empiric therapy for methicillin-sensitive *S. aureus* (MSSA) and ß-hemolytic streptococcus (BHS) are prescribed less frequently.[8,14–16] The implications of this shift in antibiotic therapy, however, are uncertain. Despite a growing body of evidence suggesting that antibiotics may not be necessary for adequately drained skin abscesses,[17–19] studies have found that use of adjuvant antibiotics is common.[14,20] These various studies have reported changes in clinical practice with respect to treatment of SSTI, although many of these consist of single institution and survey studies, and isolated pediatric or adult data.

Goals of this Investigation

The objective of our study was to investigate national practice patterns of SSTI management in the ED. Specifically, we determined national rates of I+D use and patterns of antibiotic prescribing for ED patients with SSTIs.

METHODS

Study Design, Setting, and Subjects

We analyzed data from the National Hospital Ambulatory Medical Care Survey (NHAMCS), a cross-sectional survey conducted annually by the National Center for Health Statistics (NCHS).[21] The survey is used to collect information about patient demographics, diagnoses, medications prescribed, and procedures performed on a nationally representative sample of ED visits in the U.S. To collect data from a nationally representative sample of visits, the NCHS administers the survey at participating hospitals using a four-stage probability sampling design, after sampling geographic primary sampling units (PSUs), the NCHS samples hospitals within PSUs, emergency service areas and in-scope ambulatory surgery locations within hospitals, and visits within these settings. Data from sampled visits are collected by hospital staff, who were trained by and maintained contact with trained field representatives during the reporting period. The NCHS provides probability weights – equal to the inverse probability of any visit being sampled – that allow for the generation of nationally representative estimates using data collected in the NHAMCS. The study was granted exemption from the institutional review board review.

Methods and Measurements

In our analysis, we combined data collected in the NHAMCS between 2007 and 2009. The analysis was restricted to initial visits for an SSTI; we excluded visits for follow up. Methodology for identification of SSTI in NHAMCS mirrored that of previous published studies: we identified visits for SSTI using International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM) codes for skin and soft issue infection (680.xx-682.xx), which includes carbuncle, folliculitis, cellulitis, and skin abscess.[8,9,22] Although the NHAMCS allows for up to three diagnosis codes to be assigned to a visit, we defined SSTI based upon the primary diagnosis listed. Study subjects included patients of all ages, and we analyzed participants' demographic data including race, gender, and insurance status. Location of ED care, in terms of geographic region, was also collected in the NHAMCS and described in our study. Geographic regions were defined using US Census Track Regions, including the Northeast, South, Midwest, and West.

Details of ED visits, including performance of drainage procedures, diagnostic testing, ED disposition, and prescription antibiotic use were recorded at each visit. Performance of diagnostic testing—including complete blood count, blood culture, or wound culture–was indicated via check box in the patient record form. We dichotomized ED disposition as outpatient management or hospitalization, which included admission to an inpatient ward or observation unit. Antibiotics were categorized using the Multum Lexicon Therapeutic Classification System. Starting with the 2006 surveys, the NHCS began to code drugs using the Multum system, which characterizes drugs using a three-tiered hierarchy. For example, beta-lactamase inhibitors are a "level 3" category of drugs within the "level 2" category that includes all penicillins. Penicillins, in turn, belong to a "level 1" category that includes all anti-infectives. In addition to broad categories, the Multum system allows for identification of specific drugs (e.g., clindamycin). For the purposes of our analysis, we grouped antibiotics into the following categories: anti-MRSA (trimethoprim-sulfamethoxazole, clindamycin, daptomycin, tetracyclines,

Table 1. Characteristics of initial emergency department (ED) visits for skin and soft tissue infections (SSTI) among study patients*†

	Estimated survey weighted ED visits (in millions)	All SSTI†† (n=1,806)	No I+D†† (n=1,311)	I+D†† (n=495)	p-value (X^2)
Year					
2007	2.03	30%	31%	27%	
2008	2.47	36%	35%	39%	0.51
2009	2.32	34%	34%	34%	
Age (years)					
<18	1.16	17%	18%	15%	
18-49	3.89	57%	53%	69%	<0.0001
>49	1.77	26%	29%	16%	
Race					
White	4.84	71%	77%	57%	<0.0001
Nonwhite	1.98	29%	23%	43%	
Gender					
Male	3.48	51%	50%	52%	0.64
Female	3.34	49%	50%	48%	
Insurance status					
Private	4.57	67%	67%	70%	0.23
Public/other	2.25	33%	33%	30%	
US census track region					
Northeast	1.09	16%	19%	9%	
Midwest	1.09	16%	17%	16%	
South	3.34	49%	45%	58%	<0.001
West	1.30	19%	19%	18%	

*Survey weights applied; †Totals may be >100%; ††Proportions represent total within each column; I+D, incision and drainage.

vancomycin, linezolid, and tigecycline), β-lactam (penicllins, cephalosporins, and carbapenems), and other (rifampin, macrolides, aminoglycosides, and quinolones).

Statistical Analysis

All statistical analyses took into account the complex sampling design of the NHAMCS, including sample weights, stratification, and clustering variables. Description of study subjects and ED visits were made using standard descriptive statistics. We made univariate comparisons using the $\chi 2$-test for proportions, and p-values were reported with a significance level of <0.05. Specifically, we compared patient characteristics, diagnostic testing, and adjuvant antibiotic prescription between patients with and without an incision and drainage procedure performed. To identify independent patient characteristics associated with clinical care of SSTI and to account for potential confounding, we performed multivariable logistic regression. Two regression models were created: one to identify factors independently associated with performance of I+D, and a second to assess factors associated with prescribing of adjuvant antibiotics among subjects that had a drainage procedure. We reported values as adjusted odds ratios (OR) with 95% confidence intervals (CI). We conducted all analyses using STATA 11 software (Stata Corp, College Station, TX).

RESULTS

Characteristics of Study Subjects

During the study period, based on a sample of 1,806 actual visits in the NHAMCS database, there were an estimated 6.82 (95% CI: 5.88-7.75) million initial ED visits for SSTI in the U.S. This corresponds to an average of 2.27 million visits annually. Survey weighted demographics of the study population are presented in Table 1. Most study subjects were above the age of 18 years, Caucasian, and privately insured. The largest number of SSTIs occurred among patients in the 18-49 year age group, while children (<18 years) had the fewest. The rate of ED visitation for SSTI was highest in the southern U.S., compared to other regions (Table 1).

Emergency Department Clinical Care for SSTI

Among visits for SSTI, an estimated 27% (95% CI:

Table 2. Antibiotics prescribed for study subjects.

Variable	Overall	No I+D	I+D	p-value[e]
Any antibiotic use[a]	85%	85%	84%	0.72
Anti-MRSA monotherapy[b]	43%	38%	57%	<0.0001
β-lactam monotherapy[c]	23%	27%	13%	<0.0001
Anti-MRSA + β-lactam combination	15%	16%	11%	0.08
Other antibiotics[d]	4%	5%	3%	0.18
No antibiotics	15%	15%	16%	0.72

[a] Values may not sum accurately as a result of rounding
[b] Includes sulfonamides, tetracyclines, clindamycin, vancomycin, linezolid, daptomycin, and tigecyclin.
[c] Includes cephalosporins, penicillins, and carbapenems.
[d] Includes macrolides, aminoglycosides, quinolones, and rifampin.
[e] Chi-square comparisons of No I+D with I+D
I+D, incision and drainage

24-31) had an I+D procedure performed. Performance of I+D occurred more often in patients who were 18-49 years of age (p<0.001), non-white, and when treated in the South (p<0.001). Wound cultures were performed in 16% of visits for SSTI, and they were performed more frequently when I+D was also performed (31%) than when I+D was not performed (11%) (p<0.001). Among the study population, ancillary diagnostic testing was obtained in many patients: 27% had a complete blood count and 12% had a blood culture obtained in the ED; each were more likely to be obtained in patients when an I+D was not performed (p<0.001). The majority of patients were cared for as outpatients, with only 15% of study subjects hospitalized after the ED visit. Hospitalization for SSTI was less common when I+D was performed during the ED visit (5%) than when I+D was not performed (19%) (p<0.001).

Overall, 85% of patients with SSTI received an antibiotic prescription. There was no difference in the rate of antibiotic use between those who did or did not receive an I+D (84% versus 85%, p=0.72). However, there were significant differences in antibiotic choices based on whether an I+D was performed. The majority (70%) of patients who had I+D were prescribed an anti-MRSA antibiotic, compared to 56% of those not receiving I+D (p<0.0001) (Table 2). Combination therapy, with prescription of anti-MRSA and beta-lactam antibiotics, was used in 15% of subjects; there was no association between the use of combination therapy and performance of a drainage procedure (p=0.08).

Multivariable Analysis

After adjusting for other potentially confounding factors, performance of I+D was significantly associated with patient age of 18-49 years, non-white race, and care in regions other than the U.S. Northeast, with the strongest association observed in the South. Among patients undergoing I+D, adjuvant antibiotic therapy was only associated with patients treated in the South (OR 3.23; 1.41-7.40 compared with the Northeast) (Table 3).

DISCUSSION

This study provides a nationally representative overview of ED management for patients with SSTIs. While I+D is considered the mainstay of therapy for purulent SSTI, it is performed in less than half of children presenting to the ED for an SSTI. Overall drainage procedure are less commonly performed for children <18 years compared to adults 18-48 years of age, and more commonly performed in non-white patients, and in those presenting outside of the Northeast. Furthermore, adjuvant antibiotic use for SSTIs is commonplace, regardless of whether or not I+D is performed. Though the majority of subjects are receiving CA-MRSA active therapy, consistent with current epidemiology, current evidence indicates that antibiotic therapy may be unnecessary for purulent abscesses that are adequately drained.

I+D remains the mainstay of treatment for purulent skin abscesses, irrespective of patient characteristics or site of care.[16,23,24] However, the results of our study demonstrate that for SSTIs presenting to the ED, I+D appears to be less likely to be performed in pediatric patients and white patients. While the ED is often the preferred site of care for potentially drainable SSTI, the pediatric population is less likely to receive an I+D. It is possible, though unlikely, that the prevalence of cellulitis is higher than abscess in the pediatric population; current administrative databases do not permit discrimination between ICD-9 codes for these infections. Factors such as reluctance to perform an empiric I+D procedure because of incurred pain or need for procedural sedation, or the limited use of bedside ultrasonography in children, may explain this finding, in part. For example, sedation possesses inherent logistical challenges in the ED setting, such as time required and associated risks; in addition, sedation is more likely to be employed in academic settings, which is not representative of the majority of ED visits across the U.S.15 In addition, bedside ultrasonography is underused in pediatric patients,[25,26] though it has proven benefit in adults; abscesses are often underdiagnosed compared with examination, and therefore may not receive I+D.[12,27] With respect to patient race and performance of I+D, there is suggestion that CA-MRSA and SSTI are more common in blacks, as compared to other races,[28–31] which accounts for differences in the performance of I+D; CA-MRSA infection is related to increased risk of abscess formation, and mirrors this epidemiologically.[2,6,29]

Several geographic differences with respect to SSTI management were elicited in our study, even after adjustment for multiple patient factors, including age, race, and insurance status. Patients with SSTI treated in EDs outside of the Northeast underwent I+D more frequently: compared with the

Table 3. Multivariable regression analyses of factors associated with performance of incision and drainage and with receipt of adjuvant antibiotics coupled with incision and drainage in patients with skin and soft-tissue infections.

	% Receiving I+D	AOR (95% CI)	% Receiving antibiotics	AOR (95% CI)
Year				
2007	25%	1.00	91%	1.00
2008	29%	1.30 (0.90-1.90)	80%	0.57 (0.25-1.29)
2009	27%	1.34 (0.96-1.87)	83%	0.49 (0.23-1.04)
Age				
<18	24%	1.00	87%	1.00
18-49	32%	1.77 (1.23-2.55)	84%	0.46 (0.12-1.70)
>49	17%	0.94 (0.60-1.49)	81%	0.42 (0.10-1.66)
Race				
White	22%	1.00	85%	1.00
Nonwhite	41%	2.34 (1.71-3.19)	83%	0.77 (0.43-1.40)
Sex				
Male	28%	1.00	85%	1.00
Female	26%	0.86 (0.63-1.18)	83%	1.09 (0.58-2.03)
Insurance status				
Private	25%	0.96 (0.74-1.25)	84%	0.92 (0.47-1.80)
Public/other	28%	1.00	85%	1.00
US census region				
Northeast	15%	1.00	72%	1.00
Midwest	26%	1.96 (1.19-3.22)	78%	1.90 (0.62-5.81)
South	32%	2.36 (1.52-3.65)	89%	3.23 (1.41-7.40)
West	26%	2.13 (1.31-3.45)	78%	1.31 (0.49-3.52)

I+D, incision and drainage; *AOR*, Adjusted Odds Ratio

Northeast, patients treated in the South were twice as likely to have an I+D performed and three times as likely to receive adjuvant antibiotics after the I+D. However, it is unclear whether a true association exists between region and treatment strategies. It should be noted that the prevalence of CA-MRSA is highest in urban centers located in the South (Atlanta, Houston, Dallas), in the Midwest (Chicago, St. Louis), and in the West (San Francisco, Los Angeles), with rates as high 80-85% in many of these locations.[1,3,6,7,19,29,30] Meanwhile, many centers in the Northeast (New York, Philadelphia) documented rates of MRSA less than 70%.[29,32] Nonetheless, while the incidence of skin abscesses is related to CA-MRSA prevalence, it is unclear if this regional relationship purely reflects ED visitation, population demographic, or actual differences in clinical care. These findings should be interpreted in light of the fact that our ability to identify skin abscess was based on best literature-supported methods for administrative data; the true clinical scenario of abscess versus cellulitis cannot be assessed, and the prevalence of CA-MRSA in cellulitis is not known.

Our study confirms the frequent use of systemic antibiotics for SSTIs managed in the ED, which was not influenced by the performance of I+D: approximately 85% of all patients received adjuvant antibiotic therapy. This finding has important implications. For some patients, especially children among whom barriers to performing drainage exist, ED physicians may be using antibiotic therapy instead of performing a drainage procedure. It cannot be overemphasized that adjuvant antibiotics are not a substitute for I+D when treating purulent skin abscesses, and the assumption that antibiotic therapy alone will adequately treat a skin abscess might increase the possibility of treatment failure. Moreover, this high rate of adjuvant antibiotic use suggests that ED physicians are reluctant to withhold antibiotic therapy, despite recent evidence demonstrating a general lack of efficacy of this practice.[18,19] However, recent evidence suggests that I+D alone is sufficient for most ED patients with uncomplicated abscess. Chen et al demonstrated that failure rates between pediatric skin abscesses, in a study population with 70% CA-MRSA, did not differ when treated with adjuvant clindamycin compared to the non-MRSA active cephalexin (3 versus 6%, p=0.50).[17] The most salient of these was a methodologically sound, non-inferiority study of

TMP-SMX versus placebo in drained skin abscess, by Duong et al in 2010. Treatment failure in the placebo group was 5.3%, compared with 4.1% in the TMP-SMX group (mean difference 1.2% 95% CI: -∞ to 6.8).[19] These results, in conjunction with current evidence and national guideline recommendations, strongly suggest that adjuvant antibiotic therapy does not or only minimally improves cure rates compared with placebo or use of an agent that was inactive against the pathogen.[1,3,18,19,24,24,33] These findings support the need for knowledge dissemination of these studies and guideline recommendations, continued surveillance of ED prescribing practices, and more judicious use of adjuvant therapy.

On the other hand, our findings suggest that EPs do appear to be tailoring their antibiotic selection patterns based on the epidemiology of the infection. Use of anti-MRSA therapy, including clindamycin and TMP-SMX, was higher for patient visits where I+D was performed. This is consistent with the likely differences in pathogens between purulent and nonpurulent SSTI: purulent SSTI such as abscesses are more likely to be caused by *S. aureus*, whereas nonpurulent cellulitis and erysipelas are more likely to be caused by BHS.[29,34,35] Therefore, if antibiotics are deemed necessary for the management of purulent SSTI, an antibiotic with activity against MRSA is generally recommended, typically clindamycin or TMP-SMX, based on local resistance patterns.[16,24] With respect to non-purulent SSTI, a recent study of inpatients residing in a high-MRSA prevalence community demonstrated that BHS was the causative agent in 73% of cases of non-purulent cellulitis.[34] Therefore, use of therapy with activity against BHS for cellulitis, especially beta-lactams or clindamycin is prudent, as TMP-SMX alone is not considered adequate and has been associated with treatment failure when used as monotherapy for non-drained SSTIs.[10]

Differences exist with respect to ancillary testing and ED disposition for SSTIs, based on performance of I+D. In the setting of a known abscess, clinicians will be more likely to perform drainage without additional testing. Diagnosis of and treatment of skin abscess is more straightforward as compared to non-drained lesions, where cellulitis, or even deeper skin lesions may be a consideration. As a result, it is logical that patients with non-drained SSTI were more likely to receive laboratory testing, including complete blood counts and blood cultures. While there may be an effect from institutional differences, these findings seem justified, as patients with non-drained SSTIs were also four-times as likely to be admitted to the hospital for continued therapy. Although many physicians continue to favor use of serum testing in SSTI management.[14] It should be noted that serum testing adds little to the management of SSTI, and rates of bacteremia in cellulitis and skin abscess remain quite low.[36] Notably, wound cultures were not obtained in the majority of SSTI even after drainage. This is incongruent with current recommendations from the IDSA and CDC, which recommend wound culture in the management of SSTI to monitor for therapeutic failure, and track current *S. aureus* epidemiolgy.[16,24]

LIMITATIONS

Among the limitations to our findings is the use of large-scale administrative data from NHAMCS, as has been well documented.[37] Specifically, the NHAMCS survey does not include some potentially important clinical information that could influence treatment decisions around I+D or antibiotic use, including lesion size or prior history of MRSA or SSTI. As a result, we are not able to fully evaluate the appropriateness of clinical management. NHAMCS is also limited by its use of ICD-9 codes for diagnosis. In the case of SSTI, ICD-9 does not distinguish between cellulitis and abscess, and use of ICD-9 codes for SSTI and procedure codes of I+D to identify abscesses is limited and prone to misclassification. Additionally, the limited sample of patients did not permit sub-analysis of our study population by smaller increments of age, and it is possible that further differences exist in management of younger pediatric patients compared to older adolescents. In addition, regional differences found in our study may not be accurate, as NHAMCS coding and Census Track Regions results in overrepresentation of the South in terms of ED visits. Since our data source did not contain results or microbiologic testing for ED patients with SSTI, we could not confirm this relationship between CA-MRSA prevalence and the need for incision and drainage. Although relatively unlikely, particularly because we restricted our analysis to initial ED visits, some patients may have undergone I+D previously in an office setting, which would not have been captured by the NHAMCS dataset. Finally, although we found differences in clinical care across the large geographic areas of U.S. Census Track Region, we could not comment on actual care provided, or account for potentially important differences across smaller geographic areas.

CONCLUSION

In spite of current literature disputing the need for adjuvant antibiotic therapy for uncomplicated SSTI that has undergone I+D, this practice remains common in adults and children presenting to the ED for skin abscesses. While CA-MRSA active therapy for drained SSTI has increased concomitant with the rise in CA-MRSA, prescribing practices for non-drained SSTIs such as cellulitis reflect increased use of CA-MRSA active therapy, which may not be appropriate, as Group A Streptococcus remains prevalent. Meanwhile, the practice of serum testing for non-drained SSTI remains common, despite uncertainty in the diagnostic and therapeutic utility. Nationally representative studies are essential for evaluating current practice for SSTI, and continued assessments of antibiotic therapy will be necessary to evaluate dissemination of evidence regarding appropriate use of diagnostics and adjuvant antibiotics for SSTIs.

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Expansion of U.S. Emergency Medical Service Routing for Stroke Care: 2000-2010

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Introduction: Organized stroke systems of care include preferential emergency medical services (EMS) routing to deliver suspected stroke patients to designated hospitals. To characterize the growth and implementation of EMS routing of stroke nationwide, we describe the proportion of stroke hospitalizations in the United States (U.S.) occurring within regions having adopted these protocols.

Methods: We collected data on ischemic stroke using International Classification of Diseases-9 (ICD-9) coding from the Healthcare Cost and Utilization Project Nationwide Inpatient Sample (NIS) database from the years 2000-2010. The NIS contains all discharge data from 1,051 hospitals located in 45 states, approximating a 20% stratified sample. We obtained data on EMS systems of care from a review of archives, reports, and interviews with state emergency medical services (EMS) officials. A county or state was considered to be in transition if the protocol was adopted in the calendar year, with establishment in the year following transition.

Results: Nationwide, stroke hospitalizations remained constant over the course of the study period: 583,000 in 2000 and 573,000 in 2010. From 2000-2003 there were no states or counties participating in the NIS with EMS systems of care. The proportion of U.S. stroke hospitalizations occurring in jurisdictions with established EMS regional systems of acute stroke care increased steadily from 2004 to 2010 (1%, 13%, 28%, 30%, 30%, 34%, 49%). In 2010, 278,538 stroke hospitalizations, 49% of all U.S. stroke hospitalizations, occurred in areas with established EMS routing, with an additional 18,979 (3%) patients in regions undergoing a transition to EMS routing.

Conclusion: In 2010, a majority of stroke patients in the U.S. were hospitalized in states with established or transitioning to organized stroke systems of care. This milestone coverage of half the U.S. population is a major advance in systematic stroke care and emphasizes the need for novel approaches to further extend access to stroke center care to all patients. [West J Emerg Med. 2014;15(4):499–503.]

INTRODUCTION

Stroke is the fourth leading cause of mortality and a leading cause of morbidity in the United States (U.S.).[1] Early evaluation and treatment is vital to improving outcomes because during an acute stroke, approximately 2 million neurons die every minute.[2] Delays in seeking medical care lead to underutilization of intravenous thrombolysis.[3] The Brain Attack Coalition (BAC), a collaboration of physicians, scientists, and government leaders, established guidelines for organized systems of stroke care including primary stroke center (PSC) certification and preferential emergency medical services (EMS) routing of suspected stroke patients to designated PSCs. Hospitals must meet specific standards for stroke care for certification by the Joint Commission as a PSC. Standards are set for elements pertinent to comprehensive stroke care including, acute stroke teams, neurosurgery, neuroimaging, laboratory services, and emergency medical systems.[4]

Since the publication of the BAC's initial recommendations, the Joint Commission in collaboration with the American Stroke Association (ASA) has certified over 925 PSCs nationally. An updated version of the BAC recommendations addressed EMS response to patients showing signs of acute stroke, recommending that EMS personnel should transport patients with acute stroke to primary stroke centers, unless there is another imminent life-threatening condition (level of evidence class I, level B).[4,5] This updated classification highlights the importance of rapid identification and transport of stroke patients who seek immediate medical treatment.

There is no national requirement for adoption of EMS preferential routing protocols for stroke. Adoption of routing has been on an individual state or county level. We wanted to describe the rate and the effectiveness in nationwide adoption of stroke-routing protocols by looking at individual stroke hospitalization by location over a time period from 2000-2010. Stroke hospitalizations in states having adopted organized stroke systems of care were compared to those without such protocols for each period of study to determine the rate and extent of state adoption in the U.S.

METHODS

Data Sources

The Nationwide Inpatient Sample (NIS) is the largest publicly available inpatient care database representing 20% of admissions to hospitals across the U.S.[6] Data on ischemic stroke using the ninth revision of the International Classification of Diseases (ICD-9) coding (433.01, 433.11, 433.21, 433.31, 433.91, 434.01, 434.11, and 434.91) were collected using patient discharge information from the NIS, Healthcare Cost and Utilization Project (HCUP), and the Agency for Healthcare Research and Quality during the years 2000-2010. The NIS contains data on primary and secondary patient diagnoses, patient demographics (i.e. age, gender, and race), and hospital characteristics, such as size, teaching status, and zip code. We collected the NIS patient and hospital data on 28 states from the year 2000, and on 1,051 hospitals located in 45 states in 2010; this approximates a 20%-stratified sample of U.S. community hospitals. We analyzed EMS transportation systems only for states in the NIS database from 2000-2010. States not in the NIS database as of 2010 include Alabama, Delaware, Idaho, North Dakota, and New Hampshire; they are indicated in black (Figure). Given the increase in the number of states and thus in the number of hospitals covered in the database over the study period, the NIS team specified a sample and weight strategy required for hospitals and number of discharges. We calculated hospital weights based on stratification of hospital type; hospital strata were categorized on geographic location (Northeast, West, Midwest and South), urban or rural region, teaching status, size ((small (<200 beds), medium (201-400 beds), large (>400 beds)), and control (public, voluntary, or proprietary hospital). We compared these hospital subtypes to the national number obtained from the American Hospital Association (AHA) Annual Survey Database in order to extrapolate the NIS sample hospitals to the nationwide hospitals. The number of community hospitals within each stratum in the nationwide hospitals was added to obtain the national hospital weight. Similarly, we developed discharge weights to extrapolate the NIS sample discharges to the nationwide discharge. We obtained the number of discharges on the national level from the AHA.

We obtained data on EMS systems of care from a study that reviewed online legislative archives and reports, and interviewed public health or EMS officials from all 50 states at the county-level, and employees at the American Health Association, American Stroke Association and the Centers for Disease Control.[7] NIS hospital data is not reported at the county level in the state of Texas. We analyzed all Texas data using the state-reported EMS stroke diversion policy in 2005, even though Harris County began EMS routing in 2000.

Data Analysis

We conducted analyses using Statistical Analysis System (SAS) version 9.2 software. Cases were patients from the NIS discharge database with diagnosed ischemic stroke, identified by a review of ICD-9 discharge diagnoses. Based on the NIS hospital identification number, which denotes the patients' hospital zip code, the hospital was assigned as an area with or without EMS regional system of acute stroke care by study year (2000-2010). If the protocol for EMS to transport stroke patients to the nearest primary stroke center was initiated in a given year, then the area was said to be in a transition period for that same year to account for the delay of several months for actual implementation of stroke routing on the field. We compared the proportion of stroke patients in jurisdictions with EMS regional system of stroke care to the proportion of stroke patients in other jurisdictions for each year by comparing the frequency of patients in each jurisdiction. The frequency of total ischemic

Table 1. National yearly estimates of hospitalization for ischemic stroke with state organized stroke systems of care.

