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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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Predatory Publisher Attempts to Compromise *West*JEM's Integrity

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The advance of Open Access publishing has given rise to a parallel and nefarious process called predatory publishing. Predatory publishing is defined as publishing that "upholds few if any of the best practices, yet demands payment for publishing, even from those most unable to pay."[1]

As we discussed in our 2016 article (https://escholarship.org/uc/item/64f3v9fj), there are at least 25 to 30 journals related to emergency medicine that engage in predatory practices.[1]

Recently, we became aware that *Arvin Publishers* republished an article from *West*JEM without the author's approval or acknowledgment of previous publication in *West*JEM (https://escholarship.org/uc/item/47m705bs).

The cornerstone of Open Access publishing is that the copyright remains with the authors and is not assigned to the journal. Therefore, any other journal needs the author's permission to use all or part of the material.

In this case, *Arvin Publishers* claimed the paper as their own and assigned it to their electronic website as if it had not been previously published. They did not ask for or receive authorization to do this from the paper's authors.

*West*JEM views this as a serious breach of publication ethics, and sent a letter demanding retraction to *Arvin Publishers*.

Although we received no written response, the plagiarized article was taken down from their website two days after the demand to retract the article was sent. Of note, all five of the articles included in this predatory publisher's first edition of their emergency medicine journal were stolen from other journals as well.

Predatory publishers use this tactic to appear legitimate with previously published but stolen material masquerading as their own. This can dupe authors into submitting papers for consideration and early publication, only to receive a bill for several thousand dollars after acceptance. These predatory publishers do not provide legitimate editorial services or peer review, and are not indexed in PubMed or any internationally known bibliographic databases, such that other researchers and readers can find the material to learn from and cite.

*West*JEM notified the authors of the other papers so that they could demand retraction as well.

Shortly after we discovered that the plagiarized paper from *West*JEM was removed, we then discovered that the entire current edition of stolen papers has now been taken offline.

The message of this experience is that authors should beware of predatory publishers in general and assure that journals to which they are submitting their work charge reasonable and transparent article processing fees after acceptance. Furthermore, researchers should assure that papers published in a journal are indexed widely so their work receives the attention it deserves.

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1. Hansoti B, Langdorf MI, Murphy LS. Discriminating between legitimate and predatory open access journals: report from the International Federation for Emergency Medicine Research Committee. *West J Emerg Med.* 2016;17(5):497-507.

Blunt Trauma Abdominal and Pelvic Computed Tomography Has Low Yield for Injuries in More Than One Anatomic Region

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Introduction: Most trauma centers order abdominal and pelvic computed tomography (CT) as an automatically paired CT for adult blunt trauma evaluation. However, excessive CT utilization adds risks of excessive exposure to ionizing radiation, the need to work up incidental findings (leading to unnecessary and invasive tests), and greater costs. Examining a cohort of adult blunt trauma patients that received paired abdominal and pelvic (A/P) CT, we sought to determine the diagnostic yield of clinically significant injuries (CSI) in the following: 1) the abdomen alone; 2) the pelvis alone; 3) the lumbosacral spine alone; and 4) more than one of these anatomic regions concomitantly.

Methods: In this retrospective study, we reviewed the imaging and hospital course of a consecutive sample of blunt trauma activation patients older than 14 years of age who received paired A/P CT during their blunt trauma assessments at an urban Level I trauma center from April through October 2014. Categorization of CSI was determined according to an a priori, expert panel-derived classification scheme.

Results: The median age of the 689 patients who had A/P CT was 48 years old; 68.1% were male; 64.0% were admitted, and hospital mortality was 3.6%. CSI yields were as follows: abdomen 2.2% (95% confidence interval [CI] [1.3-3.6%]); pelvis 2.9% (95% CI [1.9-4.4%]); lumbosacral spine 0.6% (95% CI [0.2-1.5%]); both abdomen and pelvis 0.3% (95% CI [0.1-1.1%]); both the abdomen and lumbosacral spine 0.6% (0.2-1.5%); both the pelvis and lumbosacral spine 0.1% (0.0-0.8%); all three regions – abdomen, pelvis and lumbosacral spine – 0.1% (0.0-0.8%).

Conclusion: Automatic pairing of A/P CT has very low diagnostic yield for CSI in both the abdomen and pelvis. These data suggest a role for selective CT imaging protocols that image these regions individually instead of automatically as a pair. [West J Emerg Med. 2018;19(5)768-773.]