	Frequency of stroke hospitalizations by regional EMS policy adoption				Percentage of total stroke hospitalization by EMS policy		
Year	No EMS	EMS	EMS In-transit	Total	No EMS	EMS	EMS In-transit
2000	582,954	0	0	582,954	100	0	0
2001	580,078	0	0	580,078	100	0	0
2002	569,887	0	0	569,887	100	0	0
2003	539,705	0	7938	547,643	98.55	0	1.45
2004	459,644	7372	65,215	532,232	86.36	1.39	12.25
2005	367,911	69,681	88,083	525,676	69.99	13.26	16.76
2006	382,256	146,074	1241	529,571	72.18	27.58	0.23
2007	351,403	156,695	12,227	520,326	67.54	30.11	2.35
2008	368,810	163,267	32,087	564,165	65.37	28.94	5.69
2009	264,436	187,681	95,525	547,643	48.29	34.27	17.44
2010	275,043	278,538	18,979	572,560	48.04	48.65	3.31

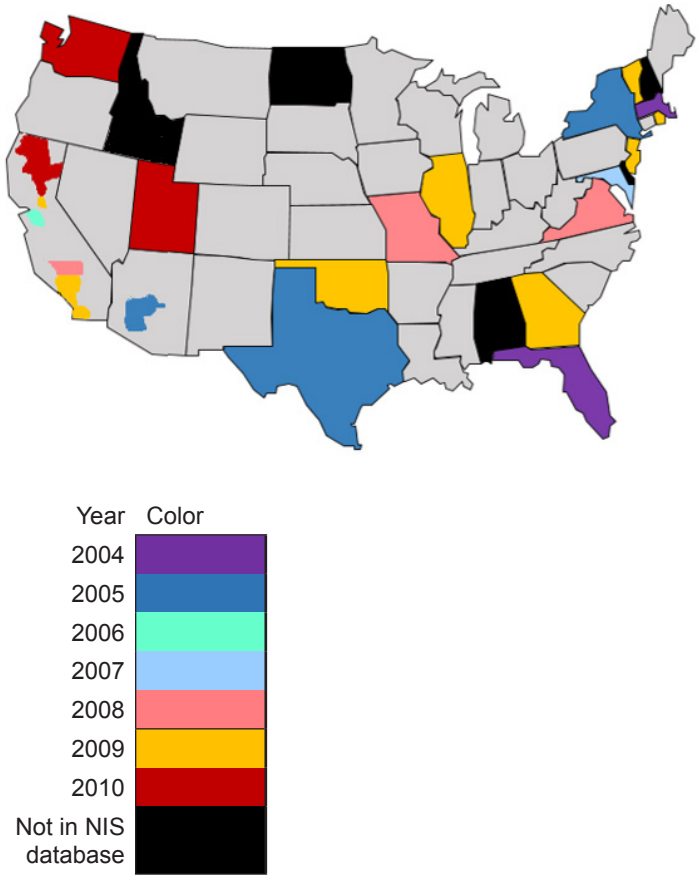
EMS, emergency medical services

patient transportations for that year is the denominator for comparing the proportions.

RESULTS

Although Texas was the first state to begin routing EMS preferential routing of acute stroke patients to designated hospitals in 2000, due to the lack of county-based reporting we were not able to capture this data. Thus the first transition to EMS routing is 2003. By 2010, the NIS database included 14 states with complete and an additional 3 states with partial (county-specific) adoption of EMS routing protocols for transportation of acute stroke patients to designated stroke centers (Figure).

From 2000 through 2010, there were 6,072,735 unadjusted individual ischemic stroke hospitalizations reported in NIS database. The overall age-adjusted hospitalization rates for ischemic stroke during this period of time declined from 169 per 100,000 population in 2000, to 138 per 100,000 population in 2010. Of the total number of stroke hospitalizations reported to the NIS in the study period 22% were in areas that adhered to EMS regional systems of acute stroke care. The proportion and frequency of U.S. stroke hospitalizations in areas with routing protocols for stroke patients increased throughout the study period (Table 1). The states and counties adopting EMS stroke protocols increased from 2004 to 2010 (Figure). From 2004 to 2010 the rate of increase in the proportion of stroke hospitalizations in regions with EMS diversion was 12%.



NIS, National Impatient Sample

Figure. Map of the United States describing year of adoption of state organized stroke systems of care from 2004 to 2010.

DISCUSSION

Adoption of EMS preferential stroke-routing protocols steadily increased during the 2000 to 2010 study period. In 2010, a majority of stroke patients in the U.S. were hospitalized in states or counties with established or transitioning EMS stroke diversion policies, demonstrating progress towards nationwide coverage of stroke care. As the average age of the U.S. population increases, the frequency of stroke is predicted to rise as well,[8] and the impact of EMS stroke routing policies is likely to increase. This paper highlights the great success in systematic implementation of the continuum stroke care for policies supporting EMS stroke routing, continued certification of primary stroke centers,[9] and use of stroke therapies,[10,11] including intravenous recombinant tissue plasminogen activator.[12]

EMS routing of stroke has followed the lead of similar systems for acute myocardial infarction and trauma. The process of routing patients to the appropriate hospital is complex and involves recognition of stroke symptoms by dispatch operators taking emergency calls. The right prehospital team with training in the use of a stroke recognition instrument has to be dispatched. Instruments commonly used by EMS personnel to identify potential stroke cases include the Los Angeles Prehospital Stroke Screen,[13,14] and the Cincinnati prehospital stroke scale.[15] Once a potential stroke case has been identified, the individual stroke diversion protocol will have criteria for activation, such as time from onset of symptoms to paramedic evaluation. As stroke diversion is likely to benefit individuals presenting within time periods of eligibility for intravenous thrombolysis, most EMS stroke diversion protocols will apply to individuals with onset less than 2 to 3 hours. There may be secondary considerations, such as patient stability and length of diversion, affecting eligibility. Prehospital notification of incoming acute stroke cases can help mobilize care teams and streamline care.[16]

We have documented a nationwide trend towards adoption of EMS routing protocols, which may be a mechanism of improving quality of stroke care. For hospitals to participate in these systems they would have to achieve some form of certification, such as local EMS approval or certification from the Joint Commission as a PSC. Adoption of the EMS routing protocols will drive greater EMS provider training in stroke recognition tools and dispatch operator training in stroke recognition.[17] A preliminary study in California seems to indicate that EMS routing protocols may be a driver of hospital PSC designation. Once a hospital learns it will be bypassed with the new protocol, there is more incentive to be certified as a PSC to maintain business.[18]

Future directions of stroke systems of care include expanding systems of comprehensive stroke centers and considerations of t2-tier systems of stroke routing.[19] Future directions of research should focus on analysis of patient-level data to understand the effect of adopting of EMS stroke-routing protocols on various stroke outcomes. This would include comparing rate of TPA use per stroke hospitalization and discharge outcomes in areas with and without EMS routing protocols. As greater proportions of acute stroke hospitalizations are occurring in states covered by EMS routing protocols, we can expect improvements in the overall quality of care and greater implementation of the entire spectrum of stroke systems of care, from patient recognition to EMS activation, dispatch, stroke recognition, transport, pre-notification, and ED/hospital treatment.

LIMITATIONS

There are limitations in this study. The category of "stroke" depends on accurate coding of ICD-9CM codes to properly capture pathology. Misidentification may lead to a systemic bias of certain codes in the cerebrovascular population. The legislation adopting EMS regional systems of stroke care was regulated on the state or county level. However, in this study we did not assess or investigate the actual implementation of this practice at the local EMS level; geographic areas implementing EMS stroke protocols includes areas that may not have primary stroke centers available. Another factor to consider is the transportation proportion, which includes patients that were transferred from one hospital to another and includes patients that insisted on a different hospital preference.

CONCLUSION

Over half of the U.S. stroke hospitalizations are in states supported by organized stroke systems of care, demonstrating the progress towards full coverage of stroke care. Extended access to comprehensive stroke care for all stroke patients in the U.S. is an achievable goal, if stroke organization leaders, national EMS and medical directors, and legislators continue to work towards a proficient and an effective stroke care system.

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Emergency Physician Awareness of Prehospital Procedures and Medications

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Introduction: Maintaining patient safety during transition from prehospital to emergency department (ED) care depends on effective handoff communication between providers. We sought to determine emergency physicians' (EP) knowledge of the care provided by paramedics in terms of both procedures and medications, and whether the use of a verbal report improved physician accuracy.

Methods: We conducted a 2-phase observational survey of a convenience sample of EPs in an urban, academic ED. In this large ED paramedics have no direct contact with physicians for non-critical patients, giving their report instead to the triage nurse. In Phase 1, paramedics gave verbal report to the triage nurse only. In Phase 2, a research assistant (RA) stationed in triage listened to this report and then repeated it back verbatim to the EPs caring for the patient. The RA then queried the EPs 90 minutes later regarding their patients' prehospital procedures and medications. We compared the accuracy of these 2 reporting methods.

Results: There were 163 surveys completed in Phase 1 and 116 in Phase 2. The oral report had no effect on EP awareness that the patient had been brought in by ambulance (86% in Phase 1 and 85% in Phase 2.) The oral report did improve EP awareness of prehospital procedures, from 16% in Phase 1 to 45% in Phase 2, OR=4.28 (2.5-7.5). EPs were able to correctly identify all oral medications in 18% of Phase 1 cases and 47% of Phase 2 cases, and all IV medications in 42% of Phase 1 cases and 50% of Phase 2 cases. The verbal report led to a mild improvement in physician awareness of oral medications given, OR=4.0 (1.09-14.5), and no improvement in physician awareness of IV medications given, OR=1.33 (0.15-11.35). Using a composite score of procedures plus oral plus IV medications, physicians had all three categories correct in 15% of Phase 1 and 39% of Phase 2 cases ($p<0.0001$).

Conclusion: EPs in our ED were unaware of many prehospital procedures and medications regardless of the method used to provide this information. The addition of a verbal hand-off report resulted in a modest improvement in overall accuracy. [West J Emerg Med. 2014;15(4):504–510.]

INTRODUCTION

Paramedics are responsible for bringing a significant number of patients into the emergency department (ED) and provide many different procedures and medications in the prehospital phase of care. The 2011 National Emergency Medical Services (EMS) Assessment estimates that there are 203,807 paramedics currently working in the United States. The 33 states that maintain EMS procedure formularies list a total of 31 different procedures. The 25 states that maintain EMS medication formularies list 29 different categories of medications.[1]

Patient safety should be a high priority during the critical transition from paramedic to emergency physician (EP). It is important for the EPs assuming care to be aware of what

treatments and medications were provided to their patients prior to ED arrival. This study was inspired by a change made in ED triage process at our increasingly busy urban teaching hospital. Previously, the paramedics would bring the patient into the ED after triage and have the opportunity to speak to the EP who would assume care of the patient. However, due to unacceptably long ambulance turnaround times, EMS was instructed to leave the patient with the triage nurse and provide details of their prehospital treatments and procedures there. This practice eliminated any face-to-face contact with the physician.

Patients brought by ambulance are more likely to be acutely ill or at risk and have more complicated medical histories than patients who walk in.[2,3] Emergency patients in general are more likely to have information gaps that lead to increased length of stay in the ED.[4] In cases in which paramedics provide significant prehospital interventions and medications under standing orders, the failure to transmit accurate information about what was done prior to ED arrival increases the potential for error.

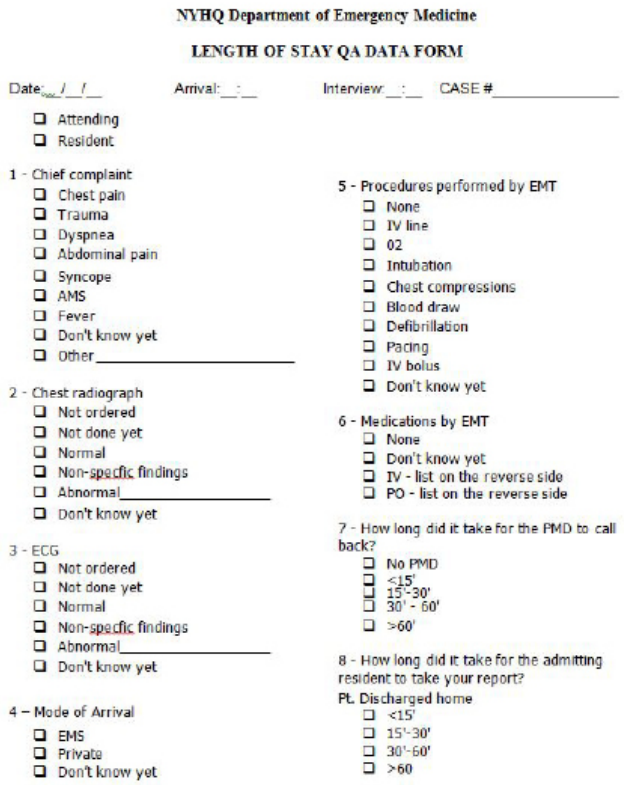
Increasing attention is being paid to transitions in patient care, and in particular, to handovers from one provider to another. Research has shown that these transitions are areas in which loss of information or poor communication can affect patient safety, lead to medical errors, and cause patient harm.[5,6] Much of the research in this area involves transfers within a specialty or after a procedure, e.g., resident to resident at shift change, or from the operating room to the recovery room.[7,8] In an effort to reduce errors and improve patient safety, the Joint Commission made a standardized approach to handoffs a national patient safety goal.[9]

Relatively little research exists on the handoff of patients from the outside to the inside, i.e., from the prehospital care provider to the ED. One such study on trauma patients showed that only 72.9% of the information verbally transmitted by the prehospital providers was received by the ED staff. Significant data such as prehospital hypotension and prehospital Glasgow Coma scale were received less than half the time.[10]

We sought to determine what effect the change in our triage process had on physician awareness of prehospital procedures and medications. We then attempted to replicate a face-to-face encounter between the paramedic and the EP, using research assistants (RA), to see if this would improve physician awareness of prehospital interventions.

METHODS

We conducted a 2-phase observational survey of a convenience sample of EPs at an urban teaching hospital with an annual census of 120,000 patients per year at the time of the study. The ED is a Level 1 Trauma Center and a STEMI/Stroke Center, and has an emergency medicine residency program. Thirty-five percent of ED patients are brought in by ambulances that are staffed by a mix of agencies -- the Fire Department of New York, voluntary hospitals, and private ambulance services. All advanced life support (ALS) ambulances participating in the 911 system are staffed with 2 paramedics; generally the private ALS ambulances have one paramedic and one emergency medical technician (EMT). Ambulance patients are triaged and then brought back to see a physician immediately; they are not sent to the waiting room. Patients were seen by a resident physician (usually emergency medicine) or physician's assistant with attending physician supervision, or by an attending physician alone.



NYHQ Department of Emergency Medicine

LENGTH OF STAY QA DATA FORM

Date:__/__/__ Arrival:__:__ Interview:__:__ CASE #_____

- ❑ Attending
- ❑ Resident

1 - Chief complaint
- ❑ Chest pain
- ❑ Trauma
- ❑ Dyspnea
- ❑ Abdominal pain
- ❑ Syncope
- ❑ AMS
- ❑ Fever
- ❑ Don't know yet
- ❑ Other_____

2 - Chest radiograph
- ❑ Not ordered
- ❑ Not done yet
- ❑ Normal
- ❑ Non-specfic findings
- ❑ Abnormal_____
- ❑ Don't know yet

3 - ECG
- ❑ Not ordered
- ❑ Not done yet
- ❑ Normal
- ❑ Non-specfic findings
- ❑ Abnormal_____
- ❑ Don't know yet

4 – Mode of Arrival
- ❑ EMS
- ❑ Private
- ❑ Don't know yet

5 - Procedures performed by EMT
- ❑ None
- ❑ IV line
- ❑ 02
- ❑ Intubation
- ❑ Chest compressions
- ❑ Blood draw
- ❑ Defibrillation
- ❑ Pacing
- ❑ IV bolus
- ❑ Don't know yet

6 - Medications by EMT
- ❑ None
- ❑ Don't know yet
- ❑ IV - list on the reverse side
- ❑ PO - list on the reverse side

7 - How long did it take for the PMD to call back?
- ❑ No PMD
- ❑ <15'
- ❑ 15'-30'
- ❑ 30' - 60'
- ❑ >60'

8 - How long did it take for the admitting resident to take your report?

Pt. Discharged home
- ❑ <15'
- ❑ 15'-30'
- ❑ 30'-60'
- ❑ >60

Figure 1. Survey used in study. Reverse side listed all possible prehospital medications and procedures.

We included cases in our study when an RA was available. They were limited to patients treated by paramedics, since basic level EMTs perform few interventions. We excluded critical cases brought directly to our trauma room,because in these cases the physician usually met the paramedic upon arrival to the ED. The RA identified these patients at triage and then surveyed the EP (resident or attending) caring for them (Figure 1). The survey was done about 90 minutes after patient arrival, to give the physician the opportunity to see the patient and review the nursing triage note and the written prehospital care report (PCR). The PCR is generally available and attached to the chart within 15 minutes of patient arrival. The 2 physicians involved in the study were excluded from participating in it.

Using a written survey, the RA asked the physician whether the patient had arrived by ambulance (100% had -- this was to test physician awareness of this fact), which of 3 prehospital procedures were done (oxygen, intravenous [IV], blood draw), whether or not any medications were given, and

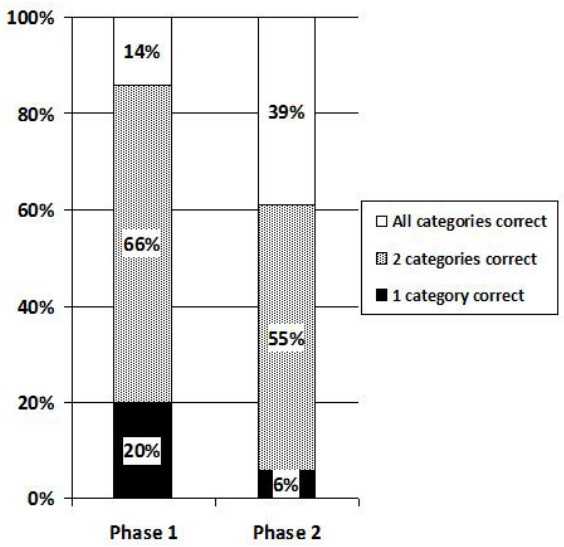


Figure 2. Awareness by surveyed providers for 3 broad categories: procedures, specific oral medications, and specific intravenous medications.

the specific names of the oral and intravenous medications given. The physicians were not aware that a study was being undertaken. The survey was labeled as an ED throughput survey, with 7 other random questions, such as chest x-ray result and time to contact an admitting resident, interspersed with the study questions. This was done to prevent a change in physician behavior if they could easily determine the true purpose of the study. We knew in advance that many of the procedures listed, such as cardioversion, would never be checked off since critical patients were excluded; this was a further effort to blind the physicians to the purpose of the study. In addition, the surveys were done no more than once per week to avoid the physicians becoming overly familiar with the survey. All questions included the answer "don't know yet" to avoid blanks and guessing on the part of the physician. Although we did not anticipate initially that physician assistants would participate in the study, some did, and in these cases the RA wrote "PA" on the survey to identify them.

In Phase 1, with our usual triage process, the paramedics gave their verbal report to the triage nurse and had no contact with the physician. The triage nurse did not give a verbal report of EMS treatment to the physician. The physicians could obtain information about prehospital care from the triage nurses' notes contained within the electronic medical record and from the paramedics' written PCR. We did not record whether or not the physician used either of these sources of information.

In Phase 2, an RA stationed at triage listened to the paramedic present to the triage nurse and took notes. The RA then transported the patient back to the assigned bed in the ED and found the physician (resident or attending) who would be assuming care of the patient, much as a paramedic would. The RA would then give the "report" on the patient's prehospital care to the treating physician. The report given by the RA repeated the paramedic's presentation as close to verbatim as possible, using the notes taken at triage. The goal was for the RA to replicate the paramedic's standard practice of giving an oral report directly to the physician, since our large, busy ED was unable to accommodate this practice. About 90 minutes later, the physician was surveyed by the same RA to determine awareness of prehospital interventions.

Only 2 RAs, both premedical students, were used for Phase 2 due to the complexity of the task. Procedures and medical terms were reviewed with them prior to the start of Phase 2. If the physician had left due to shift change, the survey was not performed. There was a 1-year gap between the end of Phase

Table 1. Demographics of patients in study of physician awareness of prehospital interventions.

	Phase 1	Phase 2	p-value
Total number	163	116	
Age mean (+/-SD)	71 (18)	68 (20)	0.1
Male (%)	88 (54%)	50 (43%)	0.07
Chief complaint (%)			
Abdominal pain	7 (4.3%)	8 (6.9%)	0.34
Altered mental status	21 (12.9%)	5 (4.3%)	0.02
Chest pain	32 (19.6%)	20 (17.2%)	0.61
Dizzy/weak	9 (5.5%)	10 (8.6%)	0.31
Dyspnea	29 (17.8%)	26 (22.4%)	0.34
Fever	5 (3%)	2 (1.7%)	0.48
GI Bleed	2 (1.2%)	2 (1.7%)	0.73
Musculoskeletal pain	4 (2.5%)	5 (4.3%)	0.39
Nausea/vomiting	5 (3%)	2 (1.7%)	0.48
Other	27 (16.6%)	20 (17.3%)	0.88
Seizure	2 (1.2%)	3 (2.6%)	0.90
Syncope	15 (9.2%)	9 (7.8%)	0.67
Trauma	5 (3%)	4 (3.5%)	0.86
Provider completing survey			
Attending physician	96 (59%)	53 (46%)	0.03
Resident physician	34 (21%)	50 (43%)	<0.0001
Physician assistant	7 (4%)	7 (6%)	0.51
Not recorded	26 (16%)	6 (5%)	0.005
Number of PCR's showing actual treatment was given			
Procedures	152 (93%)	102 (88%)	0.002
Oral medications	27 (17%)	21 (18%)	0.9
Intravenous medications	21 (13%)	4 (3%)	0.07

PCR, prehospital care report; *GI*, gastrointestinal

Table 2. Proportion of correct responses by surveyed providers in each phase.

	Phase 1 (n=163)	Phase 2 (n=116)	p-value	Odds ratio (confidence interval)
Mode of arrival (%)	140 (86%)	99 (85%)	0.89	1.04 (.53- 2.05)
Correctly name procedures	26 (16%)	52 (45%)	<0.0001	4.28 (2.45-7.46)
Correctly report if any medications were given	125 (77%)	96 (83%)	0.21	1.45 (.79-2.66)

1 and the start of Phase 2. Despite the gap, the attending group of providers and the physician assistant group of providers remained essentially the same, although the resident group changed as residents graduated and new ones started.

The PCR was copied and attached to the survey. At a later date, one experienced EP (R.W.) extracted data from every Phase 1 and Phase 2 PCR. Data extracted included actual procedures performed: oxygen (O2), IV placement, and blood draws. The EP also recorded which oral, nebulized, IV and intramuscular (IM) medications were administered. The PCRs were generally legible, and procedures and medications are listed on a flowchart, so data collection was straightforward. To simplify the analysis, and due to small numbers in each category, oral and nebulized medications were grouped together, as were IV and IM medications. The oral medications included albuterol, aspirin, oral glucose and nitroglycerin. The IV medications included adenosine, dextrose, furosemide, glucagon, magnesium, morphine, naloxone, and thiamine.

We analyzed data by using a direct comparison of the survey questions versus the data extracted from the PCR. The survey questions were either a correct match with a value of "1" or an incorrect match with a value of "0." To achieve a correct match in the category, the physician needed to be able to relate all that was done - all procedures or all medications. A correct match was also obtained if the physician answered "none" and no procedures had been done, or "none" and no medications had been given. An incorrect match was obtained if the physician answered, "don't know.". We calculated the total score of the 3 categories (procedures plus oral medications plus IV medications) by summing the correct matches of the individual categories.

We performed data analysis using SAS 9.2 for Windows. To test for differences between normally distributed continuous variables, we used the student's t-test. For non-normally distributed continuous variables, the Wilcoxon rank sum test was used. For categorical variables, we used the Chi-Square test or the Fisher's Exact test for cell counts less than five. We calculated odds ratios and 95% confidence intervals for all 2 by 2 tables.

We obtained local institutional review committee approval for all phases of the study, and the requirement for written informed consent was waived.

RESULTS

Over a 3-year period we collected 163 cases in Phase 1 and 116 cases in Phase 2. Phase 1 and 2 patients were well matched for age and gender. The 2 groups overall had similar chief complaints (p=0.544), but when analyzed by specific chief complaint we noted there were significantly more patients with altered mental status in Phase 1 (p=0.02) Resident physicians responded to a higher percentage of surveys in Phase 2 than in Phase 1 (p<0.0001) The 2 groups received a similar percentage of medications (p=0.9 oral, p=0.07 IV) but had more procedures performed in Phase 1 (p=0.002) (Table 1).

The report from RA to physician had mixed results in physician awareness of prehospital interventions, as summarized in Table 2. For the first question, whether the report improved physician awareness that the patient was brought in by ambulance, no improvement was evident. In Phase 1, the physicians correctly identified the mode of arrival as being by ambulance in 86% of cases, and in Phase 2 in 85% of cases OR=1.04 (0.53-2.05). In the remainder of the cases, the physicians either did not know or thought the patient had been brought in by private car. The report did seem to improve physician awareness of procedures performed. The physicians were able to identify all procedures performed in 16% of the Phase 1 cases and 45% of the Phase 2 cases OR=4.28 (2.5-7.5).