INTRODUCTION

With many susceptible organs that are difficult to evaluate by physical exam, the abdomen is often considered the "black box" anatomic region in trauma.[1] Because of the diagnostic limitations of focused assessment with sonography for trauma (FAST) exam, a computed tomography (CT) is very commonly used to evaluate the abdomen (and pelvis) for injury.[1] Although they are anatomically distinct, the abdomen and pelvis are traditionally imaged altogether as a single unit in blunt

trauma (ordered as abdominal/pelvis [A/P] CT), with lumbar and sacral spine CT included as part of the abdominal and pelvis regions, respectively. Furthermore, A/P CT is often included as part of head-to-pelvis CT (pan-scan) protocol.[2,3]

The greater availability of high-speed CT has fueled a dramatic increase in its utilization in acute trauma patient evaluation.[4,5] This rise in use without a concomitant increased prevalence of injury may lead to low CT yields, which in some trauma scenarios approach zero.[6] Indiscriminant CT use for multiple regions without clear indications for each region can result in harms from over-imaging including costs, unnecessary radiation exposure, and the need to work up incidental findings.[7-12] Beyond the extra costs, a primary concern is the delivery of excess ionizing radiation to radiosensitive tissues, particularly the pelvic organs.[7-9] According to the work of Smith-Bindman et al.,[7] for every 470 20-year-old women undergoing routine A/P CT with contrast, one woman is predicted to develop a cancer from radiation exposure. Additionally, the need to work up incidental findings, which are very common with A/P CT, may provoke a cascade of excessive testing, including biopsies.[9-12]

Nevertheless, the risks and expense of reflexively paired A/P CT may still produce a net benefit if the diagnostic yield in multiple regions is sufficiently high. In this study, we investigated whether the current practice of paired A/P CT in adult blunt trauma evaluation was justified from this standpoint of diagnostic yields. Specifically, we sought to determine the following: 1) the diagnostic yields of A/P CT for clinically significant injury (CSI) in three anatomic regions: the abdomen, the pelvis and the lumbosacral spine; 2) the rates of injury concomitantly in more than one of these three regions; and 3) whether injury seen in one region increases the likelihood of injury in the other regions. We hypothesized that the yield of CSIs distributed in multiple anatomic regions would be very low (< 2%).

Population Health Research Capsule

What do we already know about this issue?
Even though they are anatomically distinct, clinicians routinely pair the ordering of abdomen and pelvis computed tomography (CT) in adult blunt trauma patient evaluation.

What was the research question?
What is the diagnostic yield for detecting clinically significant injury (CSI) in both the abdomen and the pelvis in paired abdomen/pelvis CT?

What was the major finding of the study?
The diagnostic yield for CSI in both the abdomen and pelvis is very low. If injury is seen in one region, then there is a higher likelihood of finding injury in the other region.

How does this improve population health?
Our findings suggest a need for more selective, higher-yield CT, which may decrease costs and radiation exposure.

METHODS

Study Design

In this study, we analyzed data and abstracted charts from the database of our prior study that assessed the yields of CSI with head-to-pelvis CT in blunt trauma evaluation. The study site was an urban Level I trauma center that sees approximately 72,000 patients and 3,800 adult trauma victims per year. The Committee on Human Research approved this study.

Inclusion and Exclusion Criteria

In the parent study, three abstractors used standard, systematic chart abstraction techniques with frequent audits and checks on inter-abstractor reliability to review the charts of all blunt trauma activation patients older than 14 years of age who received CT imaging during their blunt trauma assessment at this trauma center from April 1, 2014, to October 31, 2014.[13-14] Discordant or ambiguous data were reviewed by the principal investigator. For this analysis, we examined only the 689 charts and data of patients who received A/P CT scans.

Data Collection and Processing

Three abstractors collected pertinent patient data using structured abstraction instruments and managed data using Research Electronic Data Capture (REDCap) hosted by the University of California, San Francisco. We transferred data worksheets to Microsoft Excel (2014) for sorting and analysis.

We noted relevant injuries on CT readings in three anatomic regions: the abdomen, pelvis, and lumbosacral spine. To classify injuries, as we have done in previous studies of this topic,[15-17] we convened a panel of 10 associate professor level (or higher) emergency physicians. Each member of the panel independently reviewed a list of traumatic abdominal, pelvis and lumbosacral spine injuries and classified them as either CSI or not. Injuries were classified as CSI if five or more physicians classified it as such. Generally in this classification scheme, injuries were classified as CSI if they required surgical intervention, an interventional radiological procedure, or if they were associated

with a blood transfusion. In terms of blood transfusions, we did not distinguish between the index injury and other injuries that could have led to the transfusion. Because of possible need for extended observation, the expert panel also deemed three or more injuries to signify CSI. In terms of location of injury for organs that extend across the abdomen/pelvis border, injuries were analyzed according to where the primary injury was seen on CT. See Table 1 for this classification.