One of the most important questions we sought to answer was how aware EPs are of the specific prehospital medications administered, and if the RA verbal hand-off report improved this knowledge. A variety of oral and IV medications were given and are listed in Table 3. When we analyzed all cases, including cases for which no medications were given, we found that the report did not improve overall awareness of whether or not a medication in any form (oral or IV) was given by EMS. The physicians were able to answer this question correctly in 77% of Phase 1 and 83% of Phase 2 cases, OR=1.5 (0.8-2.6). This high percentage of correct answers was mainly due to the fact that no medications were given most of the time, so a guess of "none" was often correct. The report did not improve awareness for any individual medications, with no significant p-values (Table 3).

When we excluded the correct "none" answers and analyzed only cases in which a medication was given by EMS, physician awareness of the specific medications was low (Table 4). The report modestly improved physician accuracy in naming all oral medications given, from 18% in Phase 1 to 47% in Phase 2, OR=4.0 (1.09-14.5). The report had no effect on physician accuracy for naming all IV medications given, with a rate of 42% in Phase 1 and 50% in Phase 2, OR=1.33 (0.15-11.35), thus with a confidence interval including one.

To analyze overall effectiveness of the report, we used a composite score that included procedures, specific names of all oral medications, and specific names of all IV medications.

Table 3. Summary of medication awareness by surveyed providers.

	Phase 1 provider correct	Phase 2 provider correct	p-value
	n (%)	n (%)	
Oral medications			
None	105/136 (77%)	82/95 (86%)	0.08
Albuterol	2/6 (33%)	2/4 (50%)	1.0
Aspirin	2/8 (25%)	5/6 (83%)	0.10
Nitroglycerin	0/1 (0%)	0/1 (0%)	--
Oral glucose	0/0	1/1 (100%)	--
Aspirin + nitroglycerin	1/12 (8%)	2/9 (22%)	0.55
Intravenous medications			
None	103/142 (72%)	81/112 (72%)	0.97
Adenosine	2/3 (67%)	0/0	--
Dextrose	1/2 (50%)	1/2 (50%)	1.0
Furosemide	2/3 (67%)	0/0	--
Glucagon	2/3 (67%)	0/0	--
Magnesium	0/1 (0%)	0/0	--
Morphine	0/0	1/2 (50%)	--
Naloxone	0/1 (0%)	0/0	--
D50 + thiamine	3/6 (50%)	0/0	--
D50 + thiamine + glucagon	0/1 (0%)	0/0	--
D50 + thiamine + naloxone	0/1 (0%)	0/0	--

Table 4. Providers' complete awareness of all oral and intravenous medications given.

	Phase 1 provider correct	Phase 2 provider correct	p-value	Odds ratio (confidence interval)
	n (%)	n (%)		
Provider correctly identified all oral medications	5/27 (18%)	10/21 (47%)	0.03	4.0 (1.09-14.5)
Provider correctly identified all intravenous medications	9/21 (42%)	2/4 (50%)	0.79	1.33 (.15-11.35)

This score ranged from "0" if none of these date were correctly reported, to "3" if all were correct. The physicians reported all 3 categories of data correctly in 14% of phase 1 and 39% of phase 2 cases ($p<0.0001$). (Figure 2) The mean score was 1.95 out of three in Phase 1 and 2.32 out of 3 in Phase 2 ($p<0.0001$).

DISCUSSION

Physician awareness of prehospital treatments in our study was improved by a verbal hand-off report, but there was significant information loss in both phases of the study. Similar results to our study were found in an investigation of hand-offs between paramedics and the trauma team. In that study, information least likely to be documented by trauma team members was treatment provided in the prehospital setting. Overall there was loss of 9% of available information.[11]

This is consistent with previous reports which show that even when using standardized approaches to hand-off, there is information loss.[12] The implications of this data loss, particularly as it regards medication administration, are concerning. Previous studies have shown that medication hand-off errors are common, and a significant percentage of ED visits may be related to medication-related complications.[13,14] Physicians who are unaware of medication given by prehospital providers have the potential to double-dose, overdose, or fail to appreciate response or lack of response to treatment. It also represents a significant failure to address a recent Joint Commission patient safety goal to use medicines safely.[15]

Survey studies of prehospital and ED providers on the transition of care from prehospital to ED found that ambulance crews felt ED staff paid attention to their handovers only 24.2 % of the time. ED staff, on the other hand, were satisfied with the quality of the information

received 35% of the time.[16] The ideal handover with respect to communication of information involved patients with distinct medical problems as opposed to those with significantly more complex medical issues.[17] This is consistent with a previous study that revealed that more errors occurred when longer hand-off times were recorded per patient, and fewer occurred when written or electronic support material was used.[18] As in our study verbal communication, no matter how it is given, often loses much in transition.

When the ED staff shows a lack of appreciation for the information provided by paramedics regarding their prehospital care, this is a failure of teamwork. The physicians and paramedics, having differing levels of ability, fail to communicate effectively. In a prior study, this teamwork breakdown was shown to be a factor in 70% of closed malpractice claims involving trainees and medical errors.[19]

Some have suggested that hand-off tools may improve transfer of care, but others have failed to corroborate this – highlighting the need for further work in this area.[10,12,18,20] Communication programs that include workshops, teamwork training, or simulation-based handoffs have been used to reduce information loss and may be a promising area of further research.[18]

LIMITATIONS

The foremost limitation of this study is the heterogeneity in treatment received between Phase 1 and Phase 2 patients. There were fewer procedures done and IV medications given to Phase 2 patients as compared to Phase 1. These differences seem mostly due to the much lower percentage of patients with the chief complaint of altered mental status in Phase 2; the reasons for this change in patient population are not clear. Since the answer of "none" was considered a correct answer, this may have biased the results in favor of greater accuracy of the report as more subjects in Phase 2 received no medications at all. A possible direction for a future study would be to conduct Phases 1 and 2 simultaneously on alternating days to avoid the influence of changes in patient chief complaints between data-collection periods.

In addition to treatment heterogeneity, Phase 2 patient surveys were more commonly completed by a resident rather than an attending physician. This difference in level of experience could affect results, as could the mix of emergency medicine and off-service residents on any given shift. Another limitation would be the possibility of change in physician behavior to pay more attention to the written PCRs because they know that they were to be surveyed (the Hawthorne Effect). We mitigated this by masking the true purpose of the survey (including questions that were irrelevant to the study), instituting a 1-year gap between Phases 1 and 2, and collecting data only once per week. This convenience sampling, while helpful at preventing the Hawthorne Effect, could introduce bias. We varied the data collection times in an effort to avoid this. Additionally, we did not quantify data lost due to physician shift change or physician refusal to participate in the study, although we were not aware of any problems with cooperation.

Although we tried to recreate the direct hand-off from paramedic to physician, as occurs in other EDs, the RA involvement is not ideal. The RAs may have been perceived by physicians as extraneous to patient care and might have been afforded less attention than a paramedic would have received. They also may have omitted some of the information given by the paramedic to the triage nurse. Lastly, the transition process is necessarily specific to the receiving institution, the EMS system, and other local factors such as setting and census. Hence our observations might not be generalizable to other facilities.

It is important to note that we did not measure what other information, such as patient history, was lost in translation either from paramedic to triage nurse/RA or from RA to physician. We did not measure what effect information loss had on ultimate patient outcome, and whether there were adverse outcomes due to physicians not being aware of prehospital treatment. As highlighted previously by other investigators, further research is needed to identify what methods optimize information transfer during transitions of care.

CONCLUSION

Physicians in our ED were unaware of many prehospital procedures and medications given to their ED patients regardless of the method used to provide this information. The addition of a verbal hand-off report resulted in a modest improvement in overall accuracy.

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Multidimensional Attitudes of Emergency Medicine Residents Toward Older Adults

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Introduction: The demands of our rapidly expanding older population strain many emergency departments (EDs), and older patients experience disproportionately high adverse health outcomes. Trainee attitude is key in improving care for older adults. There is negligible knowledge of baseline emergency medicine (EM) resident attitudes regarding elder patients. Awareness of baseline attitudes can serve to better structure training for improved care of older adults. The objective of the study is to identify baseline EM resident attitudes toward older adults using a validated attitude scale and multidimensional analysis.

Methods: Six EM residencies participated in a voluntary anonymous survey delivered in summer and fall 2009. We used factor analysis using the principal components method and Varimax rotation, to analyze attitude interdependence, translating the 21 survey questions into 6 independent dimensions. We adapted this survey from a validated instrument by the addition of 7 EM-specific questions to measures attitudes relevant to emergency care of elders and the training of EM residents in the geriatric competencies. Scoring was performed on a 5-point Likert scale. We compared factor scores using student t and ANOVA.

Results: 173 EM residents participated showing an overall positive attitude toward older adults, with a factor score of 3.79 (3.0 being a neutral score). Attitudes trended to more negative in successive post-graduate year (PGY) levels.

Conclusion: EM residents demonstrate an overall positive attitude towards the care of older adults. We noted a longitudinal hardening of attitude in social values, which are more negative in successive PGY-year levels. [West J Emerg Med. 2014;15(4):511–517.]

INTRODUCTION

Older adult patients constitute an average of 25-30% of current emergency department (ED) volumes.[1] This is predicted to increase to over 60% at some sites by 2030.[2] The demand, acuity, and complexity of older patients strain ED services and are more likely to result in adverse health outcomes experienced by this population.[3,4]

Non-emergency medicine residents have been shown to underestimate the influence of an aging society on their careers, and report they do not enjoy caring for older patients due to the chronic, complex nature of their conditions, need for frequent family communication, and time pressures in their care.[5] This is concerning as the attitude of the trainee is key to providing better care to older adults.[6] Existing literature on the attitudes of medical trainees toward these older adults shows a wide variance from negative to positive.[7-9] Attempts to enhance attitudes toward older adults through training have been studied.[4,10] The objectives of these training efforts have focused on improving attitudes toward older persons and their care as well as on increasing specific geriatrics knowledge and skills.[11-13] The call to improve emergency medicine (EM) training for this population has

resulted in many innovative curricula. [14-19] However, studies have demonstrated little or no relationship between geriatrics knowledge and attitudes.[2,8,21] No studies have been done on baseline EM resident attitudes regarding elder patients.

We examined baseline attitudes of EM residents at 6 EM residency programs.

OBJECTIVES

Our goal was to identify principle dimensions of baseline EM resident attitudes toward older adults using multidimensional analysis.

METHODS

Six EM residencies participated in this study. We administered a survey for measuring resident attitudes toward older adults by Surveymonkey® in the summer and fall of 2009. Participation in this study was completely voluntary and anonymous; and approval was obtained from each local institutional review board. The only demographic information collected was the participants' program name and level of training.

We used factor analysis to analyze interdependence of attitudes. Factor analysis combines variables within the attitude questions to create a smaller set of independent factors.[24] Factor analysis was used to group attitudes according to their correlation, thus reducing the number of attitudes from the 21 questions administered to a manageable 6 independent attitude dimensions. This allows conclusions relevant to single independent attitudes as opposed to question- based conclusions, which may combine several attitude traits.

Participants

Beginning July 1, 2009, in staggered fashion by program, we invited EM residents and fellows from 6 university- and community-based academic EM training programs to participate in this study. We sent a survey to 287 eligible residents and fellows. The final survey was closed April 1, 2010.

Survey Instrument

We based this instrument on previous work by Lee et al, who validated a multidimensional analysis survey measuring geriatric attitudes of primary care residents and fellows.[22] This instrument was adjusted from Lee's original 14 questions, to a 21-question survey with 7 additional EM-specific questions. These additional questions provide EM-specific insight clarifying EM resident attitudes toward training and didactics in the geriatric competencies for EM residents. In addition, these questions establish a first look at resident attitudes concerning the structure, systems and operations of EDs in the care of elder patients. Scoring was performed on a 5-point Likert scale with 1 being the least positive toward the elderly and 5 being the most positive toward the elderly. The numeric values of negatively worded questions were reversed so overall positive attitudes were consistently valued at the highest number of 5.

Data Analysis

We used factor analysis to abstract the principal dimensions of elderly attitude. From the correlated individual questions, principal components (a set of new linearly uncorrelated variables) were derived and then transformed by Varimax rotation so that the factor loading matrix has as simple a structure as possible. This results in any given question with high loading on a single factor but near zero loading on the remaining factors. Varimax rotation has been shown to be successful for this transformation.[23] We also calculated Cronbach alpha, an estimate of the internal consistency reliability based on the average correlation among items, for the attitudes analysis as a whole and the subscales measuring the 6 dimensions identified as a result of the factor analysis. Using a regression method, we derived factor scores for all the principal components for each participant. We compared mean factor scores using Student t, and scores among the different training levels were compared using ANOVA. Statistical significance was defined at 0.05. We performed all calculations using SPSS version 10.1 (SPSS, Inc. Chicago, Illinois).

RESULTS

Demographics

A total of 287 attitude surveys were sent, with 173 (60.3%) competed and returned. Among the 6 programs, the participation rate varied from 46.8% to 97.4%.

There was even distribution between post-graduate year (PGY) 1 (27.7%), PGY2 (26.6%), and PGY3 (30.1%) residents. There were 15.6% (27) PGY4 and PGY5 residents.

Table 1 shows the mean resident scores on the 21-survey questions. Residents demonstrated an overall mean score of 3.79, which suggests EM residents have an overall positive attitude toward older adults. For example question 10, pain medication prescribing, has a baseline score of 4.30, which suggests EM residents are aware of special pain needs in older adults. In question 4 we see EM residents in general do believe that it is society's responsibility to provide care for the elderly (score 4.05). In question 13 they demonstrate understanding of the slower pace of elders (score 4.09).

Factor Analysis

The loadings of the geriatric attitude questions in factor analysis are shown in Appendix 1. We identified 6 factors, accounting for 55.2% of the total variance of the sample. These factors were labeled "social value," "medical care," "residency training," "compassion," "geriatric education," and "resource distribution." Appendix 1 gives the individual loading coefficient used to calculate the contribution of that question to the total factor score.

The area of social value represented the greatest number of questions asked, resulting in high loading onto that factor, largest amount of variance explained by that factor, and the best internal reliability of the 6 factors (Cronbach). Social value was

Table 1. Mean scores on 21-question attitude survey of emergency medicine (EM) residents regarding treatment of geriatric patients.

Attitude question	Mean score
1. Most old people are pleasant to be with.	3.65
2. The federal government should reallocate money from Medicare to research on acquired immunodeficiency syndrome (AIDS) or pediatric disease.	3.72
3. If I have the choice, I would rather see younger patients than elderly ones.	2.75
4. It is society's responsibility to provide care for its elderly persons.	4.05
5. Medical care for old people uses up too much human and material resources.	3.00
6. As people grow older, they become less organized and more confused.	2.85
7. Elderly patients tend to be more appreciative of the medical care I provide than are younger patients.	3.32
8. Taking a medical history from elderly patients is frequently an ordeal.	2.38
9. I tend to pay more attention and have more sympathy towards my elderly patients than my younger patients.	3.04
10. Old people require special attention when prescribing pain medication.	4.30
11. Treatment of chronically ill old patients is hopeless.	3.72
12. Old persons don't contribute their fair share towards paying for their health care.	3.98
13. In general, old people act too slow for modern society.	4.09
14. Mild to moderate changes in mental status are not important in the emergency department and are better dealt with by inpatient services.	3.74
15. The current structure of emergency departments is well suited to care for our nation's elderly.	3.96
16. EM residents are well trained to care for elderly patients.	2.92
17. Sepsis guidelines will do little to improve care of elderly patients in the emergency department (ED).	3.80
18. Geriatric lectures will do little to improve the care elderly patients in the ED.	3.87
19. Systems and operations in the ED need to be adapted for the large influx of elderly patients.	3.82
20. My residency training has completely prepared me to care for the elderly ED patient.	3.10
21. I have little need for additional training in geriatric issues.	3.84
Total all 21 questions	3.79

Code: 1 = least positive attitude toward elderly 5 = most positive attitude

followed by medical care and residency training, as there were a larger number of questions attributable to these 3 factors. The overall internal validity of the factor analysis was 1.0, confirming that if this factor analysis to be repeated the results would be the same. The internal validity (Cronbach Alpha) of Lee's original 14 questions was .626, while with the addition of 9 new questions, the entire 21-question survey had Cronbach of .640, indicating no change with the addition of the new EM-specific questions.

Factor Scores

The factor scores in Table 2 demonstrate the baseline attitudes of EM residents. The mean factor score is 3.79 with 3.0 representing a neutral position. Overall the residents had positive attitudes in each of the 6 dimensions at baseline. Residents had the least positive attitude regarding compassion in care of the elderly.

Comparison of the Factor Scores

The baseline factor scores of residents in various stages of training are compared in Table 3. When combining the 6 dimensions and analyzing overall attitude PGY1 residents trended ($p=0.063$) toward more positive outlook to care for

Table 2. Comparison of factor scores (derived using regression method and rescaled to mean of 3.79).

Factor	Mean
Social value	3.90
Medical care	3.83
Residency training	3.79
Compassion	3.69
Geriatric education	3.74
Resource distribution	3.77
Overall	3.79

the elderly patient, especially in attitudes regarding the social value of older adults.

DISCUSSION

Attitudes can be defined as a complex mental state involving beliefs, feelings, values, and dispositions to act in certain ways.[24] Attitudes can change as a function of experience, knowledge and social influences, which are behavioral, cognitive, and affective-based.[25] Medical educators are interested in attitudes because human action is influenced by attitude.[26-28] Medical professionals responsible for the care of older adults understand resident and staff attitudes greatly affect both the quality of treatment of older people and the regard given them, and attitudes clearly affect the standard of care delivered.[6,29-31] Attitudes toward older adults were associated positively as knowledge of this population increased.[8] Knowledge of existing attitudes is therefore essential to determine if these attitudes will help achieve satisfactory ends or if attitudes should be altered in an attempt to enhance care.

Our study found the overall attitude of EM residents toward older adults was positive. This is in keeping with studies of internal medicine residents by Kishimoto,[10] Lee,[22] Helton,[5] and Ahmed. [32] Bragg surveyed family medicine program directors in 2001 and 2004; 32.1% reported residents' attitudes as a significant barrier to resident education in 2001. By 2004 these directors cited resident attitude as a barrier in just 3.6%.[33]

Ahmed concluded that since most of the residents had fairly good attitudes toward older patients at baseline, they were unable to show a significant change in attitude with their educational intervention.[32]

Despite our encouraging findings, review of the EM literature still shows failings in EM management of older adults.[34-38] Many practicing emergency physicians (EP) feel hesitancy when evaluating elders with complaints of weakness, dizziness, or "not feeling well." In 1992 McNamera found for each of 7 clinical presentations (abdominal pain, altered mental status, chest pain, dizziness/vertigo, fever without a source, headache, multisystem trauma), over 45% of practicing EPs have more difficulty in the management of older compared with younger patients.[39] Carpenter reexamined these areas in 2007. The majority of physicians noted all 7 presentations in older adults to use more time and resources than younger populations.[40] EPs in 2007 reported evaluation of older adults with altered mental status, chest pain and dizziness had in fact increased in level of difficulty compared with 1992 data. Understanding that the level of difficulty of a task adversely impacts attitudes toward that task, it seems the attitudes of practicing EPs would be more negative than our study suggests.

This study examines attitudes in programs with clear inter-program variations. Grouping residents from all programs by PGY year helps to control for program-specific variations to provide a clearer picture of attitudes independent of program-specific issues. Our study established deterioration in the attitudes of residents in subsequent PGY levels of training. We demonstrated that the PGY1 residents had the most positive attitude when caring for elderly patients, which raises concerns that residents may become less favorably disposed in caring for elderly patients as training progresses. Perceived behavioral control is the person's belief as to how easy or difficult performance of the behavior is likely to be. The more resources and opportunities individuals think they possess and the fewer obstacles or impediments they anticipate the greater is the perceived control.[27] Greater control leads to more positive attitudes. Residents and colleagues complain of the many medical, social, financial, and communication issues complicating the care of older adults. Is it possible that this experience repeated over time hardens the attitude of more senior emergency care providers? Is it

Table 3. Comparison of factor scores by training level.

Factor	PGY 1 n=48	PGY 2 n=46	PGY 3 n=52	PGY 4/Fellow n=27	p-value*
Social value	4.26	3.89	3.82	3.43	.006
Medical care	4.02	3.78	3.59	4.03	.112
Residency training	4.00	3.50	3.82	3.82	.142
Compassion	3.91	3.72	3.59	3.44	.242
Geriatric education	3.65	3.75	3.67	3.95	.564
Resource distribution	3.66	3.80	3.68	4.06	.373
Overall	3.92	3.75	3.70	3.79	.063

* One way ANOVA
PGY, post graduate year

possible that this increasing negative attitude would be seen in practicing EPs as suggested above?

Previous studies have shown that negative attitudes towards this segment of the population arise from fear and lack of the knowledge and skills needed to care for the elderly patient.[41] EM residency programs showed that 40% of residency directors believed that training in geriatric EM was inadequate, and 53% of residency-trained practicing physicians reported that the amount of time spent on geriatric topics during their residency was insufficient.[39,42] We know that EM resident education in geriatrics has only recently gained attention with programs slowly augmenting training in this area. Therefore, the more senior EPs likely have significantly less training in care of older adults. Again could less preparation and repeated negative experiences harden attitudes toward older adults? As the older adult population grows, we need to be aware of the negative experiences described above and ensure that programs reinforce positive geriatric care experiences to enhance resident attitudes in the care of this challenging and vulnerable population.

We agree with the many educators, clinicians, and patients who have called for an enhanced geriatric curriculum in EM residency training. Additionally, we believe the attitudes of EM residents toward this population should specifically be addressed. This will ensure optimal attitude of trainees as they advance through residency and overcome unconscious incompetence when caring for this population. Future work should focus on attitudes in concert with knowledge and skills to achieve improved care of older adults.

LIMITATIONS

All the residency programs in this study were based in the Midwest limiting generalizability. As with many survey instruments, poor rates of return could create a sample bias as only those residents with more positive attitudes may be motivated to complete them. This also impacts generalizability to the entire population of EM residents. Highly variable rates of return were noted by program. This introduces potential bias effects from different faculty or ED populations on different resident samples. Perhaps EDs that handle older adults particularly well or particularly poorly motivated completion of surveys.

EM residents could easily ascertain the survey sought response to older adult issues and positive responses could be the result of the Hawthorne effect. Use of factor analysis is a limitation since factor analysis is based on correlation alone. Therefore, causal inferences are not possible.

The 7 EM-specific sample questions number 14-21 had not been previously validated and could alter the factor analysis. However, the communality analysis in Table 2 shows how much each question has in common with the other 20 questions. It is evident that the new questions have as much in common with the old questions as the old questions had with each other. Therefore, the new questions fit in quite well with the previously validated questions.

Finally, in comparison to the work by Lee, which measured attitudes of individuals over time, this work measures one point in time. Longitudinal inferences are drawn by comparison of different individuals grouped by PGY year. The validity of such conclusions assumes educational exposure and clinical experiences are reasonably similar in each program over time. This may fail to capture the evolution of attitudes in specific individuals.

CONCLUSION

EM residents demonstrate an overall positive attitude towards the care of older adults. We noted a longitudinal hardening of attitude in social values, which are more negative in successive PGY year levels.

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Impact of the Balance Billing Ban on California Emergency Providers

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Introduction: The objective of this study was to examine reimbursement trends for emergency provider professional services following the balance billing ban in California.

Methods: We conducted a blinded web-based survey to collect claims data from emergency providers and billing companies. Members of the California Chapter of the American College of Emergency Physicians (California ACEP) reimbursement committee were invited to participate in the survey. We used a convenience sample of claims to determine payment rates before and after the balance billing ban.

Results: We examined a total of 55,243 claims to determine the percentage of charges paid before and after the balance billing ban took effect on October 15, 2008. The overall reduction in percentage of charges paid was 13% in the first year and 19% in the second year following the balance billing ban. The average percentage of charges paid by health plans decreased from 91% to 86% from 2008 to 2010. Payments by risk-bearing organizations decreased from 72% to 46% of charges during the same time frame.

Conclusion: Payment rates by subcontracted risk-bearing organizations for non-contracted emergency department professional services declined significantly following the balanced billing ban whereas payment rates by health plans remained relatively stable. [West J Emerg Med. 2014;15(4):518–522.]

INTRODUCTION

Many health plans offer health insurance through health maintenance organizations (HMOs) that in turn provide medical services to enrollees through contracted provider networks. According to a 2011 report by the Kaiser Foundation, almost 16 million Californians were enrolled in HMOs.[1] In California, HMOs are regulated by the Department of Managed Health Care (DMHC). California and a few other states allow health plans to delegate financial responsibility for payment of emergency providers' claims to risk-bearing organizations (RBOs). RBOs are usually medical foundations, medical groups or independent physician organizations that receive fixed periodic payments from health plans.[2] In return, the RBO is responsible for providing healthcare services to health plan enrollees. In California, when a HMO patient receives out-of-network emergency care services, health plans or the delegated RBOs are obligated to pay the non-contracted provider directly for the emergency care rendered.[3] HMO enrollees may receive out-of-network emergency services when the enrollee goes to the nearest out-of-network emergency department (ED) or when the emergency provider in an in-network hospital is not contracted with the health plan.

Payment disputes often occur when the health plan or RBO submits payment that is below the billed amount that a non-contracted provider considers reasonable for the service. To recoup the difference, emergency providers in many states "balance bill" the patient to recover the total amount owed to the provider. According to a 2007 study sponsored by the California Association of Health Plans, over a 2-year period more than 1.76 million insured Californians received balance bills following an ED visit.[4] Several states prohibit emergency providers from balance billing patients for out-of-

Table 1. Balance billing survey questions.

Average percentage of billed charges allowed:
For each non-contracted Knox-Keene plan your practice deals with of significant volume, please calculate the average percentage of billed charges that plan 'allowed,' after all non-legal dispute efforts have been exhausted (closed commercial non-contracted claims only). (e.g., If a plan on average allowed $60 on $100 billed charges, the average percentage of billed charges allowed is 60%.)

network services.[5] Some states, such as Maryland, establish payment standards whereas other states do not specifically establish payment rates.[5] On October 15,2008, the California DMHC issued regulations that defined balance billing as an unfair billing practice when HMOs and certain Knox-Keene regulated PPO plans insure the enrollee.[6] The regulation was intended to leave patients out of billing disputes between the health plans and providers.[7] The California Chapter of the American College of Emergency Physicians (California ACEP) argued that the DMHC did not have jurisdiction to prohibit non-contracting emergency physicians (EP) from balance billing patients.[8] On January 9,2009, the California Supreme Court issued an opinion regarding the legality of balance billing. In this landmark decision involving Prospect Medical Group versus Northridge Emergency Medical Group, the California Supreme Court ruled that emergency providers may not balance bill patients enrolled in Knox-Keene regulated health plans including HMOs and some preferred provider organizations (PPOs) that are regulated by the Department of Managed Health Care.[9,10] The ruling does not apply to health plans that are not regulated by the DMHC, such as Employee Retirement Income Security Act (ERISA) plans and most PPOs. The Prospect decision did not determine the amount that the non-contracted provider should be paid, only that out-of-network providers "are entitled to reasonable payment for emergency services rendered to HMO patients."[9]

Following the balance billing ban that took effect on October 15, 2008, emergency providers were concerned that Knox-Keene-regulated health plans and their delegated payers would have the unfettered ability to unilaterally decide the amount paid for emergency services. California ACEP conducted a survey to determine the impact of the balance billing ban on EPs.

METHODS

This study was funded by a public policy grant from the American College of Emergency Physicians (ACEP). California ACEP conducted a blinded web-based survey in 2012 to determine the impact of the balance billing ban on payments for non-contracted commercial claims. Members of the California ACEP reimbursement committee were asked to participate in the study. Committee members represented over 20 different physician groups or billing companies. Individuals, groups or billing companies representing several groups were allowed to submit claims data. The survey asked EPs or billing companies to report specified claims payment data (Table 1). We obtained a convenience sample of EP and billing companies' claims data to perform the analysis. Any partially completed survey results were included in the analysis. The claims examined included only non-contracted commercial claims for health plans and RBOs regulated by the DMHC. We derived the selection of payers examined in the survey from the DMHC website listing of RBOs and Knox-Keene licensed health plans.[10,11] The survey asked for the percentage of charges paid from June-August 2008, before the balance billing ban took effect, and the same months in 2009 and 2010, after the balance billing ban took effect on October 15, 2008. We determined the average percentage of charges paid by aggregating all of the claims for a payer and dividing the sum of the percentages by the number of claims.

RESULTS

A total of 55,243 claims were available for analysis to determine the percentage of charges paid before and after the balance billing ban (Table 2). Data were available for 12 of 54 health plans listed on the DMHC website and 114 of 291 RBOs. The overall reduction in percentage of charges paid from 2008 to 2010 was 19%. The average percentage of charges paid by health plans from 2008 to 2010 decreased from 91% to 86%. RBOs demonstrated a more dramatic decrease in payment (from 72% to 46% of charges) during the same time frame (Figure).

DISCUSSION

Health plans are required by California law to reimburse emergency providers directly for the reasonable and customary value of emergency services the provider rendered to the health plan's enrollee.[3] Under DMHC regulations, health plans are required to pay a reasonable amount based on a statistically credible database of usual and customary charges that is adjusted annually.[12] Payment must also take the following factors into consideration, which are collectively known as the Gould criteria:[12,13]

1. The provider's training, qualification, and length of time in practice;
2. The nature of the services provided;
3. The fees usually charged by the provider;
4. Prevailing provider rates in the general geographic area in which the services were rendered;
5. Other aspects of the economics of the medical provider's practice that are relevant; and
6. Any unusual circumstances in the case.

This study examined the impact of the balance billing ban

Table 2. Percentage of charges paid before (2008) and after the balance billing ban (2009 & 2010).

Payer category	Number of claims before balance billing ban (2008)	Percentage of charges paid before balance billing ban (2008)	Number of claims after balance billing ban (2009)	Percentage of charges paid after balance billing ban (2009)	Number of claims after balance billing ban (2010)	Percentage of charges paid after balance billing ban (2010)
Health plans	9,101	91.05%	7,557	86.68%	6,528	86.23%
RBO	10,100	72.03%	11,517	56.36%	10,440	46.13%
Total	19,201	81.04%	19,074	68.37%	16,968	61.56%

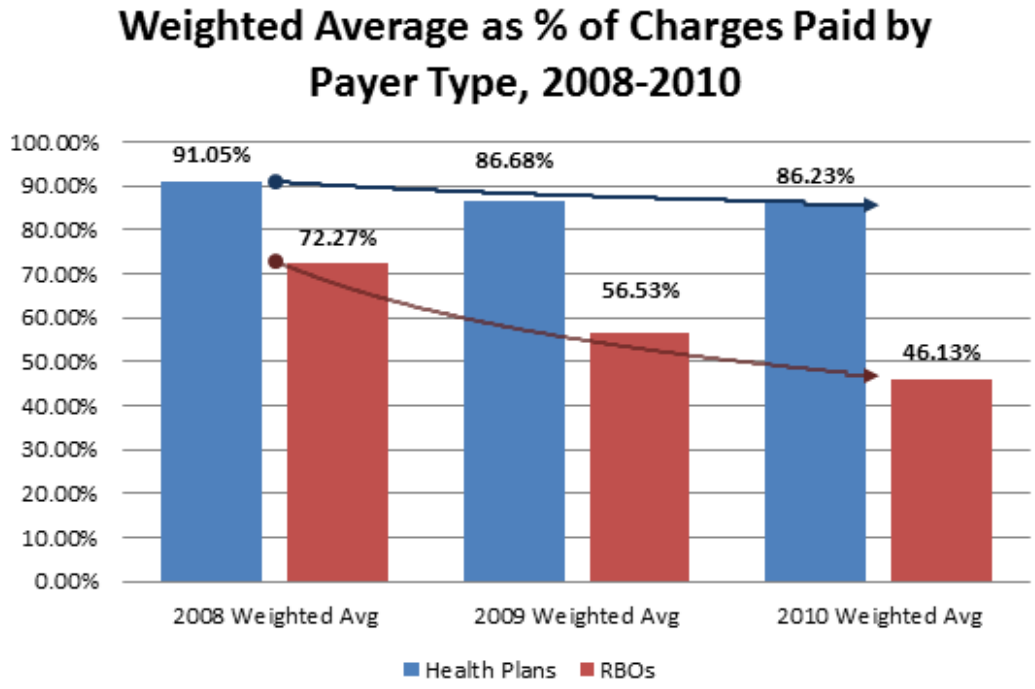
RBO, risk bearing organizations

on emergency providers. Following the balance billing ban, our study indicates that emergency providers did experience a significant decline in percentage of charges by RBOs, whereas percentage of charges paid by health plans remained relatively stable. Data on many health plans were not available, which may be due to the possibility that these health plans were able to secure contracts with most emergency care providers. As a result, the contracted providers would not have any non-contracted claims data to submit to the survey.

Part of the percentage decline could be due to increases in the providers' fee schedules. However, health plans and RBOs are required to adjust payments annually based on a statistically credible database of provider charges, which should mitigate the impact of changes in usual and customary charges on the percentage of charges paid. Health plans, in general, appear to reimburse claims at higher rates and adhered to the Gould criteria more frequently than RBOs.

One possibility for the payment discrepancy is the stricter enforcement of the Gould criteria upon health plans compared to RBOs. For example, in 2005 the DMHC fined Health Net for underpaying emergency care providers.[14] In 2010, the DMHC fined the 7 largest health plans in California for underpaying or incorrectly paying physician claims.[15] Through legal action, the DMHC established statutory authority and regulatory jurisdiction over RBOs and previously issued a cease-and-desist order against a RBO for the underpayment of non-contracted provider claims.[16] However, a review of the DMHC enforcement actions has not revealed any fines against an RBO for underpayment of emergency provider claims.[17] A second possibility for closer adherence to the Gould criteria by health plans is the result of previously successful class action lawsuits against health plans for systematically underpaying physician claims. In 2009 a class action settlement was reached between the American Medical Association and United Healthcare for the underpayment of non-contracted out-of-network provider services.[18]

The balance billing ban did serve the purpose of removing patients from billing disputes between emergency providers and health plans. RBOs, which are not directly regulated by the DMHC, appear to have taken advantage of the balance billing ban by substantially reducing payments to non-contracted emergency providers. Payments by the health



RBO, risk-bearing organization

Figure. Percentages of charges paid before (2008) and after the balance billing ban (2009 & 2010).

plans did not appear to change significantly. However, the issue of fair payment between providers and health plans remains unresolved. A previous attempt to reduce billing disputes in California through fair payment legislation failed when such legislation was vetoed by then-Governor Arnold Schwarzenegger.[19] As a result, the lack of a clear fair payment standard will likely perpetuate billing disputes between providers and health plans.

Reduced emergency provider payments by health plans and RBOs may ultimately impact access to emergency care. By reducing payments to emergency providers in California, physician groups may have more difficulties staffing EDs. Emergency providers may leave California to go to states without a balance billing ban. Specialist may increasingly abandon the emergency department on-call roster. There may be a disproportionate impact on rural hospitals that already face difficulties staffing EDs. Additional studies will be required to determine if the reimbursement trends seen in this study will continue and potentially negatively impact access to emergency care.

LIMITATIONS

There are several limitations to the study given that the survey was conducted in a blinded fashion. Since the survey participants were not asked to identify themselves, the study is unable to determine if the payment patterns are representative of all emergency providers in the state of California. The survey was conducted through the reimbursement committee of California ACEP and non-members were not able to participate. California ACEP does represent approximately 80% of EPs in the state of California. The survey also did not ask how many providers were associated with the claims that were submitted. The data submitted were not reviewed by an independent body to ensure accuracy.

It is possible that the survey was subjected to a selection bias and concentrated in a small percentage of providers. Information technology barriers could have prevented some emergency providers from submitting data for the survey. This might be particularly true for small groups of EPs that conduct self-billing. The survey may not have included small-volume payers. Since a small-volume payer was not defined in the survey, participants used their own judgment of what was considered to be a low-volume payer. Survey participants may have also submitted claims data for small-volume payers that reduced payments and excluded claims data for small-volume payers that did not reduce payment. The degree of this bias cannot be determined from this study.

Claims data for some health plans and RBOs were not available. The most likely explanation is that some health plans and RBOs are widely contracted with emergency care providers and therefore the contracted claims data would have been excluded from the study. The other possibility is that the survey respondents did not provide emergency care to enrollees in a particular health plan or RBO.

One other limitation of the study is the inability to establish a direct cause and effect between the balance billing ban and the decrease in emergency provider reimbursement. Other, unidentified factors may have produced the decreased payment over the time period of the study.

Finally, the reduction in percentages of charges paid may not represent a true reduction in payment per unit of service. For example, payment may not have changed based on a specific common procedural terminology (CPT) code. This explanation is unlikely to be true for RBOs since the reduction in the percentages of charges paid was much greater than the reduction by health plans. A percentage of charges was chosen as the outcome measure to avoid any anti-trust concerns associated with revealing actual charges, and remains a valid way to differentiate the payment policies of plans and RBOs.

CONCLUSION

In conclusion, percentage of charges reimbursed for emergency provider services by RBOs decreased substantially following the prohibition of balance billing in California whereas this measure of reimbursement by health plans remained relatively unchanged. At this time, the impact of a balance billing ban on quality of care cannot be determined. However, there is concern that less stringent enforcement of fair payment standards following balance billing ban will lead to a decline in the financial viability of the emergency care safety, and threaten adequate access to timely and appropriate emergency department care.[20]

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Outlaw Motorcycle Gangs: Aspects of the One-Percenter Culture for Emergency Department Personnel to Consider

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Outlaw motorcycle gangs (OMGs) are an iconic element of the criminal landscape in the United States, the country of their origin. Members of OMGs may present to the emergency department (ED) as a result of motor vehicle accidents or interpersonal violence. When one member of an OMG is injured, other members and associates are likely to arrive in the ED to support the injured member. The extant literature for ED personnel lacks an overview of the culture of OMGs, a culture that promotes the display of unique symbols and that holds certain paraphernalia as integral to an outlaw biker's identity and pride. The objective of this manuscript is to discuss various aspects of the culture of OMGs so that ED personnel may better understand the mentality of the outlaw biker. Knowledge of their symbols, values, and hierarchy can be crucial to maintaining order in the ED when an injured outlaw biker presents to the ED. We used standard search engines to obtain reports from law enforcement agencies and studies in academic journals on OMGs. We present the observations of 1 author who has conducted ethnographic research on outlaw bikers since the 1980s. [West J Emerg Med. 2014;15(4):523–528.]

INTRODUCTION

The emergency department (ED) is at particularly high risk for violence against healthcare workers.[1,2] The arrival of an injured gang member should cause ED personnel to become more vigilant for violent outbursts. The Gang Threat Assessment published by the National Gang Intelligence Center in November 2011 indicates that there are an estimated 1.4 million active street, prison, and outlaw motorcycle gang members in more than 33,000 gangs operating in all 50 American states, the District of Columbia, and Puerto Rico.[3] Outlaw motorcycle gangs (OMGs) are an iconic element of the criminal landscape in the United States, the country of their origin. ED personnel may encounter members of these groups. The authors aim to elucidate certain aspects of the culture of OMGs so that ED personnel can better understand the mentality of the outlaw biker. OMGs present a challenge to ED personnel in that they are well organized and thus able to mobilize their members quickly to assist an injured comrade, and are often impulsive and heavily armed. These gangs have expertise in sophisticated weapons and possess an intricate intelligence network.[4]

Outlaw bikers refer to their organizations as "one-percenter" motorcycle clubs (MC) rather than gangs. The term "one-percenter" originated from a statement made by the American Motorcycle Association in response to a motorcycle rally held in 1947 in Hollister, California, that turned violent.[5] The American Motorcycle Association stated: "99% of the motorcycling public are law-abiding; there are 1% who are not." Thus, the "1%" patch (Figure 1) is worn only by clubs immersed in criminality and large enough to defend the claim to be the "baddest of the bad" against all.[6,7]

CRIMINAL HIERARCHY

Quinn and Forsyth[7] divide one-percenter clubs into 4 categories:

- Support clubs, which have minor to moderate involvement with criminal activity and maintain a relationship with a larger one-percenter club for protection

and to bolster their reputations (e.g., Gray Ghosts MC).

- Satellite clubs, which are created and controlled by members of the larger one-percenter clubs and serve as sources of recruits to the larger clubs; members of a satellite club perform tasks related to the criminal activity of the larger club (e.g., Red Rockers MC).
- Regional clubs, which have limited membership and territory (e.g., Devils Disciples MC); these groups usually have some links to larger one-percenter clubs and may or may not claim one-percenter status.
- The larger one-percenter clubs (e.g., Hells Angels MC, Mongols MC, etc.) are at the top of the criminal hierarchy in the world of the outlaw biker and determine much of its dynamics.

Interclub relations are complex. Interclub affiliations may reflect a temporary alliance (primarily among large clubs) or a partial surrender of a small local club to a larger international club. While many regional clubs have surrendered their "1%" logos, these clubs retain the aggressiveness, impulsivity, and intense personal loyalties that typify the culture of the outlaw biker. Satellite clubs provide an expendable criminal labor force for the larger clubs and serve as proving grounds for men who want to join large international clubs. Furthermore, OMGs are almost entirely white in the U.S., with the exception of the largely Chicano Mongols MC. Many outlaw bikers are racists, and there are strong links between the respective cultures of outlaw bikers and white supremacists.

Black OMGs exist, but these groups operate within a different milieu and have their own symbols and values. OMGs composed of African American or mixed race members are less extreme in their entrepreneurialism and organization compared to OMGs composed of white members, and do not use the Internet as much as white OMGs do. Most black OMGs are local or regional rather than national or global in their reach, and are usually encountered on the East and West Coasts of the U.S. Many but not all black OMGs have a color scheme. For example, the California-based Chosen Few MC use red and white, but the Pennsylvania/East Coast-based Wheels of Soul MC do not appear to have a color scheme. These are the most powerful and widely known among the black OMGs. Black OMGs often use slogans, symbols, and even names of white OMGs. For example, a white OMG based in Canada and upstate New York that is loosely affiliated with the Outlaws MC also bears the name "Chosen Few MC." Sports bikes are often used among members of black OMGs, but sports bikes are anathema to most white OMGs. While members of white OMGs in the U.S. are required to have a Harley-Davidson motorcycle, the use of Harley-Davidson motorcycles varies among black OMGs. Although black OMGs are repressed by most white OMGs, affiliations between these two groups do exist. For example, the Baltimore-based Thunderbirds MC answers to the Pagans MC.[8,9]

Figure 1. The "one-percenter" patch.

Figure 2. The "colors" of the Mongols motorcycle club.

The Hells Angels, Bandidos, Mongols (Figure 2), Outlaws, Sons of Silence, and Pagans MCs are the most powerful OMGs.[7] Statistics regarding membership for these clubs can be found at http://www.justice.gov/criminal/ocgs/gangs/motorcycle.html. ED personnel should be aware of which OMGs are active in their state of practice. The Los Angeles County Sheriff's Department[10] and the Rocky Mountain Information Network[11] list which OMGs are active in each state. Because such national data are often out of date and may neglect smaller clubs, they should be supplemented with information from local authorities or the clubs' own websites. Some of these websites provide information about

Figure 3. The "Death's Head" logo of the Hells Angels motorcycle club.

smaller clubs affiliated with the larger club. However, not all clubs will have such websites (e.g., Pagans MC):

- Bandidos MC: http://www.bandidosmc.com
- Hells Angels MC: http://www.hells-angels.com
- Outlaws MC: http://wwww.outlawsmc.com
- Sons of Silence MC: http://www.sonsofsilence.com
- Mongols MC: http://www.mongolsmc.com

In addition, links to the websites of major OMGs can be found at http://www.bikernews.org/wtn/news.php.

GANG INSIGNIA

Patches and tattoos reflect the sect-like symbolism of a gang's subculture[12,13] and can provide information about a gang member's social history, such as past incarcerations, drug use, and allegiance to the gang.[14] Central to the attire of outlaw bikers is the sleeveless and collarless jacket that identifies the specific club to which a biker belongs. These jackets, referred to as "colors," are made from leather or denim.[5] The patches, or "rockers," that indicate full membership to an OMG are embroidered on a biker's colors, and are regarded with great reverence by members and club affiliates.[15] The back of a biker's colors typically has a top rocker, which bears the club's name; a center patch, which bears the club's logo; and a bottom rocker, which indicates the location of the chapter of the club to which the biker belongs.[5] A biker's colors are integral to his identity as a member of the club. Should a biker's colors be removed during the course of his care in the ED, physicians and staff would be prudent to treat his colors with respect or otherwise risk a hostile reaction from the biker and his associates.

Because there are so many OMGs active in the U.S. it would be impractical for ED personnel to memorize every specific logo or insignia associated with each one. However, the authors advise ED personnel to be familiar with the hues worn by each locally active OMG and its support and satellite clubs, and the ubiquitous "1%" patch. Most OMGs have two hues associated with their respective insignias. For example, the Hells Angels MC use red and white with their "Death's Head" logo (Figure 3), whereas the Bandidos MC use red and gold with their "Fat Mexican" logo (Figure 4).[7] Non-member associates of the club and members of support and satellite clubs often use the color scheme, but never the insignia, of the larger sponsoring club. For example, the LA Riders MC are a support club of the Bandidos MC and incorporate red and gold into their colors, which consist of a red and gold image of the state of Louisiana, but do not wear the "1%" patch or the "Fat Mexican" logo of the Bandidos MC. Only "full-patch" members may display the club logo. Full-patch members are fiendishly protective of the exclusivity of their insignia, and clubs hold copyright on their logos and other major symbols.

The "1%" logo encased in a diamond-shaped patch is worn on the front or back of the biker's colors. Club officers have a patch listing their rank sewn onto the front breast of their colors, and some bikers will display the locations of chapters with which they have ties on the side of their colors. Some independent clubs do not wear the "1%" patch in order to avoid challenges from larger clubs, but these clubs can be just as violent as clubs who sport the "1%" patch.[7] Thus, the absence of a "1%" patch does not rule out criminal ties or intense loyalties among members of the club. Knowledge of color schemes is consequently more important for recognizing members of OMGs.

Members may wear tattoos, T-shirts, and jewelry that incorporate acronyms, symbols, or logos associated with the club.[16] Associates may wear "support" jewelry or T-shirts that incorporate a separate set of symbols but use the dominant club's color scheme. For example, the logo of the Outlaws MC consists of a skull and two crossed pistons, but associates of the Outlaws MC may sport a logo that features a hand clenching a pistol, or a Harley-Davidson logo that reads "Support Black & White," as black and white are the two

Figure 4. The "Fat Mexican" logo of the Bandidos motorcycle club.

main hues associated with the Outlaws MC. The process of joining a club often involves tattooing the club's logo onto the biker's body, and these tattoos may be displayed anywhere on the body.[15] Some tattoos are immediately visible, but others will be covered by clothing or lost in a maze of body art. Any biker who is not in good standing with the club must burn off club-related tattoos, usually by heating a butter knife and applying it repeatedly onto his skin.[17] Alternatively, he may have them covered with other tattoos.

Acronyms, such as "LPDP" for "Live Pagan, Die Pagan" and "AFFA" for "Angels Forever, Forever Angels,"are also prominent in the OMG culture. An acronym prevalent among OMGs is "FTW" for "Fuck the World," an expression that has become widespread in the "saloon society" milieu in which the one-percenter culture originated. In addition, references to a specific OMG as a "nation" are also common in their written and spoken vocabulary (e.g., "Mongol Nation" for the Mongols MC or "Green Nation" for the Vagos MC).

POTENTIAL FOR VIOLENCE IN THE ED

If a gang member perceives disrespect from anyone, including ED staff, the outcome can be deadly, as gang members have an overarching requirement for respect and for saving face in all encounters and from every individual with whom they come in contact. The gang member will not hesitate to injure or kill someone if he believes that person has shown disrespect to himself or his gang.[18] Power and respect are the chief values of OMGs, which are now composed of impulse-driven traditionalists and more conventional entrepreneurs. The latter are more likely to take reasoned actions within or beyond legal boundaries, but both are very capable of expressive violence.[19] Most members of OMGs are a hybrid of these 2 personas. Outlaw bikers should always be treated with respect, regardless of whether their behavior warrants it.

If an injured member arrives at the ED, other members of his club will often arrive to protect him or inquire into his welfare. OMGs are an amalgam of a tribe, family, and corporation, and an ethos of "one on all, all on one" prevails, meaning that to assault or injure one member is to attack the entire club, and restoring the club's honor is a sacred duty to which all members are bound.[7] An attack on a man in 2013 illustrates the reactivity of an outlaw biker against a perceived offender. A man was alleged to have briefly argued at a bar with a member of the Sin City MC, who returned with 15 to 20 other members and attacked the man with a machete.[20] Multiple news reports evidence that outlaw bikers are willing to fight with members of rival OMGs in public settings.[21,22,23,24]

The fact that OMGs are well-organized and primed to respond swiftly with aggression in the event of a member being injured should make ED personnel alert law enforcement with greater urgency in the event that supporters of the injured biker start to congregate at the hospital.[25] As motorcyclists, their mobility aids them in evading law enforcement,[16] and thus police may have a more difficult time detaining members of the club and preventing their arrival en masse at the hospital.

The cause of the biker's injury must be clarified, as some incidents provoke immense anger from the club (e.g., a citizen ramming into a biker with a car or a biker being assaulted by members of a rival OMG), whereas others evoke only concern (e.g., a single-vehicle accident). If a biker's injuries are secondary to interpersonal violence, the biker may avoid disclosing this fact to avoid attention. The emergency physician should take a thorough history in a non-threatening manner to improve his chances of eliciting these details from the biker and thereby avoid not anticipating dangerous complications of the biker's injuries. For example, a fight bite is a laceration of the hand sustained by striking another individual in the mouth with a clenched fist, and such a wound can result in devastating infections if it is not treated early and correctly.[26] Thus, appropriate antibiotics must be administered if a biker has sustained a fight bite.

Outlaw bikers may have weapons hidden on their persons that are discovered as their clothing is removed during the course of care. These weapons are not limited to guns and knives. Members of a specific OMG sometimes carry a particular everyday item as a weapon, the possession of which contributes to their sense of membership to the club. For example, a member of the Hells Angels MC may carry a ball-peen hammer, whereas a member of the Sons of Silence MC may sport an industrial flashlight. Emergency physicians should be particularly cautious of a biker in the ED whose colors bear a rocker reading "prospect," "probate," or "probationary". A biker with such a rocker is a candidate for membership to the club and may be more prone to committing acts of aggression than a full-patch member to prove that he is worthy of membership.[27] Prospective members spend 1 month to 1 year in a probationary status and are known to carry weapons for full-patch members, and some clubs have their prospective members commit felonies with full-patch members present to weed out weak candidates and curb infiltration by law enforcement.[4]

Women who support the club can also facilitate violence in the ED. The culture of OMGs is notoriously misogynistic, and women affiliated with these gangs are generally forced into prostitution or street-level drug trafficking.[4] Women are not allowed to be members of the club, but they may wear "property" belts or vests adorned with "property" patches to indicate their affiliation with a specific club. However, female associates often do not display such insignia, which makes identifying their affiliation with an OMG more difficult. Female associates are often extremely loyal to the club and assist members with illegal activities. ED personnel should be aware that women who arrive to see an injured outlaw biker may carry weapons or drugs for the biker or members of his club.[6]

Rivalries among OMGs can lead to a war when 2 or more OMGs are vying for territory. If the members of rival OMG

meet each other in the ED waiting room, a violent altercation is inevitable.[27] Emergency physicians should inquire as to whether an outlaw biker's injuries are secondary to a conflict with a rival OMG. If members of a rival OMG injured the biker, the biker's adversaries may come to the hospital to finish the job.[3] Although these incidents are rare, they do occur.

ED personnel must be aware that outlaw bikers do not always resemble the stereotypical "drunken, swaggering Hells Angel of 1969." Many outlaw bikers are clean cut, and some even prefer 4-wheeled vehicles. Many OMGs consider themselves to be in a perpetual state of war with law enforcement. Thus, police officers providing security in the ED, especially if they are in uniform, may have an inflammatory effect on bikers who arrive at the hospital.

CONCLUSION

ED personnel may encounter outlaw bikers who have been injured in motor vehicle accidents or through interpersonal violence. Knowing the hues of local OMGs and their support and satellite clubs and recognizing the "1%" patch can assist ED personnel in anticipating gang-related violence. Determining the cause of the biker's injuries is critical, as scenarios in which a biker has been injured by enemies of his club or by a citizen can predispose the biker and his associates to hostile behavior. Outlaw bikers follow a pack mentality that demands that every member support each member to the utmost.[7,19] Treating these men respectfully at all times is of paramount importance to decrease the likelihood of aggression in the ED. Although OMGs share characteristics of many other types of gangs in the U.S., members sport idiosyncratic symbols that reflect the values and hierarchy of their OMG culture. Knowledge of the OMG's symbols, values, and hierarchy can help ED personnel understand the mentality of the outlaw biker. The authors hope that this article will encourage ED personnel to conduct formal studies that focus on outlaw bikers who arrive at the ED for treatment and the outcomes of such visits.

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Availability of Insurance Linkage Programs in U.S. Emergency Departments

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Introduction: As millions of uninsured citizens who use emergency department (ED) services are now eligible for health insurance under the Affordable Care Act, the ED is ideally situated to facilitate linkage to insurance. Forty percent of U.S. EDs report having an insurance linkage program. This is the first national study to examine the characteristics of EDs that offer or do not offer these programs.

Methods: This was a secondary analysis of data from the National Survey for Preventive Health Services in U.S. EDs conducted in 2008-09. We compared EDs with and without insurance programs across demographic and operational factors using univariate analysis. We then tested our hypotheses using multivariable logistic regression. We also further examined program capacity and priority among the sub-group of EDs with no insurance linkage program.

Results: After adjustment, ED-insurance linkage programs were more likely to be located in the West (RR= 2.06, 95% CI = 1.33 – 2.72). The proportion of uninsured patients in an ED, teaching hospital status, and public ownership status were not associated with insurance linkage availability. EDs with linkage programs also offer more preventive services (RR = 1.87, 95% CI = 1.37–2.35) and have greater social worker availability (RR = 1.71, 95% CI = 1.12–2.33) than those who do not. Four of five EDs with a patient mix of ≥25% uninsured and no insurance linkage program reported that they could not offer a program with existing staff and funding.

Conclusion: Availability of insurance linkage programs in the ED is not associated with the proportion of uninsured patients served by an ED. Policy or hospital-based interventions to increase insurance linkage should first target the 27% of EDs with high rates of uninsured patients that lack adequate program capacity. Further research on barriers to implementation and cost effectiveness may help to facilitate increased adoption of insurance linkage programs. [West J Emerg Med. 2014;15(4):529–535.]

INTRODUCTION

Uninsured patients accounted for approximately 20% of emergency department (ED) visits nationally in 2009.[1] Many uninsured individuals, including one-third of non-elderly adults and two-thirds of children, are eligible for public insurance programs.[2-5] Given the high proportion of uninsured patients, the ED is uniquely positioned to help uninsured but eligible patients obtain public insurance coverage. ED insurance linkage programs screen to identify uninsured but eligible patients, and then either directly assist with enrollment

or provide a referral to another entity that facilitates insurance enrollment. These programs have the potential to benefit both patients and hospitals; patients who obtain insurance have increased access to care and reduced unmet medical needs,[6,7] and hospitals benefit from a cost-effective program that has the potential to save millions of dollars in uncompensated care costs due to retroactive insurance reimbursements.[8-10] Moreover, increasing insurance linkage is an especially pertinent issue now given the recent expansion of Medicaid eligibility with the Affordable Care Act.[11]

A recent national survey of preventive services in EDs found that only 38% of EDs routinely offer insurance eligibility screening and linkage.[12] Furthermore, ED directors rated insurance linkage the third highest priority among 11 preventive services most commonly offered in the ED (after primary care linkage and tobacco cessation counseling and tied with alcohol screening).[12] Despite the relatively high priority of these programs, there is a gap in the literature regarding ED insurance linkage programs. While we estimate (based on the preventive survey results) that over 1,000 EDs offer insurance linkage programs across the country, to our knowledge, there have been only 4 studies published discussing a total of 6 ED insurance linkage programs.[9,10,13,14] From a national standpoint, it is unknown what kind of EDs have insurance linkage programs, and which ED characteristics increase or decrease the likelihood of having such a program. This information would help ED directors and policymakers identify target areas for ED insurance linkage programs to reduce uninsured rates across the United States.

This is the first study of which we are aware to examine characteristics associated with U.S. EDs providing insurance screening and linkage services. Specifically, we compared patient demographic and hospital characteristics of EDs with and without insurance linkage programs. We hypothesized that 4 variables would be positively associated with the presence of insurance linkage programs: (1) higher rates of uninsured patients in the ED, (2) teaching hospital status, (3) public hospital status, and (4) availability of other preventive services. EDs with higher rates of uninsured patients may be more likely to have insurance programs given the greater benefit to be derived from successful insurance linkage, including increased healthcare access for patients and retroactive claim reimbursements for the ED. Teaching hospitals may be more likely to have insurance linkage programs given their published success at other teaching hospitals.[9,10] We also felt public hospitals may have a lower barrier for program establishment given existing relationships with other public entities (e.g. local Medicaid offices) that enroll patients into insurance, especially as a partnership with a public organization has been shown to be an effective model for insurance linkage.[10] Additionally, an increased number of preventive services offerings may indicate the availability of resources or an ED administrator's belief in the importance of providing various patient services; an ED administrator's perceived barriers to providing preventative services have been found to be associated with a decreased likelihood of a preventative service being offered.[15]

METHODS

Study Design and Population

This study was a secondary analysis of data from the National Survey of Preventive Health Services in U.S. EDs (September 2008 to April 2009).[12] The authors of the primary study randomly sampled 350 (7%) of 4,874 EDs from the 2007 National Emergency Department Inventory (NEDI)-USA database. The response rate of 80% (n=277) amounted to a nationally representative sample of 6% of EDs in the United States. The local institutional review board found this study exempt from human subjects research.

Survey Content and Administration

The National Survey asked ED directors about availability and interest in 11 preventive services including ED insurance linkage.[12] We obtained information on insurance linkage from the response to the question, "Is there a system in place that routinely performs screening for insurance and linkage of eligible uninsured patients to insurance programs in your ED?" Respondents who answered "no" were asked a follow-up question on ED capacity to offer insurance linkage: "If not, could you offer this service routinely with existing staff and funding?" We determined the priority of preventive services needed with the question, "Of the services above unavailable in your ED, which services would you most like to offer given your patient population?" In addition to information on preventive services, the survey also asked ED directors for information on social work availability, percentage of uninsured patients, and measures of ED crowding.

We also collected the following baseline ED characteristics from the 2007 NEDI-USA database: annual ED visit volume, teaching hospital status (membership in the Council of Teaching Hospitals and Health Systems), Urban Influence Code (a validated county-based measure of urban/rural status), and U.S. geographic region (Northeast, South, Midwest, and West). Public hospital status was determined by linking the 2007 American Hospital Association Annual Survey data to the 2007 NEDI-USA database. We collected information on state-level insurance rates was from the U.S. Census Bureau's 2009 Current Population Survey Annual Social and Economic Supplements (http://www.census.gov accessed October 29, 2012).

Data Analysis

We first tabulated sociodemographic and operational variables of the EDs in our entire sample. We then compared how EDs that offer insurance screening and linkage differed from EDs that did not offer this service. We analyzed unadjusted comparisons of the characteristics between the two groups of EDs using Fisher's exact tests given our

small sample size. A p-value of less than 0.05 was a priori designated as statistically significant.

We then tested our hypotheses using multivariable logistic regression. To adjust for potential confounders, we *a priori* chose to include in the model any variables that were not part of our original hypothesis but had p<0.20 in the unadjusted analysis. We then removed non-key variables from the model if the coefficients were not significant at the 95% confidence interval level and if they did not change other coefficients by more than 10% for the final model. This 2-step method has previously been applied by Berg et al. in a similar analysis of the National Survey of Preventive Health Services in U.S. EDs data.[15] As the prevalence of insurance linkage programs is greater than 10%, we report coefficients using relative risk ratios (RR) instead of odds ratios (OR) as recommended in the literature.[16,17] This was done using the Stata plug-in program "oddsrisk."

We also conducted a sub-group analysis of EDs with no insurance linkage program separately to determine if there was a relationship between their reported program capacity, uninsured patient load, and priority among 11 public health initiatives by tabulating the frequencies of these variables. All analyses were conducted using Stata 12.1 (StataCorp, College Station, TX).

RESULTS

The availability of ED insurance linkage programs within our nationally representative sample compared across different demographic and operational characteristics is shown in Table 1. ED insurance linkage differed significantly by geographic region (p=0.01). Urban settings were found to have a higher proportion of insurance linkage programs than rural settings (40% vs. 20%), but this was not statistically significant (p=0.08). The proportion of uninsured patients in the ED was not found to be associated with the availability of insurance linkage. There were no significant differences in the rate of insurance linkage by several operational variables including visit volume, crowding, teaching hospital or public hospital status. EDs with more than the average number of preventive services were more likely to have an insurance linkage program (p<0.01). Availability of social work services 24 hours per day was also associated with having an insurance linkage program (p<0.01).

The multivariable logistic regression result is shown in Table 2. After adjustment for ED characteristics, a greater proportion of uninsured patients was not significantly associated with having an insurance linkage program; compared to the reference group of a patient population of <15% uninsured, EDs with 15-24% uninsured and more than 25% uninsured had a RR of 1.12 (95% CI = 0.65 – 1.73) and 1.17 (95% CI = 0.67 – 1.81) respectively. Teaching hospital and public hospitals status were also not found to be associated with the availability of insurance linkage services (RR = 0.72, 95% CI = 0.27 – 1.59 and RR = 0.94, 95% CI = 0.57 – 1.45, respectively). EDs with a greater number of preventive services were more likely to have an insurance linkage program (RR = 1.87, 95% CI = 1.37-2.35). The visit volume was not significantly associated with having an insurance linkage program.

We found two ED characteristics not included in our original hypotheses which were strongly associated with insurance linkage programs in the multivariable model: region and social worker availability. Compared to an ED in the Midwest, an ED in the West was more likely to have an insurance linkage program (RR= 2.06, 95% CI = 1.33 – 2.72). After adjusting for state-level uninsured rates, the relative risk for an ED in the West vs. Midwest having a linkage program decreased to 1.90 but remained statistically significant (95% CI = 1.11 – 2.66). Additionally, the model supported our finding from the univariate analysis that EDs with insurance linkage programs were more likely to have a social worker available 24 hours per day (RR = 1.71, 95% CI = 1.12–2.33).

Finally, a sub-group analysis of EDs with no insurance linkage program availability found that 70% of all EDs with no insurance linkage program, including 80% of EDs with a patient mix of ≥25% uninsured, reported insufficient staff and funding to offer an insurance linkage program. These EDs with both ≥25% uninsured patients and inadequate program capacity represent 27% of EDs without insurance linkage programs. Moreover, the proportion of ED directors ranking insurance linkage programs a top 3 priority did not differ significantly by the proportion of uninsured patients served. Of EDs with no insurance linkage program, 37% of EDs with ≥25% uninsured rated insurance linkage among their top 3 priorities compared to 45% of EDs with <25% uninsured (p=0.33).

DISCUSSION

Our analyses suggest that the availability of ED insurance linkage programs is associated with location in the U.S. West but not with the proportion of uninsured patients in the ED, hospital teaching status, or public ownership status. EDs offering a greater number of preventive services and 24-hour social worker availability were found to be more likely to have an ED insurance linkage programs. Among EDs with the highest rates of uninsured patients, 4 out of 5 reported lacking necessary funding for programs.

Our findings indicate that insurance linkage program prevalence varies widely across U.S. regions, with insurance linkage programs being most common in the West. This result cannot be explained by regional-level differences in the uninsured rate (12% in Midwest, 12% in Northeast, 17% in West, and 18% in South),[18] but may be better explained by state-level differences in uninsured rates. Adjusting for the percentage of uninsured patients in each state attenuated the association between regions and insurance linkage program availability (Table 2). However, the fact that the RR for the West region remained statistically significant even after adjusting for state-level insurance rates suggests that other

Table 1. Emergency department (ED) and hospital characteristics by insurance linkage availability.

Characteristic	Insurance linkage program n=104 (38%)		No insurance linkage program, n=173 (62%)		Total	p-value
	n	%	n	%	N	
ED demographics						
Region						
West	27	54%	23	46%	50	0.01
Northeast	17	49%	18	51%	35	
South	38	34%	75	66%	113	
Midwest	22	28%	57	72%	79	
Urban influence code						
Urban (metro/micro)	90	40%	135	60%	225	0.08
Rural (rural/frontier)	14	27%	38	73%	52	
Percentage of uninsured patients*						
Less than 5%	2	18%	9	82%	11	0.39
5-24%	65	40%	99	60%	164	
25% and greater	36	38%	59	62%	95	
ED operations						
Teaching hospital						
Teaching	9	43%	12	57%	21	0.64
Non-teaching	95	37%	161	63%	256	
Publicly owned hospital						
Yes	27	34%	52	66%	79	0.58
No	76	39%	121	61%	197	
Offers preventive programs (excluding insurance linkage)						
0 - 3 programs	40	27%	107	73%	147	<0.01
4 - 10 programs	64	49%	66	51%	130	
Offers social worker services (24 hours per day)						
Yes	28	57%	21	43%	49	<0.01
No	76	33%	152	67%	228	
Visit volume (2007)						
Less than 10,000	25	29%	62	71%	87	0.09
10,000-19,999	15	33%	31	68%	46	
20,000-39,999	39	46%	45	54%	84	
40,000 and greater	25	42%	35	58%	60	
Crowding status (by Center for Disease Control and Prevention criteria+)						
Crowded	55	43%	72	57%	127	0.08
Not crowded	49	33%	101	67%	150	

*n=270 for this variable only.

+Presence of at least one of the following 3 criteria, as reported by the ED director: left without being seen rate ≥ 3%, any annual time on ambulance diversion, and mean waiting room time ≥ 1 hour.

Table 2. Multivariable models of factors related to insurance linkage availability.

	Original model		Model adjusted for state-level insurance rate	
Characteristics	Relative risk	95% CI	Relative risk	95% CI
Midwest (reference)	1.00		1.00	
South	1.14	0.64 – 1.79	0.96	0.45 – 1.73
Northeast	1.51	0.80 – 2.35	1.54	0.81 – 2.38
West	2.06	1.33 – 2.72	1.90	1.11 – 2.66
Proportion uninsured <15% (reference)	1.00		1.00	
Proportion uninsured 15-24%	1.12	0.65 – 1.73	1.11	0.64 – 1.72
Proportion uninsured ≥25%	1.17	0.67 – 1.81	1.16	0.66 – 1.80
Teaching hospital	0.72	0.27 – 1.59	0.74	0.28 – 1.60
Publicly owned hospital	0.94	0.57 – 1.45	0.93	0.56 – 1.44
Preventive services available (>3)	1.87	1.37 – 2.35	1.84	1.34 – 2.33
Social worker available (24 hours/day)	1.71	1.12 – 2.33	1.72	1.12 – 2.34
Annual visit volume (by 1,000s)	1.01	0.99 – 1.01	1.01	0.99 – 1.02
2009 state uninsured rate (%)			1.03	0.97 – 1.09

CI, confidence interval

factors are involved. Some possible explanations, which we were not able to resolve with this study, include regional differences in public insurance policy, hospital associations and practices, or knowledge sharing with nearby programs.

Contrary to our hypothesis, the rate of uninsured patients in an ED was not significantly associated with having an insurance linkage program. We had expected that EDs with a higher proportion of uninsured patients would be more likely to have an insurance program, as the potential benefits for both patients and the hospital are greater. One explanation is that EDs with high rates of uninsured patients lack adequate resources to start an insurance linkage program. In our sample, 4 out of 5 EDs with an uninsured patient population of ≥25% reported not having adequate staff or funding to support an insurance linkage program. This may be due to the fact that the hospitals with a high burden of uninsured patients are also the same hospitals with limited resources (e.g. large safety-net hospitals). Another possible explanation is that EDs with high rates of uninsured patients do not necessarily see insurance linkage as a top priority; we found that ED directors' ratings of insurance linkage as a priority did not differ based on the proportion of uninsured patients. Perhaps EDs with high uninsured patient loads face other burdens that ED directors feel are a better use of their resources, or these EDs are more willing to absorb uncompensated care costs given their Medicaid Disproportionate Share Hospital payments.

A third possible explanation on why the rate of uninsured patients in an ED is not associated with insurance linkage availability is that ED directors lack knowledge on benefits and costs of insurance linkage programs. The few studies published on this subject show remarkable cost effectiveness. For example, programs as low cost as simply handing out public insurance applications have been found to be successful at enrolling uninsured patients.[14] Furthermore, while EDs may require an initial investment to help establish a program, retroactive reimbursements from successfully enrolled patients have been shown to be enough to sustain the program and even yield gains for the hospital.[9,10] It is possible that some ED directors overestimate costs and/or underestimate benefits of these programs despite a high ratio of uninsured patients. Dissemination of previous results on low-cost and successful models of insurance linkage programs, and additional research on the return on investment of these programs, are needed to encourage more ED directors to consider starting these programs.

We also found that, contrary to our hypothesis, neither teaching hospital status nor public hospital status was associated with insurance linkage program availability. Given the success of ED insurance linkage programs at teaching hospitals,[9,10] we expected that more teaching hospitals would have adopted insurance linkage programs. However, perhaps a publication bias exists, as academic institutions may just be more likely to evaluate these programs. Public (county-owned) hospitals may not have higher rates of insurance linkage programs for several reasons, including that their mission to take care of all patients regardless of ability-to-pay and their existing uncompensated care budget may render insurance linkage a lower priority. It is possible that public hospitals are not fully using potential partnerships with other public organizations who conduct insurance enrollment, as this has been found to be an effective method of insurance linkage from the ED.[10] We recommend that teaching hospitals and publicly owned hospitals, especially those with high rates of uninsured patients, consider establishing insurance linkage programs.

Our findings suggest a strong association between availability of insurance linkage programs and existing ED preventive and social work services. One reason for this result may be that EDs with a higher level of resources tend to have multiple programs, due to similar resource requirements of these programs. Also, EDs with existing preventive or social work programs may have a mission that encompasses public health programs outside of medical care, making them more likely to adopt an insurance linkage program.

The next steps in this research area are two-fold: 1) to disseminate existing studies and conduct additional research supporting the potential cost effectiveness and return on investment from ED insurance linkage programs and 2) to elucidate barriers besides limited staff and funding to insurance linkage program adoption, especially among EDs with adequate resources but still without an insurance linkage program. Research that demonstrates the effectiveness of, and estimates the positive return on investment for, insurance linkage programs will help hospital leaders and ED directors more accurately assess the value of insurance linkage programs within their own EDs and may encourage hospitals with limited resources to start an ED-based program. Research on barriers to insurance linkage programs will help policymakers establish interventions specifically aimed at reducing these barriers to adoption.

Continued expansion of insurance linkage programs will allow the nation's EDs to reduce the high number of uninsured but eligible individuals, and subsequently increase patient access to care and decrease unmet medical needs.[6,7] In particular, the ED has the potential to serve as an important intervention site for the Affordable Care Act's Medicaid Expansion in which an additional 10 -11 million people are newly eligible for public insurance,[11] especially as recent estimates indicate that 1 in 10 of these individuals currently use the ED as their routine source of healthcare.[19] We recommend that policy or hospital-based interventions to increase insurance linkage programs first target providing resources for the 27% of EDs that report having both high rates of uninsured patients and inadequate program capacity, as both patients and the ED would reap the greatest benefit from insurance programs. Furthermore, policymakers should also focus on the EDs with high rates of uninsured patients who report having adequate financial and staff capacity to determine and address additional barriers besides financial and staff resources that may exist to establishing an insurance linkage program.

LIMITATIONS

There are several potential limitations that must be considered when interpreting the study findings. First, we gathered our data from a survey that collected information from one individual at each ED rather than objective reported hospital measures. However, it is likely that ED directors (respondents) are knowledgeable about the services and characteristics of their ED. and that this did not introduce significant bias into the study. Second, although we were able to determine several characteristics associated with insurance linkage availability, our relatively small sample size constrained the number of variables we were able to include in the model. This limitation may have prevented us from finding significant associations between additional variables and insurance linkage. Third, the proportion of ED patients who are uninsured could not be compared between our sample and the total 2007 NEDI-USA database as this information was not available. It is possible that our sample overestimated the proportion of EDs with greater than 25% of patients uninsured, as the 2009 National Hospital Ambulatory Medical Care Survey estimates the average proportion of uninsured patients in EDs to be 15% (vs. 34% in our sample).[20] However, as our sample was randomly selected and all other demographic and operational characteristics were nationally representative, it is likely that this variable is also representative of all U.S. EDs.

CONCLUSION

ED insurance linkage programs are a cost-effective outreach intervention that both increases enrollment rates for uninsured eligible patients and decreases financial losses of uncompensated care for hospitals. The surprising finding that rates of uninsurance are not associated with EDs having insurance linkage programs may be explained by inadequate resources, lack of priority, or limited knowledge of cost effectiveness of these programs. We recommend that policymakers and hospital-based interventions trying to increase insurance enrollment target EDs with high rates of uninsured patients, starting with financial assistance for the EDs that also report having inadequate staff and funding to establish an insurance linkage program. Further research on return on investment and insurance linkage program barriers may also help increase the proportion of EDs with these services, and allow the ED to serve as an important intervention site to meet national goals to reduce the uninsured population.

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Novel Ultrasound Guidance System for Real-time Central Venous Cannulation: Safety and Efficacy

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Introduction: Real-time ultrasound guidance is considered to be the standard of care for central venous access for non-emergent central lines. However, adoption has been slow, in part because of the technical challenges and time required to become proficient. The AxoTrack® system (Soma Access Systems, Greenville, SC) is a novel ultrasound guidance system recently cleared for human use by the United States Food and Drug Administration (FDA).

Methods: After FDA clearance, the AxoTrack® system was released to three hospitals in the United States. Physicians and nurse practitioners who work in the intensive care unit or emergency department and who place central venous catheters were trained to use the AxoTrack® system. De-identified data about central lines placed in living patients with the AxoTrack® system was prospectively gathered at each of the three hospitals for quality assurance purposes. After institutional review board approval, we consolidated the data for the first five months of use for retrospective review.

Results: The AxoTrack® system was used by 22 different health care providers in 50 consecutive patients undergoing central venous cannulation (CVC) from September 2012 to February 2013. All patients had successful CVC with the guidance of the AxoTrack® system. All but one patient (98%) had successful cannulation on the first site attempted. There were no reported complications, including pneumothorax, hemothorax, arterial puncture or arterial cannulation.

Conclusion: The AxoTrack® system was a safe and effective means of CVC that was used by a variety of health care practitioners. [West J Emerg Med. 2014;15(4):536–540.]

INTRODUCTION

The use of catheters to access the central venous system is a well-established and important method for administering life-saving drugs and fluids as well as monitoring patient hemodynamics. Since 1984, research has shown that using ultrasound (US) to assist with central venous cannulation (CVC) improves success rates and lowers complications.[1] Multiple studies have confirmed these findings and demonstrated that ultrasound guided CVC increases success rate, lowers complications and reduces costs.[2-4] This evidence has led several large medical organizations and government agencies to recommend the use of ultrasound guidance for CVC.[5-9] Despite the evidence and recommendations, surveys have found that the availability of ultrasound in community emergency departments (ED) is less than 50% [10-11] and in those hospitals where access to ultrasound in the ED is higher, almost half of physicians felt they had inadequate training and a quarter of physicians indicated that they felt "uncomfortable" or "very uncomfortable" using ultrasound for CVC.[12]

To make US guided CVC easier, many different ultrasound systems have been proposed. One such system, the AxoTrack® System, was developed by Soma Access Systems

(Greenville, SC) to simplify ultrasound guided CVC. The AxoTrack® system is an ultrasound probe with a built-in needle guidance system that incorporates technology to give the operator real-time information not only on the direction of the needle but also actual knowledge of the needle location at all times throughout the procedure. The purpose of this study is to describe the safety and efficacy of the AxoTrack® system in the first 50 subjects following FDA clearance in February 2012.

METHODS

The AxoTrack® System

The AxoTrack® system includes an ultrasound probe with a needle guide that extends through the body of the ultrasound probe making the path of the needle coincident and coplanar within the ultrasound beam (see Figure 1). Additionally, the probe houses a separate set of magnetic sensors that monitor the depth of the needle and projects on the ultrasound system monitor a real-time, virtual image of the needle as it moves toward the intended central vein. The procedure is performed by first aligning the on-screen target line (which corresponds with the path the needle will take when inserted) with the intended central vein that is displayed on the monitor. Once the target line and intended central vein are aligned, the needle is inserted through the needle guide in the probe and advanced while observing its progress until the needle enters the intended central vein. The AxoTrack®system also incorporates a needle clamping mechanism that can be used to stabilize the needle once it has reached the intended central vein. This mechanism allows the operator to leave the probe on the body and continue scanning during guide-wire passage, allowing for real-time confirmation of guide-wire positioning.

The AxoTrack® system is incorporated onto the FUJIFILM SonoSite M-turbo (Bothell, WA) and Terason t3000 (Burlington, MA) platforms. Both machines were used in this study at each study location.

Training

The AxoTrack® system was cleared by the FDA for human use in February, 2012. Since that time, three systems were made available for clinical use by Soma Access Systems. These systems were placed at Vanderbilt University Medical Center, Nashville, TN, Palmetto Health Richland, Columbia, SC and Palmetto Health Baptist, Columbia, SC. Resident and attending physicians as well as nurse practitioners who worked in the intensive care unit (ICU) or ED and who routinely placed central lines were trained how to use the system. Training included a standard 20-minute lecture and orientation to the system. Following this lecture, trainees were given hands-on instruction with the use of a Blue Phantom (Bothell, WA) head and neck ultrasound phantom that featured simulated anatomy of the Internal Jugular, Subclavian and Axillary veins. They were required to successfully place the needle in at least the Internal Jugular or Subclavian vein of the phantom during the hands on training.

Patient Selection

Patients in whom the AxoTrack® system was used for CVC were selected on a convenience basis. Inclusion criteria included patients at least 18 years of age who needed CVC and where no clinical contraindications existed, as determined by the treating physician or nurse practitioner. There were no explicit exclusion criteria for the study.

The study author (RMF) and one other emergency physician placed their first CVC with the AxoTrack® system without supervision. For the remaining proceduralists, their first CVC with the AxoTrack® system occurred when a physician or nurse practitioner who had previously been through the didactic and hands-on training process contacted an attending physician who had previously performed CVC with the AxoTrack® system. That attending physician then supervised this first line placed by the novice user. After the first successful CVC, subsequent CVCs did not require supervision by an experienced AxoTrack® system user. Because the ultrasound machine with the dedicated AxoTrack® system was in a secure location, that could only be accessed by one designated physician for each of the three locations, standardized data was collected by each of these designated physicians with access to the machine immediately following the procedure. This data was recorded in a Microsoft Excel worksheet (Redmond, WA). The anatomic site of CVC was according to the preference of the physician or nurse practitioner performing the procedure.

Study Definitions

Prior to data analysis, we defined *a priori* procedural success and procedural complication. We defined "procedural success" as the successful insertion of a central venous catheter in the desired central vein using the AxoTrack® system. We defined "procedural complication" as any complication entered into the database that was immediately known to have occurred during the procedure or detected by chest radiography following the procedure. Specifically, we determined if any of the following complications occurred: pneumothorax, hemothorax, arterial cannulation, hematoma formation at the insertion site, and location of the distal catheter tip in a location other than the distal superior vena cava or right atrium of the heart. We did not record any complications that occurred beyond the performance of chest radiography such as infections or skin irritation.

Data Collection

Following local institutional review committee approval at each of the participating institutions, a unique database was created using REDCap electronic data capture tools hosted at VUMC.[13] REDCap (Research Electronic Data Capture) is a secure, web-based application designed to support data capture for research studies, providing: 1) an intuitive interface for validated data entry; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical

packages; and 4) procedures for importing data from external sources.[13] One physician (RMF) consolidated the data that had been collected from each institution into a REDCap database form . Data included the following: the type of practitioner and their current level of training, if the procedure was the first time they had used the device clinically, success or failure of the procedure, procedural site, and complications at the time of the procedure or detected by chest radiography following CVC.

RESULTS

The AxoTrack® system was used by 22 different health practitioners at all 3 institutions to obtain central venous access in fifty subjects from September 2012 to February 2013. Subjects included 37 (74%) patients in the ED and 13 (26%) patients in the ICU. There were no lines placed during cardiac arrest, however, all lines were placed on an urgent or semi-emergent basis. The most common indications for central venous catheter insertion were: sepsis, gastrointestinal bleeding, respiratory failure and end-stage renal disease with need for emergent dialysis.

System users included 4 attending physicians, 16 resident physicians, 1 nurse practitioner and one surgical/critical care fellow. All 4 attending physicians were emergency physicians. Of the 16 residents, all were emergency medicine residents and included two interns, five in their second year of residency training and nine in their third year of residency training. The 1 fellow was a surgeon in a surgical /critical care fellowship. The nurse practitioner worked in the medical ICU. All proceduralists had inserted more than five CVCs prior to using the AxoTrack® system. Of the 50 lines placed, 20 (40%) were the very first lines placed by the operator using the system. All 50 subjects had successful CVC using the AxoTrack® System. Forty-nine (98%) subjects had successful CVC at the first anatomic site attempted. There were no procedural complications recorded at the time of the procedure or detected by chest radiography immediately following the procedure. The table lists the number of successful CVC by anatomic site.

One patient had failure at the first site attempted (infraclavicular approach to the Subclavian vein). The Internal Jugular vein in this patient was completely collapsed when visualized with ultrasound and no attempt was made at this site. The second site attempted (a supraclavicular approach to the Subclavian vein) was successful after the first attempt.

Table. Number and percentage of successful central venous catheterizations by anatomic site and approach.

Anatomic site	Successful line placement
Right internal jugular vein	20 (40%)
Right subclavian (supraclavicular approach)	12 (24%)
Right femoral vein	6 (12%)
Left internal jugular vein	4 (8%)
Left subclavian vein (infraclavicular approach)	4 (8%)
Right subclavian vein (infraclavicular approach)	3 (6%)
Left subclavian vein (supraclavicular approach)	1 (2%)
Left femoral vein	0

DISCUSSION

With the introduction of ultrasound guided CVC, there has been a marked improvement in the first-pass success rate and an overall decrease in the rate of complications.[1-4] Despite this improvement, complications still occur, although at a much lower rate than the traditional landmark-only based approach.[1-4, 14] Despite these studies and the endorsement of many professional organizations, the widespread use and adoption of ultrasound guided CVC insertion is low,[15-18,25] with one recent study reporting as few as 13% of anesthesiologists routinely performing CVC with US guidance.[15] The routine utilization of ultrasound for central venous access by emergency physicians is unknown since ultrasound guided CVC training has become mandatory in residency, however, two small regional surveys have shown acceptance rates as high as 97% among residents currently in training and 78% for those beyond residency.[26-27]

Several different ultrasound systems have been proposed or designed to improve needle tip localization, improve the human interface and simplify the insertion process in an attempt to continue to improve CVC, reduce insertion errors, and make it easier for new users. In addition to lack of appropriate ultrasound training, one possible reason for the lack of use of ultrasound for CVC is that complications, while reduced, continue to occur even when ultrasound is used.[19-21] A video review of accidental carotid artery cannulations during real-time US guidance found that a short axis approach, where it is difficult to precisely identify the location of the tip of the needle during cannulation, was a common factor identified in all cases of accidental arterial cannulation.[21]

The AxoTrack® system offers 2 unique advantages that potentially can help improve the process of CVC. First, like many needle guidance systems, it overlays information about the potential path (trajectory) of the needle on top of the ultrasound image. Second, unique to the AxoTrack® system, it uses Hall effect technology that supplies real-time information about the location of the needle tip in relation to the probe (Figure 1 and 2). When using the system, the operator not only knows the trajectory of the needle, but also knows where the tip of the needle is at all times without having to move or adjust the needle or probe. In theory, these two properties of the AxoTrack® system should improve successful insertion rates, reduce complications even further and make it easier for novice users of ultrasound

technology to incorporate ultrasound guided CVC into their practice. While small, our retrospective review of QA data provides support for the theoretical basis behind the technologic advances of the AxoTrack® system.

During our study, we also found that the Subclavian vein was commonly used for CVC with the AxoTrack® system. While ultrasound guided Femoral and Internal Jugular venous access has relatively straightforward landmarks, ultrasound-guided Subclavian venous access is much more difficult due to the clavicle that directly overlies the Subclavian vein making it difficult to both visualize with ultrasound and guide the needle into the vein. Several studies have shown ultrasound guided CVC of the Subclavian vein to be a plausible technique.[22-24] Fragou et al,[22] performed a study comparing an ultrasound guided infraclavicular approach to the Subclavian vein with the standard landmark technique and showed ultrasound guidance to be superior in procedural success and complication rates. However, while there was greater success with ultrasound guidance, the proceduralists involved in the study rated this approach an 8 on a 10-point Lickert scale for difficulty, where 0 was "simple" and 10 was "complex." Interestingly, we found that the small footprint of the AxoTrack® probe makes an infraclavicular or supraclavicular approach to the Subclavian vein relatively straightforward. While we did not ask the proceduralists to rate how difficult they thought the procedure was from a given approach, it is interesting to note that 40% of all lines placed in our study were Subclavian lines, with the supraclavicular approach being used almost twice as much as the infraclavicular approach.

LIMITATIONS

This retrospective review has several limitations. It is important to note that first-time users received direct instruction during the procedure by a more experienced operator. While this may occur in residency training, it is difficult to replicate with physicians who are beyond residency training. In addition, all operators in the study had at least some prior experience with ultrasound guided CVC. A practicing physician without experience using ultrasound may have a more difficult time using the system.

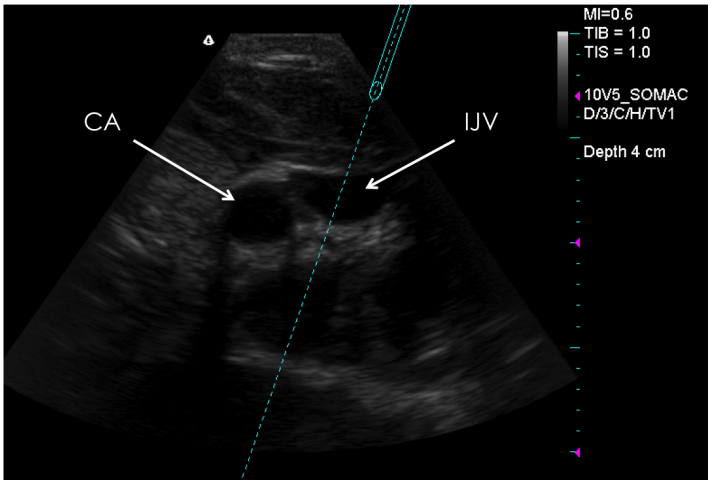

Figure 1. Screenshot of AxoTrack® System during internal jugular vein cannulation.
CA, carotid artery; *IJV*, internal jugular vein

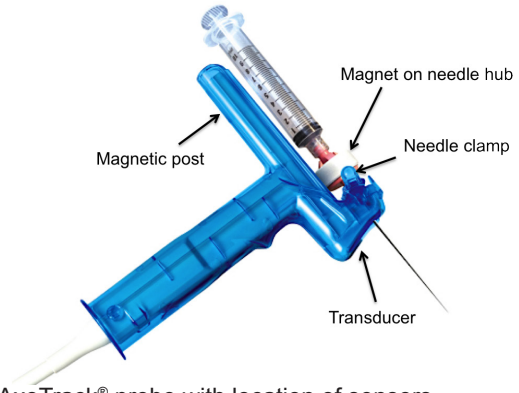

Figure 2. AxoTrack® probe with location of sensors.

Our data was limited to only a few data points. This was because the original QA data set was limited in scope and did not include any protected health information. This limited our ability to describe the subjects who received CVC using the AxoTrack®system. Furthermore, the retrospective nature from data collected during a very short and finite time frame limited our ability to assess for other complications that may have been a direct result of the procedure but delayed in their presentation such as infection, pain or hematoma at the insertion site. To our knowledge, this did not occur, but it is important to note nonetheless. An ongoing prospective observational study is currently taking place that will better describe any delayed complications and more details about the CVC procedure.

CONCLUSIONS

The AxoTrack® system is a safe and effective means of guiding CVC in patients in the ICU or ED. Furthermore, several different health care practitioners, with limited training, used the AxoTrack® system effectively for CVC.

Study Support

The ultrasound machines and probe covers for this study were provided at no cost by Soma Access Systems and FUJIFILM SonoSite to the study sites. No additional funding or support was provided. The company had no role in design, data analysis or drawing conclusions for the study.

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Typed Versus Voice Recognition for Data Entry in Electronic Health Records: Emergency Physician Time Use and Interruptions

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Introduction: Use of electronic health record (EHR) systems can place a considerable data entry burden upon the emergency department (ED) physician. Voice recognition data entry has been proposed as one mechanism to mitigate some of this burden; however, no reports are available specifically comparing emergency physician (EP) time use or number of interruptions between typed and voice recognition data entry-based EHRs. We designed this study to compare physician time use and interruptions between an EHR system using typed data entry versus an EHR with voice recognition.

Methods: We collected prospective observational data at 2 academic teaching hospital EDs, one using an EHR with typed data entry and the other with voice recognition capabilities. Independent raters observed EP activities during regular shifts. Tasks each physician performed were noted and logged in 30 second intervals. We compared time allocated to charting, direct patient care, and change in tasks leading to interruptions between sites.

Results: We logged 4,140 minutes of observation for this study. We detected no statistically significant differences in the time spent by EPs charting (29.4% typed; 27.5% voice) or the time allocated to direct patient care (30.7%; 30.8%). Significantly more interruptions per hour were seen with typed data entry versus voice recognition data entry (5.33 vs. 3.47; p=0.0165).

Conclusion: The use of a voice recognition data entry system versus typed data entry did not appear to alter the amount of time physicians spend charting or performing direct patient care in an ED setting. However, we did observe a lower number of workflow interruptions with the voice recognition data entry EHR. Additional research is needed to further evaluate the data entry burden in the ED and examine alternative mechanisms for chart entry as EHR systems continue to evolve. [West J Emerg Med. 2014;15(4):541–547.]

INTRODUCTION

Recent healthcare reform has placed a high emphasis on the electronic health record (EHR).[1] The Centers for Medicare and Medicaid Services has gone as far as rewarding hospitals to implement EHR and computerized physician order entry (CPOE) systems through incentive programs. Accompanying these incentives is a 2015 deadline that threatens to decrease reimbursement for institutions that do not implement these

systems. As a result, EHR and CPOE systems are more widely used in today's emergency departments (ED). EHR and CPOE have the advantages of keeping patient information organized and readily accessible in addition to decreasing medical errors resulting in poor patient outcomes.[2-4] An unintended consequence of this shift towards an electronic working environment is the time burdens it places on the ED providers that use it. One of the major concerns of EHR and CPOE is that ED providers are spending more time in front of their computers charting and placing orders and away from their patients than through traditional paper or dictation systems.[5,6] In addition, the ED has been described as "interrupt-driven," whereby workflow is subject to high numbers of interruptions and breaks in tasks.[7-9] This has been shown to lead to increased risk for medical error and poor patient outcomes.[10-13] Placing ED providers away from the bedside and in front of computers for prolonged periods of time puts them at risk for interruptions and increases in the number of tasks they leave incomplete.[5] The pressures from CMS make it unlikely for a paper-based system to survive in today's healthcare reform climate. Finding ways to work efficiently in these electronic environments has become an important issue discussed at the administrative level of most EDs, The use of scribes is one example of how some departments have intervened to make EHR and CPOE work more efficiently.[14-16] The cost and turnover of such services make implementation of this technique unavailable to some. Software engineers have developed a potential solution to these problems in voice recognition dictation software. The voice recognition software has been proposed as a way to reduce time in front of the computer compared to more traditional charting. The goal of voice recognition data entry is to reduce the amount of time the emergency physician (EP) spends interacting with the computer and increase the amount of time the EP spends interacting with patients.

The purpose of this study is to compare time use and the number of interruptions between a group of EPs using EHR with typed data entry and a group of EPs using EHR with voice recognition data entry. The study compares the time an EP spends performing data entry and the time spent performing direct patient care between typed data entry and voice recognition data entry. The study also compares interruptions that occur during the data entry phase of the 2 data entry modalities.

MATERIALS AND METHODS

We performed a prospective observational study at 2 community teaching hospital EDs. Site 1 used Cerner FirstNet EHR (Cerner Corporation, North Kansas City, MO, USA) with typed data entry and Site 2 used Meditech EHR (Meditech, Westwood, MA, USA) with voice recognition-assisted dictation software (Dragon, Nuance, Burlington, MA, USA). The study was reviewed and approved by our local Institutional Review Board.

We used observation research assistants in the study. Only 3 observesr were trained and used to minimize variation in data collected. The assistants included 2 medical students and 1 undergraduate research assistant. None of the research assistants had worked in either department prior to the study and were new to each hospital staff. Their training included a half-hour training session with the primary investigator reviewing their job descriptions and primary observation goals. Each research assistant then performed a training observation shift with the primary investigator with receptive feedback to help standardize their performance on data collection. After the training shift, the research assistants then performed formal observation shifts during which data were collected on individual physicians in a structured fashion over 180-minute time frames. These shifts were performed between the hours of 9am and 9pm at each site during the bulk of each ED's visit volume. Throughout the data collection phase of the project, the research assistants made contact, after each shift, with the primary investigator to address any concerns or issues identified during the shift. Permission was obtained from the EPs being observed; however, all were blinded as to what data were being collected during their observation periods. A convenience sample of data was then collected based upon research assistant availability, and each research assistant performed observations at both ED sites.

Both sites have rotating residents; however, observations were only completed when no residents were present to control for any effect they would have on collected data. During the observation periods,the research assistants noted and logged physician tasks in 30-second intervals. Tasks listed were identified from a predetermined standardized list presented at observer training (Table 1). Tasks were noted if they were completed, truncated, or placed in queue once a change in task was observed. We defined completed tasks as those not needing any immediate follow-up after a change in task. Truncated tasks were defined as tasks that were finished prematurely after a change in task that required no immediate follow up. We defined a task placed in queue as a task that was left incomplete following a change in task that later required follow-up.

We then collected and compiled data collected between the two sites. Tasks were further categorized as direct patient care and indirect patient care to compare patient contact times between the two sites (Table 1). We tabulated time spent with direct patient contact along with percentiles, means, and standard deviations calculated for both sites. Physician interruption data were tabulated by defining an interruption as a change in task with the previous task left incomplete or truncated. We tabulated the number of interruptions, and calculated means along with standard deviations for comparison. We performed all analyses using SAS v9.2 statistical software (SAS Institute Inc., Cary, NC, USA)

RESULTS

We compiled aggregate data for the 2 study sites.

Table 1. Standardized physician task list and categorization.

Direct patient care	Indirect patient care
Evaluating new patient	Charting (computer)
Evaluating old patient	Charting (paper)
Answering patient question	Dictating
Answering relative question	Asking nurse question
Performing procedure	Answering nurse question
	Talking with nurse
	Asking technician question
	Answering technician question
	Talking with technician
	Asking medical doctor question
	Answering medical doctor question
	Talking with medical doctor
	Asking student question
	Answering student question
	Talking with student
	Offline
	Reviewing old records
	Working on patient disposition
	Reviewing test results
	Reviewing radiology report
	Looking for chart
	Talking on phone
	Listening to student presentation
	Giving orders
	Writing orders

Table 2. Emergency department demographics at the two sites used in physician time use study.

	Site 1	Site 2
Average daily patient volume	190	147
Daily midlevel hours	38	39
Daily physician hours	76	43.5
Patients/ hour/ provider	1.7	1.8
Length of physician shifts	12	11
Admission rate	20.02%	11.60%
Average length of stay	248.3 minutes	179.2 minutes

Demographics of each ED are shown in Table 2. A total of 7 providers were observed at Site 1 and 5 providers at Site 2. All observed were attending physicians at their respective EDs. The number of months experience each site had with their EHR system was 8 years months at Site 1 and 10 months at Site 2. We collected a total of 4,140 minutes of data. Site 1 was observed for 2,340 minutes, and Site 2 for 1,800 minutes. Raw data totals for each site are included in Table 3 and 4.

Overall, the observed physicians spent 29.4% of the time charting using typed data entry (688/2340 minutes) vs 27.5% (495/1800 minutes) using voice recognition data entry. We identified no significant difference was identified between the 2 techniques (p=0.61). No significant differences were observed between the sites with regards to the time spent on direct patient care. Observed physicians spent 30.7% (718/2340 minutes) of their time in direct patient care at the site with typed data entry and 30.8% (554/1800 minutes) at the site using voice recognition data entry (p=0.98).

Regarding interruption data, EPs who used typed data entry were interrupted 5.33 times an hour compared to 3.47 times an hour using voice recognition data entry. This difference was statistically significant (p=0.017). Although the students are not allowed to chart for attendings, there did appear to be a difference in the time spent interacting with students between the sites (5.4% of physician task time at Site 1 and 1.4% at Site 2).

DISCUSSION

Our study data indicate there is no difference in the amount of time EPs spend charting between the 2 data entry techniques examined at our study sites. When comparing the 2 sites it is important to note that at Site 2 time allotted overall for charting involved 2 categories, "dictating" (333 minutes) and "charting (computer)" (129.5 minutes). In reviewing the notes from the observers, "charting (computer)" correlated with the time spent by providers reviewing and correcting their dictations. This indicated that although EPs spent less time dictating at Site 2 than EPs at Site 1 did with traditional charting, the time savings were spent on correcting dictated charts. This is somewhat consistent with previous studies that found voice recognition data entry led to more average corrections per chart and more time for review and correction than that compared with tradition dictation using a transcription service.[12,13,17-19] These studies have also suggested a steep learning curve for physicians to become efficient with this technology. Through our search in the literature, there were no studies or guidelines as to how long it takes physicians to become efficient with voice recognition data entry. The voice recognition site studied had 10 months of experience with the system compared to 8 years of experience in the typed data entry site. This experience discrepancy may have had an effect on the data collected as there is a chance efficiencies may be gained with continued use. However, Kennebeck et al. reported a return to a steady-state workflow after 3 months of implementing a EHR in a pediatric ED.[20] It is unknown the magnitude of efficiency gains that would occur after 10 months of continued use of the voice recognition data entry system.

The data from this study also displayed no significant difference in the amount of time physicians spent with their

Table 3. Data collection at site 1 (no voice recognition).

Task	Number of times placed in queue	Number of times truncated	Number of times interrupted	Time spent on task (minutes)
Charting (computer)	161	9	170	668
Charting (paper)	2	2	4	20.5
Dictating	0	0	0	0
Evaluating new patient	7	1	8	352.5
Evaluating old patient	0	0	0	180
Asking nurse question	2	0	2	23.5
Answering nurse question	3	2	5	86.5
Talking with nurse	0	4	4	64
Asking technician question	0	0	0	10
Answering technician question	0	0	0	9
Talking with technician	0	0	0	21.5
Asking medical doctor question	0	0	0	10
Answering medical doctor question	1	1	2	26.5
Talking with medical doctor	0	0	0	107
Asking student question	0	0	0	4.5
Answering student question	0	0	0	8
Talking with student	5	1	6	66.5
Answering patient question	0	0	0	8.5
Answering relative question	0	0	0	28
Offline	0	0	0	60.5
Reviewing old records	1	0	1	44.5
Working on patient disposition	2	0	2	37
Reviewing test results	6	1	7	53
Reviewing radiology report	8	3	11	37
Looking for chart	2	0	2	15
Talking on phone	1	0	1	127
Listening to student presentation	5	0	5	48
Giving orders	1	2	3	49
Performing procedure	0	0	0	149
Writing orders	1	0	1	25.5
Total	208	26	234	2340

patients with either charting method. EPs roughly spent a quarter of their time in direct patient evaluation, half of their time with indirect patient care, and a quarter of their time charting at both sites. These numbers are similar to those previously reported. [21,22] Hollingsworth et al., 1998 reported on average physicians spend 32% on direct patient care, 47% on indirect patient care, and 21% on non-patient care activities, while Chisholm et al., 2011 reported on average physicians spend 30% on direct patient care, 53% on indirect patient care and <1% on non-patient care activities.[21,22] Both these studies looked at academic teaching hospitals.[21,22] The difficulty in comparing these numbers arises with the definitions of direct and indirect patient care used in each study. Both previous studies included patient charting in the realm of indirect patient care. Hollingsworth included a sub-analysis comparing resident and attending charting time and found they spent 21% and 11.9% of their time charting, respectively.[22] Although not formally reported in their study, contacts with the studied site

Table 4. Data collection at site 2 (with voice recognition/dictation).

Task	Number of times placed in queue	Number of times truncated	Number of times interrupted	Time spent on task (minutes)
Charting (computer)	22	7	29	129.5
Charting (paper)	3	0	3	32.5
Dictating	44	6	50	333
Evaluating new patient	2	2	4	284.5
Evaluating old patient	4	4	8	168
Asking nurse question	0	2	2	19.5
Answering nurse question	0	0	0	63
Talking with nurse	0	0	0	58
Asking technician question	0	2	2	6.5
Answering technician question	0	0	0	9
Talking with technician	0	0	0	13
Asking medical doctor question	0	0	0	1.5
Answering medical doctor question	0	0	0	3.5
Talking with medical doctor	7	4	11	83
Asking student question	0	0	0	0
Answering student question	0	0	0	2.5
Talking with student	2	0	2	18
Answering patient question	0	0	0	27.5
Answering relative question	0	2	2	16.5
Offline	0	0	0	33.5
Reviewing old records	7	3	10	96
Working on patient disposition	1	1	2	2.5
Reviewing test results	3	1	4	56.5
Reviewing radiology report	0	0	0	9
Looking for chart	0	0	0	11.5
Talking on phone	1	1	2	117
Listening to student presentation	0	0	0	4
Giving orders	0	0	0	41.5
Performing procedure	1	0	1	57.5
Writing orderS	7	5	12	102
Total	104	40	144	1800

verify that paper charting was used. When compared to our study sites that used EHR, attendings at our teaching hospitals spent more time charting (29.4% and 27.5%). If we included charting into our analysis of indirect patient care and compared it to those previously recorded the EPs we observed spent roughly 1.5 times more time on indirect patient care. This supports the statement that the introduction of EHR adds an extra workload to attendings working in the ED. Interestingly, when looking at percent time spent in direct patient care, percentages were similar across all study ranging from 30-32%. The increase ddemands EHR adds to indirect patient care times seems to have been shifted away from that time previous reported as "non-patient care" activities. These included breaks, social time, and personal time. The "Offline" task classification used in our study is the best comparison we could use against previously reported "non-patient care" activities. Both of our study sites had EPs spent 2-3% of their time "Offline," which is far less than that reported by Hollingsworth at 21%.[22]

When analyzing interruptions data we found that EPs at Site 2 were interrupted almost 2 times less an hour than their counterparts at Site 1. This was found to be significantly different. The number of interruptions documented at each site was less than that found in previous studies reporting 6.9-15 interruptions per hour.[5,8,9,23] The differences found could be attributed to the study classification of an interruption, staff operations of each studied institution, and medical recordkeeping system. It is unknown what type of medical record techniques were being used at the previously studied institutions. However the 5.33 interruptions per hour found at Site 1 approximates what has been previously reported.[23] It has been noted that EPs were interrupted most frequently while reviewing data or charting.[5] One possible explanation of the decrease in interruptions recorded at Site 2 could be the fact that when physicians are dictating they are not interrupted and are allowed to finish. When comparing measures of site patient acuity and length of stay, Site 1 had a much higher admission rate and length of stay for its patients (Table 2). Higher acuity patients with longer stays in the ED could result in increased physician tasks and increased likelihood for interruptions.

LIMITATIONS

There are several limitations to the study. One limitation is that we did not collect the amount of time EPs spent charting outside the. There is a possibility that EPs at each of the sites may have spent additional amounts of time outside the ED reviewing and finishing charts started during the observation periods. This additional charting time could have an impact on the overall charting time observed for each site. A second limitation with the charting data may involve the total amount of observation minutes used for the study. The observed effect size between the 2 sites with regards to time spent charting was -1.9% for the voice recognition data entry site. We would have needed 331 individual 3-hour time blocks from each hospital for that difference to be statistically significant. Additional observation shifts were planned but not completed. However, Site 1 made a significant change to its ED operations, implementing increased provider hours in a front-end triage process. Site 2 shortly followed with a similar change in operations. We determined that inclusion of data from observation shifts after these ED changes would further compromised our findings. These types of operation changes within the ED environment will present a challenge for future studies in this area.

A third limitation of this study is that it was performed at 2 different EDs serving different patients and operating with different staff, resources, and administration. The 2 sites studied were chosen given that are were 0.6 miles away from each other in a metropolitan area of ~200,000 people serving a similar population base. Each site has similar lab and imaging capabilities. The majority of patients in the area receive their care via 2 large clinical practice groups. Both of these clinical groups have privileges at each site and rotate the same hospitalist, surgery, and specialty surgery staff, which does limit some variation with regards to consultation services and tasks. ED providers also see patients at similar rates at both facilities (1.7 and 1.8 patients/hr/provider).

As noted in the discussion section, patient acuity was different between the 2 sites with admission rates of 20.02% at Site 1 and 11.60% at Site 2 suggesting that even though both EDs serve the same population, the patients that visit each ED differ in their complaints and resource consumption. Length of stay was also much longer in Site 1 (248.3 min) than Site 2 (179.2 min) suggesting likely differences in ED operations and patient flow. These numbers, however, may also be skewed as each site uses different methods to measure and report these metrics. In regards to nursing and ancillary staff differences, 214.5/2,340 (9.2%) minutes at Site 1 and 169/1,800 (9.4%) minutes at Site 2 of physician task time were devoted to nursing and ancillary staff communication. These numbers suggest differences in nursing and ancillary at each site had minimal effect on direct patient care time data. However, differences in their staffing hours and experience could have skewed interruption data. Increased number of staff and inexperience of staff during any observations could have an effect of increased interruptions. Thesedata were not available for comparison. Physician pay and incentives also differ between the sites. Site 1 physicians were paid on a strict hourly basis while Site 2 had an RVU component based on patient satisfaction. This RVU incentive could have led to inflated direct patient contact times during data collection.

CONCLUSION

We identified no significant difference in the amount of time physicians spend charting or in direct patient contact between the two EHR systems examined in this study; typed data entry versus voice recognition data entry. However, we found a significant decrease in the amount of interruptions at the site that used voice recognition data entry for their EHR. Although voice recognition data entry does not necessarily require less time for data entry, our findings provide preliminary evidence for the potential to decrease the number of provider interruptions that occur during data entry. Additional studies are needed to further examine and better define the relationship between the data entry charting options to improve overall ED efficiency and workflow operations.

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Evaluation of Karl Storz CMAC Tip™ Device Versus Traditional Airway Suction in a Cadaver Model

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Introduction: We compared the efficacy of Karl Storz CMAC Tip™ with inline suction to CMAC with traditional suction device in cadaveric models simulating difficult airways, using media mimicking pulmonary edema and vomit.

Methods: This was a prospective, cohort study in which we invited emergency medicine faculty and residents to participate. Each participant intubated 2 cadavers (one with simulated pulmonary edema and one with simulated vomit), using CMAC with inline suction and CMAC with traditional suction. Thirty emergency medicine providers performed 4 total intubations each in a crossover trial comparing the CMAC with inline suction and CMAC with traditional suction. Two intubations were performed with simulated vomit and two with simulated pulmonary edema. The primary outcome was time to successful intubation; and the secondary outcome was proportion of successful intubation.

Results: The median time to successful intubation using the CMAC with inline suction versus traditional suction in the pulmonary edema group was 29s and 30s respectively (p=0.54). In the vomit simulation, the median time to successful intubation was 40s using the CMAC with inline suction and 41s using the CMAC with traditional suction (p=0.70). There were no significant differences in time to successful intubation between the 2 devices. Similarly, the proportions of successful intubation were also not statistically significant between the 2 devices. The proportions of successful intubations using the inline suction were 96.7% and 73.3%, for the pulmonary edema and vomit groups, respectively. Additionally using the handheld suction device, the proportions for the pulmonary edema and vomit group were 100% and 66.7%, respectively.

Conclusion: CMAC with inline suction was no different than CMAC with traditional suction and was associated with no statistically significant differences in median time to intubation or proportion of successful intubations. [West J Emerg Med. 2014;15(4):548–553.]

INTRODUCTION

Emergency physicians (EP) manage most of the airways including difficult intubations that occur in emergency departments (ED).[1-2] Endotracheal intubation can be difficult for many reasons, including limited time until oxygen desaturation and suboptimal views of the cords due to c-collars, blood, vomit and other secretions in the airway.[3] Obscured airway secondary to secretions may require suctioning to adequately visualize the vocal cords and the endotracheal tube passing through the cords. EPs may already start with a suboptimal view of the airway, and first attempt failure increases potential complications for the patient.[4]

The CMAC inline suction device is a novel device (Karl Storz, El Segundo, CA) with a suction catheter attached to

the tip. The inline suction device fits in a groove alongside the CMAC blade with the suction opening on the tip of the blade. The suction device is not adjustable once placed (Figure 1).The CMAC laryngoscope is shaped like a traditional Macintosh laryngoscope blade and it also attaches directly to an LCD screen. This allows for direct laryngoscopy (DL) in addition to video laryngoscopy. We attempted to evaluate the new Storz inline suction device created for the CMAC device in cadavers with simulations of airway secretions of different viscosities representing pulmonary edema and vomit.

The primary objective of this study was to determine if the CMAC with inline suction was superior to the CMAC with traditional suction when comparing time to intubation. The secondary objective was to compare the proportion of successful intubations.

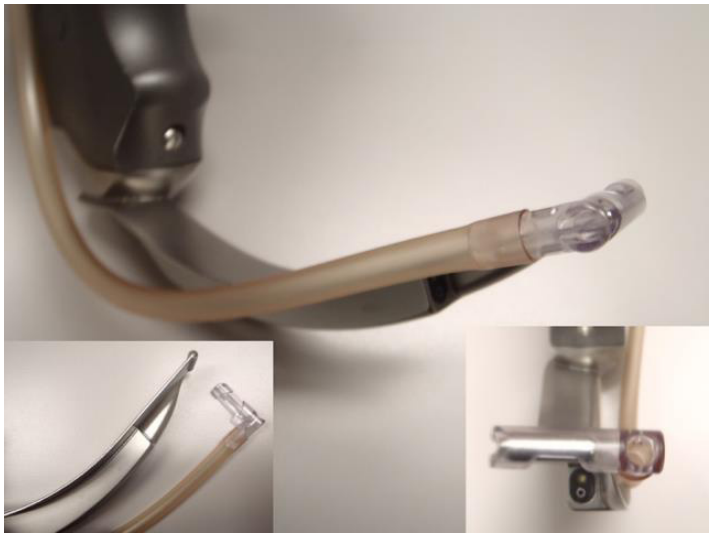

Figure 1. Karl Storz CMAC inline suction device.

METHODS

This was a prospective, cohort study using the CMAC inline suction device versus CMAC with traditional handheld suction device in simulated cadaveric airways, complicated by simulation vomit or pulmonary edema. Vomit was simulated by placing 60 ml of cream of mushroom soup into the oropharynx of fresh frozen cadavers prior to start time (Figure 2). Pulmonary edema was simulated by placing baking soda in the oropharynx and then adding vinegar with red food coloring, just prior to starting the intubation attempt (Figure 3).

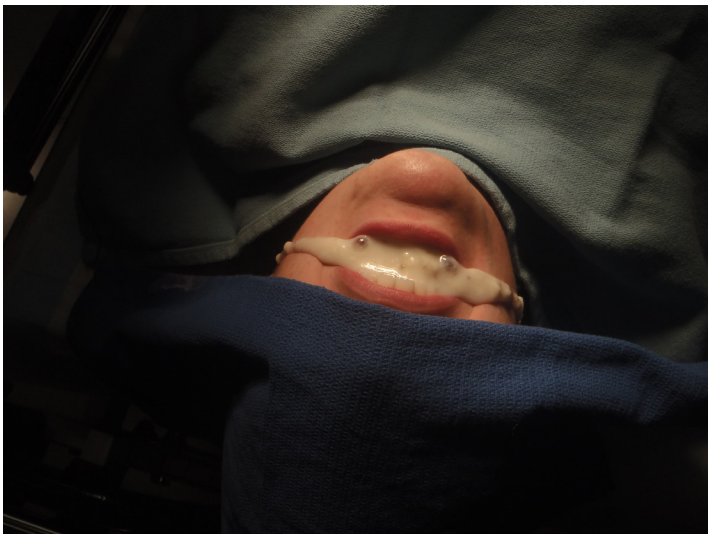

Figure 2. Vomit simulated fluid.

To simulate vomit, we used canned condensed cream of mushroom soup (Campbell's, Camden NJ). The pulmonary edema simulation was done by adding 1 tablespoon of baking soda (Arm and Hammer, Church and Dwight Company, Princeton NJ) and mixing it with 10 ml of vinegar (Heinz, H.J. Heinz Company, Pittsburgh Pennsylvania) with 1 teaspoon of red food coloring (McCormick, McCormick & Company, Sparks Maryland). Mixing this just prior to the intubation attempt, allowed for a more realistic simulation as the bubbles of the reaction collected at the surface of the mix simulated a pink, frothy sputum. The simulated fluids have not been previously validated; however, they have face validity and were considered to be good training aids by the participants during informal feedback.

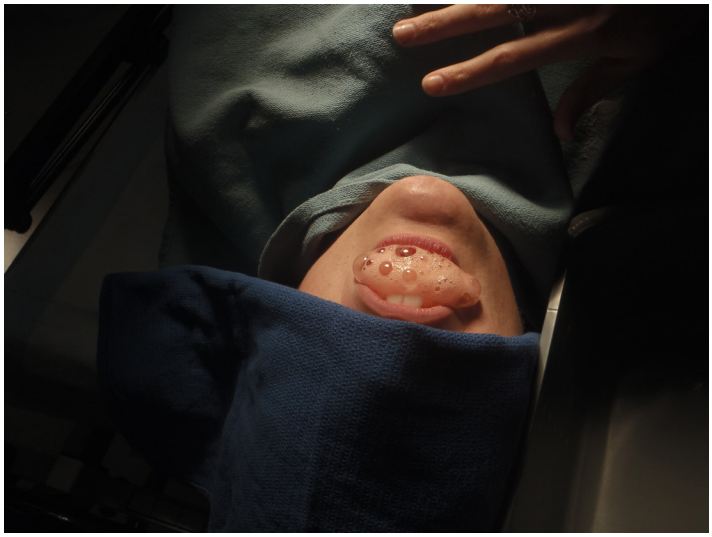

Figure 3. Pulmonary edema simulated fluid.

Thirty participants volunteered from 2 U.S. Army emergency medicine residency programs. The volunteers consisted of a combination of resident physicians (post-graduate year (PGY)1, PGY2, and PGY3 skill levels), as well as physician assistants and attending physicians. Intubations were attempted on 6 different fresh frozen cadavers. Equal number of participants started on each of the cadavers, and each participant endotracheally intubated 2 cadaver models. Participants were asked to intubate the cadavers using a 7.5 mm internal diameter cuffed endotracheal tube with a CMAC size 3 using the inline suction and with traditional handheld suction. The participants were given instruction on the handling of both the CMAC with inline suction and traditional handheld suction prior to the study. In both groups the suction

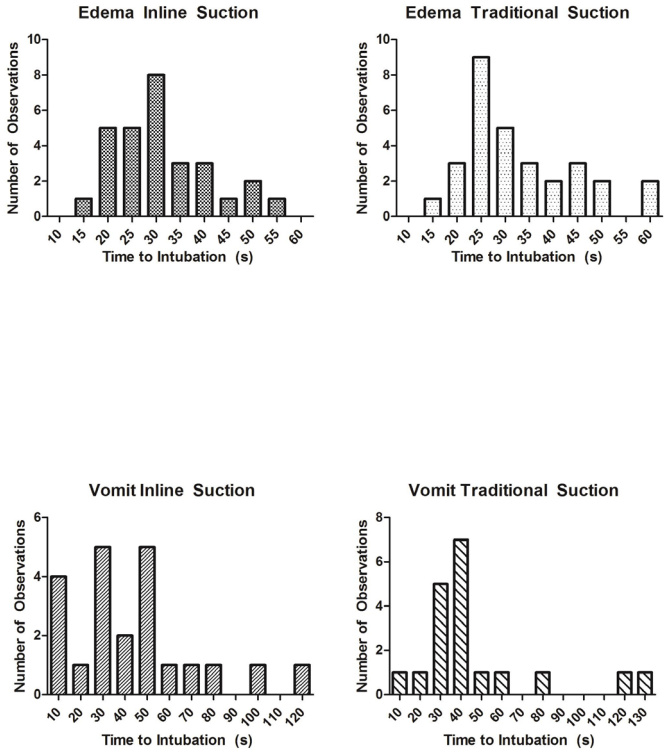

Figure 4. Frequency distribution of time to intubation for each simulated media and technique. Time to intubation is noted in 10 second intervals. "Inline Suction" refers to the CMAC with attached suction device and "Traditional Suction" refers to CMAC with detached standard suctioning.

catheters were connected to standard emergency medicine portable suction devices at maximal suction (for SSCOR Inc SCORT II Model 15006 this is approximately -525 mmHg).

We timed each participant for successful intubation, which was measured via stopwatch. Time was assessed beginning when tools were picked up from the table and stopped after the endotracheal (ET) tube cuff was inflated and stylette removed. Each participant was only allowed 1 attempted intubation per CMAC, suction, and vomit or edema combination. Successful intubation was confirmed with video and direct laryngoscopy by a single reviewer for each simulated substance. We recorded the number of successful versus unsuccessful intubations, in addition to time.

We excluded participants who were unsuccessful at intubation or placed the ET tube in the esophagus from our primary data because we were looking at overall time to successful intubation. However, as a secondary outcome we looked at the overall proportion of successful intubation for the inline versus traditional suction.

After breaking down the participants into skill groups, we performed a post-hoc analysis on both the primary and secondary outcomes Novice intubators were considered to be physician assistants, post-graduate level 1, and post graduate level 2 residents. Experienced intubators were considered to be post-graduate level 3 residents and attending physicians. This breakdown was considered appropriate in this data set since the data collection occurred toward the beginning of an academic year and therefore participants had only been in their year group for approximately 2 months.

The standard adjunct to assist endotracheal intubation has been traditional "wall mounted" suction, which can operate from -120 mmHg to -300 mmHg in our hospital. For this study, a portable suction device was used to replicate this handheld suction. Participants acted as their own controls in regards to their time to successful intubation with simulated vomit and pulmonary edema using the inline suction device versus their time to intubation with the handheld suction device. The subjects randomly selected 1 of the 4 simulations to start with so that approximately 1/4 of the subjects started on different simulations.

There were no prior studies to suggest a likely effect size, so we did not undertake a formal power analysis. The sample size was based on convenience and included all participants in a scheduled training event for residents. We described all time data with medians and interquartile ranges, and performed statistical analysis by comparing time to intubation using Mann-Whitney as the data was not parametrically distributed. We compared the proportions of successful intubation using Fischer's Exact Chi Square. A p-value <0.05 was considered significant.

RESULTS

The data failed normality tests as they were non-parametrically distributed (Figure 4). The distributions suggest positive skew, but are equal within comparison groups (edema with inline suction versus edema with traditional suction; vomit with inline suction versus vomit with traditional suction) and therefore comparison is possible. Due to the non parametric distributions we presented the medians.

The median time to successful intubation in the pulmonary edema simulation group using the CMAC with traditional suction was 30 seconds (s), while the median for inline suction was found to be 29s (p=0.54). Similarly, when comparing the CMAC with traditional suction in vomit simulation, the median time to successful intubation was 40s versus 41s with the inline suction (p=0.70). Neither result was statistically significant (Table).

The secondary outcome was overall proportion of successful intubation (Table). The simulated pulmonary edema group had an overall success rate of 100% with the handheld suction device, while the success rate with inline suction was 96.7%, (p=1.0). Success rates for the vomit simulation were 73.3% for inline suction and 66.7% with traditional suction (p=0.78).

As described previously, we conducted a post-hoc analysis of several subgroups. In both subgroups (novice and experience intubators) there were no statistically significant differences in either time to intubation or successful intubation (Table).

Table: Time to intubation and intubation success rates with two different suction devices.

	Inline suction	Traditional suction	p-value*
Time to intubation (s)†			
Edema fluid	29 (24-38)	30 (25-41)	0.54
Novice‡	28 (23-44)	27 (25-44)	0.91
Experienced§	29 (25-38)	31(26-40)	0.57
Vomit	41 (23-52)	40 (31-56)	0.70
Novice	32 (11-45)	40 (24-62)	0.39
Experienced	49 (29-74)	39 (31-60)	0.82
Intubation success (%)‖			
Edema fluid	96.7%	100%	1.0
Novice	100%	92.3%	1.0
Experienced	100%	100%	n/a¶
Vomit	73.3%	66.7%	0.78
Novice	69.2%	69.2%	1.0
Experienced	76.4%	64.7%	0.71

* Time to intubation compared using Mann-Whitney-U. Intubation success compared using Fischer's Exact Chi Square.
† Median with interquartile range
‡ Total (13), Physician assistant (1), Post graduate Level 1 (5), Post graduate level 2 (7)
§ Total (17), Post graduate level 3 (12), Attending (5)
‖ Proportion
¶ No calculation possible with <5 observations per cell

DISCUSSION

Overall, we found no statistical difference between the CMAC with inline suction and the CMAC with traditional suction when measuring time to intubation and proportion of successful intubations in a cadaveric model. Time to successful intubation and proportion of successful intubations are important measures in the ED. Multiple intubation attempts or a prolonged time to successful intubation are both associated with increased complications and adverse events. [5-7]

Several studies have looked at managing difficult airway using the CMAC with inline suction or other similar devices.[8-12] As Wadman et al[8] reported, they found no significant difference in the success rates when comparing the CMAC inline suction device versus the CMAC with traditional suction. Their study however, did not check time to successful intubation and only included one type of airway secretion. Mitterlechner et al[11-12] studied the effects of a suction laryngoscope that they created and compared the device to a regular Macintosh blade with traditional suction. They found no difference in time to intubation in a manikin study; however the success rate of orotracheal intubation was increased with the integrated suction laryngoscope. Other studies, such as the one conducted by Aziz et al[13] compared the effectiveness of the CMAC video laryngoscope versus direct laryngoscopy in the setting of the predicted difficult airway. They found that there was an increase in first attempt success at intubation with the CMAC but the time to intubation was on average 13 seconds longer than traditional direct laryngoscopy. This study did not include any secretions; therefore, suction was not used.

Our current study was different in several regards. First, we used the Storz inline device, instead of making our own. The lumen of the inline suction had a predetermined size and could not be adjusted. All of the subjects performing the intubations were emergency medicine provides. We also used two mediums with different consistency as the simulated difficult airway. To our knowledge, the specific mediums had not been tested before. This allowed us to collect data on the performance of this new integrated suction device as sold commercially.

By using two different media we ensured a broader experience for our participants. While our simulated secretion models were not previously tested, they appeared to be consistent with secretions found in the ED. Informal feedback after the study suggested that these were good simulated models; however, formal evaluation of them was not performed. Future studies could formally investigate these novel models.

Our primary outcome was time to successful intubation. Overall, patients presenting to the ED that need to be intubated have a less desirable clinical condition when compared to those of the operating room environment. According to Taryle et al there was an increase in number of prolonged intubation attempts in their study of patients with acute respiratory failure in the ED versus the operating room.[4] Their study looked at the complications of intubation in the ED and how

those complications related to the survival of the patients. As mentioned, complications in a controlled operating room environment are usually limited to sore throat and soft tissue trauma that is considered minor. Complications of ED intubations include increased prolonged intubation attempts (>90 seconds) and aspiration among others. Since our study shows no difference in time to intubation when testing the two different suction models, this might potentially indicate that either method could be useful in the ED. Prior studies have reported time to successful intubation while using a CMAC or integrated suction ranging from 33 s to 52 s.[11-13] Our results are similar to these previously reported times.

Our secondary outcome was proportion of successful intubations. Other studies have suggested that there was no statistical difference in overall success rate when comparing different intubating devices, including the CMAC.[14-16] Emergency physicians would like to minimize the number of intubation attempts, especially in a difficult airway as multiple and prolonged attempts lends itself to increased complications for the patients, such as hypoxia, trauma of airway, aspiration and even cardiac arrest.[4-7] Several studies have reported first attempt success rates from 82.2% to 87.3% for emergency physicians with several different intubating devices.[16-20] While our simulated pulmonary edema success rate appears to be higher, our vomit medium success rates appear to be lower than the previously reported average. This is likely due to the addition of simulated media in our study making it difficult to directly compare successful intubation rates.

Although other studies have shown that level of training has an effect on first pass success, our analysis of the subgroups based on level of training did not show a statistical difference in success rates. [20-22] It is possible that with an increase in subject size, a statistically significant difference may be discovered. And while there might be a possibility that the devices are equivalent, a non-inferiority design would be more useful to make this conclusion.

Overall, our results suggest no difference between the inline device and traditional suctioning when compared in 2 simulated media. This is in line with other studies that have studied various devices, but without the addition of simulated secretions.

LIMITATIONS

Our study has several limitations. As with all simulation studies, evaluating the performance of a technical skill in a controlled setting does not allow for variation in patients, preference of tools, or preparation. Therefore, generalizing results to real patients is difficult. Also given the environment of a simulation participants may have had less emphasis on proper technique; it is difficult to distinguish those who had a decreased level of skill from those who simply could not "suspend disbelief." We do believe that each subject, however acted as their own control when comparing the 2 suction devices thus minimizing potential bias.

As this was a trial performed on fresh frozen cadavers, the tissue may have responded differently than live tissue and may not be generalized to clinical practice. In addition, the study was performed on a select number of cadavers with multiple intubation attempts. Even though cadavers were switched throughout the study, it is likely that repetitive trauma and distortion of the airway contributed to difficulty recognizing the airway and successful placement. Slight variations in the amount and consistency of the simulated secretions could also have affected time to successful intubation and we could not simulate continuous airway secretions as a clinical scenario may present.

The simulated vomit and pulmonary edema models have not been previously validated. Formal validation of these models may be possible in the future using direct surveying of experienced providers; however, informal feedback sessions during the study had overwhelming positive feedback on the realistic nature of the simulated fluids.

There were no prior studies to suggest an effect size, and so a power analysis was not completed. As such, it is difficult to know if the study was underpowered to detect a difference. The study included 60 intubations (30 intubations per group for each of the 2 simulated substances). It is possible a larger study would show a statistically significant difference between the two devices.

In regards to the video laryngoscopy using the CMAC device, while most resident physicians were novices to the device, some of the attending physicians might not have been. The exact number of those familiar with the CMAC with inline suction was not formally evaluated before the study. All subjects were given an orientation to the CMAC device before use. While we were evaluating the inline suction, a confounding factor to time to successful intubation would be the inexperience of operators with the CMAC device itself. Comparison of the 2 devices (inline suction versus traditional suction) might pose a bias if the operators are not equally trained or equally proficient.[21-22]

Finally, subjects randomly selected which simulation they wanted to start with. This may allow for learning; however with only one intubation attempt allowed per device per simulated media (4 total), the significance of this is likely limited. Randomization was not performed as it was felt that to truly randomize the subjects, randomization would have to be done for each attempt for each subject. If not, then subjects would simply start with a different simulation but proceed in the same order. As learning across 4 attempts seemed limited, and randomizing all steps added complication, it was not attempted.

CONCLUSION

This prospective, laboratory study suggests that the Karl Storz CMAC suction tip device and traditional means of suctioning are no different. Differences in times to successful intubations were not statistically significant and neither were proportion of successful intubations.

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Epidemiology of Nursemaid's Elbow

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Introduction: To provide an epidemiological description of radial head subluxation, also known as nursemaid's elbow, from a database of emergency department visits.

Methods: We conducted a retrospective medical record review of patients 6 years of age and younger, who presented to the ED between January 1, 2005, and December 31, 2012, and were diagnosed with nursemaid's elbow. Inclusion criteria consisted of chart information, including date, unique account number, medical record number, weight, age, sex, and arm affected. Exclusion criteria included any charts with missing or incomplete data.

Results: There were 1,228 charts that met inclusion criteria. The majority of patients were female (60%). The mean age was 28.6 months (±12.6). The left arm was affected 60% of the time.

Most of the included patients were over the 75th percentile for weight and more than one quarter were over the 95th percentile in each gender.

Conclusion: The average age of children presenting with nursemaid's elbow was 28.6 months. Females were affected more than males, and the left arm was predominately affected. Most patients were above the 75th percentile for weight and more than one quarter were over the 95th percentile for weight. [West J Emerg Med. 2014;15(4):554–557.]

INTRODUCTION

Nursemaid's elbow, also known as radial head subluxation, is a common pediatric condition that typically occurs in children between 1 and 4 years of age, with a slight predominance in females. Reports suggest that the left arm is affected more often than the right in both males and females, and associated with the usual history of a pull to the arm, such as when a child is suddenly picked up from the floor by their hand or pulled at the wrist to prevent a fall. Radial head subluxation occurs when axial traction is applied to an arm that is extended while the forearm is pronated, allowing for slippage of the head of the radius under the annular ligament.[1,2] The distal attachment of the annular ligament covering the radial head is weaker and thinner in children as compared to adults, allowing it to be more easily torn or displaced.[3] The condition is characterized by acute onset of pain in the elbow and inability to manipulate the arm at the elbow.[3,4] The diagnosis is classically made by history and physical examination and confirmed by the patient using the affected arm after reduction. There are several techniques that may be employed for reduction, the most traditional being supination of the wrist followed by flexion at the elbow.[2,5,6]

Previous studies and reviews have identified epidemiological characteristics of nursemaid's elbow while using smaller sample sizes and larger ranges for most affected ages;[3,5] others have appraised various techniques for reduction of radial head subluxation.[2,6,7]

We wished to provide a larger epidemiological description

Table 1. Characteristics of patients diagnosed with nursemaid's elbow during 7-year study period.

Characteristic *N*=1,228	
Female visits	59.7% (733)
Mean age (months)	28.6 ±12.6
Left arm	59.8% (734)

of nursemaid's elbow from a large database of emergency department (ED) visits retrospectively reviewed over a 7-year period.

METHODS

This was a retrospective electronic medical record review to determine the epidemiology of nursemaid's elbow. We conducted the study at a suburban academic community hospital ED with an annual census of nearly 100,000 patients, of which 30,000 are pediatric patients (birth-21st birthday). This study has been approved by the hospital's institutional review committee.

We conducted a search for all patients 0 to 6 years of age who had a final diagnosis of nursemaid's elbow or subluxation of radial head, or the electronic medical record assigned the diagnosis code 832.2, between January 1, 2005, and December 31, 2012. We abstracted the following data points: date, unique account number, medical record number, weight, age, sex, and arm affected. Exclusion criteria included any charts with missing or incomplete data.

DATA/STATISTICAL ANALYSIS

We abstracted data from the electronic medical record (Allscripts ED™–formerly Healthmatics A4™). This computerized patient charting and order entry system enabled the collection of standardized information for each patient and integrated that information into a relational database. We queried the database by SQL Cognos Impromptu™ (Cognos) IBM (Armonk, New York), which allows the administrator to create reports using criteria filters. This has been described elsewhere.[8,9] Using the inclusion criteria, we created a report with Cognos that queries all patients seen in the ED who fit the criteria for study enrollment. This report was further analyzed by Excel 2007 (Microsoft; Redmond, WA), using tools that Cognos does not possess.

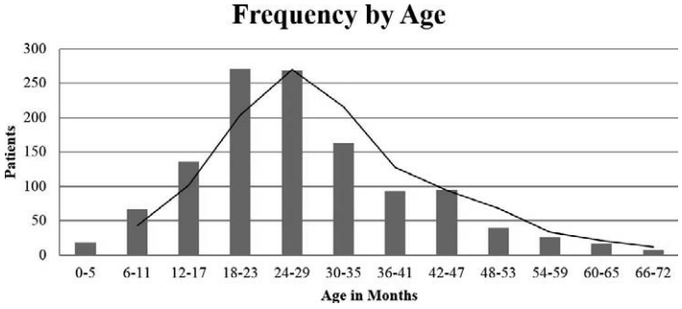

Figure 1. Age distribution of children with nursemaid's elbow or radial head subluxation.

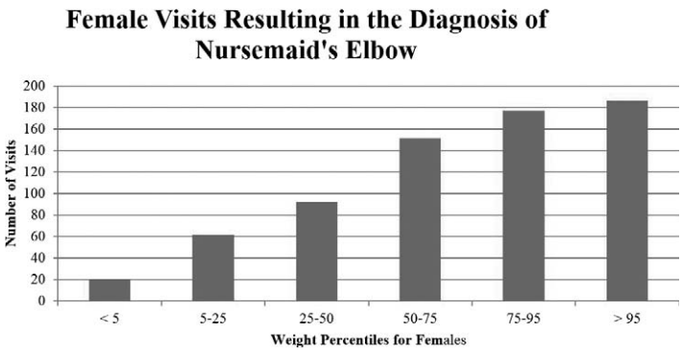

Figure 2. Distribution of affected females by weight.

RESULTS

There were a total of 1,228 visits to the ED with nursemaid's elbow between January 1, 2005, and December 31, 2012. All 1,228 charts contained the queried information, except for 78 that did not record the patient's weight. We included 1,150 charts in the weight analysis (Table 1).

We grouped patients by age in 6-month intervals. The average age at diagnosis was 28.6 months ±12.6. Forty-four percent (540) of all children affected presented in the 18–29 month old period.

We broke down charts by month and gender, comparing patients' weights to expected norms.[10] For females, 363/689 (53%) were over the 75th percentile for weight and 186/689 (27%) were over the 95th percentile for weight. For males, 279/461 (61%) were over the 75th percentile for weight and 150–461 (33%) were over the 95th percentile for weight (Figures 1,2, and 3). One hundred thirty-seven patients presented to the ED multiple times, resulting in 177 additional visits, as shown in Table 2.

DISCUSSION

As other studies have demonstrated, we also show a majority of patients with nursemaid's elbow are female.[4,5] As noted by Quan et al,[5] it is not clear if this female predominance

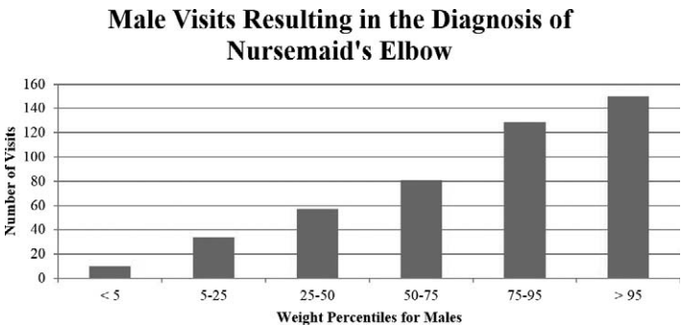

Figure 3. Distribution of affected males by weight.

Table 2. Repeat patient encounters resulting in diagnosis of nursemaid's elbow.

Number of repeat ED visits by a patient	Number of patients
7 (n=7)	1
6 (n=6)	1
5 (n=5)	1
4 (n=16)	4
3 (n=60)	20
2 (n=220)	110
Total repeat visits = 314	Total patients = 137

ED, emergency department.

is related to behavioral differences of females versus males or to anatomic factors.

We also illustrate, as previous studies have found, the left arm is more frequently affected than the right. This is thought to be due to the fact that most adults are right handed and will likely hold the left hand of their child, thus predisposing that child to nursemaid's elbow of the left arm.[11]

Our age distribution is consistent with that discussed in prior studies.[2,4,5] After exploring case histories, Illingworth[4] theorized that at the toddler age, 1–2 years, children are more prone to having the arm pulled by a parent.

Two other proposed theories to explain the age range when nursemaid's elbow commonly occurs are the small size of the radial head in relation to the shaft and the fact that the annular ligament is thinner in children under the age of 5.[3,4]

Our study shows that nursemaid's elbow is predominately a disease affecting children with elevated weight for age. The majority of patients were over the 75th percentile for weight, and over one quarter of all affected children were over the 95th percentile. Since 1980, the prevalence of obesity among children and adolescents has more than doubled.[12] This is believed to be due to multiple different cause, including genetics and food preferences,[13] increased TV viewing,[14,15] fewer family meals together,[15] gender, lower socioeconomic status and lower activity,[16] and maternal employment.[17] Our study demonstrates a relationship between overweight status and a physical condition, radial head subluxation, whereas other studies have demonstrated a psychosocial relationship between being obese or overweight and depressive symptoms, lower self-esteem,[18,19] and social marginalization.[20] Due to the numerous recognized consequences of elevated body weight and obesity, including radial head subluxation, emergency physicians should remain aware of their responsibility as physicians to promote increased physical activity and encourage healthy eating patterns among children presenting with radial head subluxation.

The data also show that about 1% of patient visits are repeat encounters, possibly due to predisposing factors previously mentioned, such as abnormal anatomy of the annular ligament or body weight.

Nursemaid's elbow is a clinical diagnosis, and the treatments have a subjective endpoint. Having epidemiological characteristics of this disorder established will allow clinicians to feel more confident in diagnosing and treating the condition. After reviewing current studies, to the best of our knowledge, we believe this is the largest study to date, as well as the first report illustrating the clear association between nursemaid's elbow and elevated body weight.

LIMITATIONS

This study was limited by its retrospective nature, as well as the fact that it was performed at a single suburban academic community hospital ED, which limits the applicability to other locales. Also, there may have been patients who had recurrences of radial head subluxation but were seen in a different medical facility for treatment.

In addition, there is a somewhat subjective nature in diagnosing nursemaid's elbow. Most current literature on the subject describes sudden relief of pain and spontaneous movement of the affected arm as a confirmation of successful reduction and diagnosis, but it is up to the physician to determine what degree of movement constitutes successful reduction.[4–6,11]

In spite of these limitations, however, our study presents several features of interest. This study reviewed charts from a substantial period of time, and to our knowledge this is the largest epidemiological description of nursemaid's elbow to date, as well as the first study to demonstrate a relationship between nursemaid's elbow and elevated body weight.

CONCLUSION

Nursemaid's elbow is a condition that affects mainly females, with left arm predominance, at an average age of 28.6 months. Most patient affected are above the 75th percentile for weight, and more than one quarter are over the 95th percentile for weight.

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Wordsmithing in Medical Toxicology: A Primer on Portmanteaus

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port•man•teau[1]
1. a large suitcase
2. a word or morpheme whose form and meaning are derived from a blending of two or more distinct forms (as smog from smoke and fog)

The history of language is littered with neologisms. When different cultures met, some words were subsumed - "hamburgesa," the Spanish word for hamburger is an example. Sometimes spelling is changed in order to denote a cultural difference. There are a number of words that end in 'er' in American English, but finish with a 're' in the British usage. Finally, some words are simply combined, deriving their meaning from their individual components, but in their artistry and simplicity are able to exceed the sum of their parts. Words such as these, a particular form of neologism called a portmanteau, can denote an entire idea in a single instant and provide the wordsmith with a particular type of joy.

The art of the portmanteau has had a recent resurgence. In popular culture names such as "TomKat," "Brangelina," and "Bennifer" have been used ad nauseam to refer to celebrity couples. When discussing the weather, it has been difficult to avoid "snowpocalypse" or "snowmageddon." These types of terms have other more pervasive entries into everyday life - who hasn't had a Frappuccino® while enjoying a brunch, perhaps using a spork to do so?

The benefit to these shortcuts involves speaking in a more efficient manner. The practice of medicine itself frequently employs not only portmanteaus, but also other neologistic shortcuts, such as by turning acronyms into words in the case of "cabbage" (CABG), "foosh" (fall on an outstretched hand), or the very well known "cat scan" (computed axial tomography). Emergency Medicine also has its own lexicon: "rectalizing" when needing to perform a rectal exam and "antibiosing" when one plans to provide antibiotics are examples. Even our staffing patterns are fair game, with "nocturnalists" frequently providing our overnight emergency department coverage. Finally, other terms such as "dilaudopenic" or "opiophilic" are self-explanatory. The art and practice of Medical Toxicology plays well to this type of verbal repartee, and it is in this vein the following terms are shared:

POISONTATION

Perhaps the best known toxicologic portmanteau is the "toxidrome" – a concept with which we are all familiar. A toxidrome is a constellation of signs and symptoms that point in the direction of a particular ingestant or class of medications, such as opioids, sedative-hypnotics, cardiovascular drugs, etc. However, the converse ought also be true – if a patient has ingested a particular medication or drug, one would expect them to manifest certain signs and symptoms as "proof" that they have done so. This concept of drug-centered symptomatology is better referred to as a "poisontation" – how ought a patient's presentation be influenced by their poison?

SYMPATHOMIMESIS

Medications that activate the fight-or-flight side of the autonomic nervous system are referred to as "sympathomimetics." Cocaine and amphetamines are likely the best known illicits, while therapeutically our armamentarium of pressor agents behaves in this manner. However, there is no great term for how they work. The root of "mimetic" belongs in the Greek word mimesis which means "to imitate." As these substances imitate our naturally occurring catecholamines, it is no great stretch to define their mechanism as acting through the process of sympathomimesis.

ASYMPTOMATICITY

The corollary to "poisontation" is the concept of "asymptomaticity." As we know from the father of medical

toxicology, Paracelsus, "all things are poison but for the dose." Similarly, patients may present with symptoms that exist on a spectrum, or may have no symptoms at all.

The degree to which asymptomatic patients present is what defines "asymptomaticity" – the pediatric patient that may have ingested a medication but who is actively running around the room, unless they are manifesting sympathomimesis, would be considered to have a high degree of asymptomaticity. However, the depressed young adult who may have ingested a bottle of his or her antidepressants but is pleasant, conversant, and not somnolent nor tachycardic at the time would not as they are at a higher risk for a serious ingestion and these medications can have delayed effects.

Asymptomaticity should be used in a manner that allows for rapid and concise clinical communication of how asymptomatic the patient currently is, and what our predicted course will be. We will likely discharge the first patient home, but may admit the second patient for observation to ensure that he does not become symptomatic.

DIGIBOUND

Patients who take digoxin are at risk of becoming toxic from this medication due to its narrow therapeutic window. In either acute overdose or in chronic use complicated by changes in renal function or protein binding, significant elevations in the serum concentration may affect multiple organ systems. Classically, this presents with nausea and vomiting, cardiac conduction abnormalities (AV block, atrial fibrillation with slow ventricular response), and hyperkalemia. In these patients, the use of a very elegant antidote is preferred – digoxin-Fab fragments. This antidote, which goes by the trade name of Digibind®, uses antibody fragments targeted at the digoxin molecule to bind it and prevent its clinical effects. Thus, when the patient has been dosed with Digibind, he or she may be considered to be Digibound, as "bound" is the past tense of "bind."

CHARCOTHORAX

One of the great fears of using activated charcoal as a decontamination method in patients who may become somnolent or obtunded and then vomit without an ability to adequately protect the airway is the potential for aspirating charcoal. In these patients, some toxicologists recommend against the routine use; however, if the patient is intubated one can easily instill it through a nasogastric tube, keeping in mind that intubation solely to administer activated charcoal is generally not recommended.

Occasionally, and potentially more disastrously, NG tubes will find their way out of the esophagus and into the pleural space and may appear to be in the correct location radiographically; this has been described in the literature following difficult intubations.[2] While the available data do not necessarily paint this as a high-probability occurrence, when it does occur "activated charcoal administration misadventure" is a bit lengthy and wordy for discussing the clinical entity. As such, the author proposes the term "charcothorax" – as a play on such terms as pneumothorax and chylothorax, it describes the presence of activated charcoal in the pleural cavity perfectly.

TOXANTHEM

In the realm of infectious disease, an exanthem is a dermatologic manifestation of a systemic disease, typically viral – though Strep and Staph species have been considered causative for Second Disease and Fourth Disease, respectively.[3] Exanthems may also be caused by immunologic disorders such as lupus, or by drugs and toxins.

An acronym already exists to discuss drug-associated rashes, namely DRESS syndrome. DRESS refers to Drug Rash with Eosinophilia and Systemic Symptoms, and is an umbrella term for any drug-related rash that manifests these findings. However, reactions such as the anticonvulsant hypersensitivity syndrome are due to specific biochemical processes and cause specific dermatologic changes that can be seen on biopsy, and deserve to have a specific subset dedicated to them.

As such, to prevent confusion when discussing medication-associated exanthems, as well as to differentiate these conditions from the more broad DRESS syndrome, this author uses the term toxanthem – a toxic exanthem – as it evokes the meaning of exanthem while clearly delineating it as being caused by a certain subset of medications.

HONORABLE MENTIONS

The following two terms are not the author's creations, but do hold special significance to medical toxicologists. Acetadote® - the branded intravenous formulation of N-acetylcysteine, used in cases of acetaminophen poisoning to both prevent and treat hepatotoxicity – is a portmanteau of acetaminophen antidote. Apocryphally, Reversed – one proposed trade name for flumazenil, which directly antagonizes GABAA receptors in the case of benzodiazepine poisoning – comes from the desired outcome of reversing Versed®. Due to concerns about accidental dosing, the ultimate trade name of flumazenil became Romazicon®.

CONCLUSION

The practice of emergency medicine is fast-paced and frequently requires being able to adequately and accurately convey information in a rapid manner. The development of pronounceable abbreviations and frank neologisms facilitates this, and this author would argue that concept is nearly universal within the emergency medicine community. These added terms presented above can help bring this to the realm of medical toxicology, especially as we often interact with our fellow emergency physicians. To the author's knowledge, these terms have not been used previously within the emergency medicine or medical toxicology literature,

per an exhaustive search within PubMed and multiple online search engines – Google, Bing, and WolframAlpha. The author's words, however, are not the be-all and end-all of this phenomenon, but rather are hoped to be a starting point for an entirely new generation of wordplay that adds both substance and style to the practice of medical toxicology.

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The Law of Unintended Consequences: Illicit for Licit Narcotic Substitution

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The dealers will not use it. Heroin dealers have explicit knowledge of the addictive properties of their product. The heroin addict is no longer the desperate character living under a bridge. She is a 17-year-old high school senior who runs out of her grandmother's oxycodone. He is the stockbroker who weighs the economics of purchasing one oxymorphone on the street for $100 or ten doses of heroin for $200. Because these people are ingesting and injecting products of unknown composition and unfamiliar potency, they can potentially overdose. If lucky, they end up in the emergency department rather than the morgue.

Kentucky ranks third in the nation in drug overdose mortality rate per 100,000 persons, with opioid pills making up the majority.[1] In response to these statistics, the State of Kentucky passed House Bill One (HB1) in April 2012, effective October 2012. Also known as "the pill mill bill," HB1 contains provisions intended to limit opioid prescriptions by pain management physicians and by other acute care providers such as emergency physicians. To prescribe narcotic pain medications, physicians must perform a full history and physical, prescribe only a short course, educate the patient on risks of controlled substances, and obtain a report from a statewide prescription monitoring program (PMP) (Kentucky All Schedule Prescription Electronic Reporting [KASPER]).[2]

As a result, the number of registered KASPER users in Kentucky has gone from 7500 to 23,000 from December, 2011 to November, 2012. Reports are up from 3300 to 17000 in the same time frame.[3] According to the same press release, Kentucky witnessed a decrease of 10.4% total prescriptions in the first six months since HB1 was enacted.[3]

Mandating PMP reports, as sixteen states currently do, leads to an increase in reports, but so far no statistical difference in opioid overdose mortality.[1,4,5,6] In fact, this legislation may not even lower the rate of opioid consumption, rather may shift which opioids are being prescribed.[6]

Researchers in Ohio looked at the impact of real time PMP information on opioid prescriptions. With PMP data, providers changed prescriptions in 41% of cases; 61% giving fewer opioids but 39% prescribing more opioids.[7]

House Bill One was intended to and has reduced opioid prescriptions in Kentucky. Forty-four pain clinics in Kentucky closed overnight.[8] Preliminary analysis at a large, metropolitan emergency department has shown a decrease in prescriptions for hydrocodone and oxycodone, along with a decrease in ED administration of these medications. This type of "pill mill" legislation has been passed in Louisiana, Florida, Texas and California with varying results.[9]

Florida had a sharp decrease in opioid prescriptions after similar legislation. Having 90 of the top 100 physicians on the Drug Enforcement Agency (DEA) 2010 list of top opioid purchasers, Florida saw the number decrease to 13 in 2011, and zero as of April 2013.[10] In 2011, Ohio passed a "pill mill bill" to crack down on pain management clinics.[11] This legislation led to seizing of 91,000 prescription pills with 38 doctors and 13 pharmacists losing their medical licenses. In the end, 15 medical professionals were convicted on diversion charges.[11] With all of this, pill overdose deaths began to decline, but heroin overdoses "skyrocketed."[11]

The unintended but foreseeable consequence of such measures has been increase in distribution, abuse, and overdose of heroin. Heroin has gained market share in a similar way in the past. In 2010, Purdue Pharma began manufacturing a reformulated OxyContin after a $600 million fine for misrepresentation.[12] Endo Pharmaceuticals Inc. followed in 2011 with an Opana ER reformulation. This resulted in making the pills harder to crush into powder for snorting or injecting.[13,14] States such as Florida, Ohio, Minnesota, and Utah have seen patients turn to heroin after crackdown on prescription opioid availability.[11,14]

The *New England Journal of Medicine* warned us of what would be a two-fold increase in heroin use after the reformulation of Oxycontin.[15] In the 2010 ODLL report, the United States DEA also attempted to warn health care organizations that Oxycontin users might switch to heroin.[16,17]

The first paper we know of to report this warning was published 3 years later in 2013.[16] This paper, a qualitative study of the transition of opioid pill users to heroin users, provides insight into the economic and convenience factors associated with the switch. The researchers interviewed a small sample of heroin users, forty-one in all. All but one of the 19 heroin users aged 20-29 started with pills and progressed to heroin – "termed pill initiates."[16]

Numerous popular news reports directly implicate decreased opioid pill availability in the rise of heroin abuse and overdose.[16] However, very little discussion of this phenomenon has entered the emergency medicine literature.

The drug cartels have capitalized on the United States opioid appetite and now decreased supply of pills. The route from Mexico to Detroit, then south through Ohio, ends up in northern and central Kentucky. The Kentucky State Police recovered 433 samples of heroin in 2010. In 2012 the number was 1349.[13] In Lexington, KY, the eight total heroin arrests in 2011 exploded into 160 in the first 6 months of 2013.[18,19] Undercover narcotics officers in Lexington find it easier to buy heroin than marijuana.

Heroin-related overdoses in Kentucky increased from 22 cases in 2011 to 143 cases in 2012, and 170 in the first 9 months of 2013.[8,20,21] Kentucky's percentage of overdose deaths involving heroin went from 3.2 in 2011 to 19.5 in 2012 and up to 26 in 2013.[8,21] This phenomenon has occurred in Florida, California, Massachusetts, New York, Oregon, Washington and Ohio.[11,22-24]

The emergency medicine literature has minimal recent discussion of heroin overdose management in the ED; nor have we discussed secondary prevention. Supportive therapy suffices in the ED, with liberal naloxone use and airway protection. State and federal actions to curb heroin deaths can be effective. Good Samaritan laws, present in only one third of states, protect from prosecution those lay individuals attempting to help themselves or companions in overdose situations.

Also present in only one third of states are laws to expand community access to reversal agents such as naloxone. Twenty-two states have laws requiring or recommending education for opioid prescribers. Medicaid expansion to cover substance abuse treatment has occurred thus far in less than half (24) of states.[1]

As more states enact measures intended to reduce total opioid prescriptions, legislators and healthcare providers alike must be aware of the predictable and devastating rise in heroin sales, abuse, and overdose. Funding for this legislation should include monies allocated toward substance abuse treatment programs and availability of naloxone. Similarly, pill mill bills could universally be coupled with Good Samaritan laws in anticipation of the increase in parenteral opioid overdoses. Funds could be allocated to lay population education via public service announcements. Stricter punishments for drug traffickers could accompany such legislative changes. Many of these measures have been presented as interventions to combat prescription opioid abuse and can now be applied to the subsequent heroin abuse and overdose dilemma.[9]

At the first line of medical care, emergency physicians must be involved in efforts to minimize collateral damage in this long-term process of curing America's addiction to opioid drugs and their horrible consequences.

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Simulation for Professionals Who Care for Bariatric Patients: Some Unanswered Questions

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Gable BD, Gardner AK, Celik DH, et al. Improving Bariatric Patient Transport and Care with Simulation. *West J Emerg Med*. 2014;15(2):199-204.

To the Editor:

Gable et al have presented an interesting study into the effectiveness of an educational intervention involving simulation and didactic teaching.[1] Certainly the problems with caring for obese patients are not going to go away quickly – so it is vital that we have adequate numbers of fully-trained staff that can care for them. However, there are some parts of the intervention and study that could have been improved upon.

Firstly, the authors attribute the improvement in knowledge scores and confidence to the educational intervention – but this attribution might not be correct. Assessment in itself may prime learners or may actually be a means of delivering learning. So it is possible that the pre-test may have resulted in improvement.

Secondly, an educational intervention of almost any type will naturally result in improvement in knowledge scores and confidence. It is unthinkable that an educational intervention would not. This does not make the authors' findings wrong – but rather less reportable. This argument is further strengthened by the fact that we already know that simulation works in a variety of topics, in a variety of contexts and for a variety of professionals. To be fair the authors do point out that this is the first time that simulation has been used in the training of pre-hospital personnel caring for bariatric patients. This question is perhaps one for the medical education world more generally: when can we accept principles that can be extrapolated to new contexts? And when do we have to prove the point of principle again in a new context? I would argue that we can go too far in trying to re-prove a point of principle again and again.

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