Table 1. Multidisciplinary expert-panel classification of clinical significant injuries.

All abdominal aortic or great vessel injuries
Splenic injury requiring surgical intervention or blood transfusion
Liver injury requiring surgical intervention or blood transfusion
Kidney injury requiring surgical intervention or blood transfusion
Pancreatic injury requiring surgical intervention or blood transfusion
Small or large bowel injury requiring surgical intervention or blood transfusion
Bladder or urethra injury requiring surgical intervention or blood transfusion
Uterine or ovarian injury requiring surgical intervention or blood transfusion
Pelvic bone fracture requiring blood transfusion, stabilization or surgical intervention
Lumbar spine fracture requiring orthotic brace or surgical intervention
Pelvic vessel injury requiring surgical or interventional radiologic procedure or blood transfusion
Three or more injuries in the abdomen or pelvis (chosen as an outcome by the panel's consensus)

Outcomes and Data Analyses

Our primary outcome was the yield of CT for CSIs in each of those regions and in various combinations of those regions. We defined yield as the number of patients with at least one CSI to the region or regions of interest divided by the total number of patients receiving A/P CT (n=689). Our secondary outcome was the yield of CT for *any injury* to the three regions and various combinations of those regions. Yield for this secondary outcome was defined as the percentage of the number of patients with at least one injury, regardless of clinical significance, to the region or regions of interest divided by 689. To determine whether CSI in one region was associated with a greater likelihood of CSI in other regions, we calculated odds ratios (ORs) using an online statistics calculator.[18]

RESULTS

Of the 2,120 eligible patients who presented as blunt trauma activations and had CT during our study period, 689 had A/P CT during their initial work-up. All of these A/P CT were paired; i.e., no patient received isolated abdominal or isolated pelvis CT. A total of 508 (73.7%) of these A/P CTs were ordered as part of head-to-pelvis CT imaging. The median age of patients receiving paired A/P CT was 48 years old (range 15-102 years old), and 469 (68.1%) were male. Refer to Table 2 for patient characteristics.

We list injuries and their classification in Table 3. In Table 4 and Table 5, we present the distributions and yields of CSI injuries and of any injuries. CSIs were seen in the abdomen in

Table 2. Patient characteristics (N = 689).

Characteristic	Number (%)
Gender (Male)	469 (68.1%)
Admitted	441 (64.0%)
In-hospital mortality	25 (3.6%)
	Median (Interquartile range)
Age (years)	48 (31,66)
Injury Severity Score	5 (1,14)
Length of hospital stay	4 (2,7)

15 (2.2%, 95% confidence interval [CI] [1.3-3.6%]) patients, in the pelvis in 20 (2.9%, 95% CI [1.9-4.4%]) patients, and in the lumbosacral spine in four (0.6%, 95% CI [0.2-1.5%]) patients. CSIs to both the abdomen and pelvis were seen in two (0.3%, 95% CI [0.1-1.1%]) patients, to the abdomen and lumbosacral spine in four (0.6%, 95% CI [0.2-1.5%]) patients, to the pelvis and lumbosacral spine in one (0.1%, 95% CI [0.0-0.8%]) patient, and to the abdomen, pelvis, and lumbosacral spine in one (0.1%, 95% CI [0.0-0.8%]) patient.

Any injury, both clinically significant and clinically insignificant, was seen in the abdomen in 50 (7.3%, 95% CI [5.6-9.4%]) patients, in the pelvis in 64 (9.3%, 95% CI [7.3-11.7%]) patients, and in the lumbosacral spine in 52 (7.5%, 95% CI [5.8-9.8%]) patients. Any injury was seen in both the abdomen and pelvis in 12 (1.7%, 95% CI [1.0-3.0%]) patients, in the abdomen and lumbosacral spine in four (0.6%, 95% CI [0.2-1.5%]) patients, in the pelvis and lumbosacral spine in 13 (1.9%, 95% CI [1.1-3.2%]) patients, and in the abdomen, pelvis and lumbosacral spine in four (0.6%, 95% CI [0.2-1.5%]) patients.

CSI in one anatomic region was associated with an increased likelihood of finding CSI in another region (OR [5.6], 95% CI [1.2-26.7]). Likewise, any injury in one

Table 3. Distribution of injuries to abdomen, pelvis, and spine.

Abdominal injuries	Clinically significant	Total
Splenic injury	8	22
Liver injury	4	18
Kidney injury	3	13
Pancreatic injury	0	3
Small bowel injury	1	2
Large bowel/colon injury	0	1
Abdominal aortic injury	3	3
Pelvic		
Bladder/urethra injury	1	4
Uterine injury	0	0
Ovarian injury	0	0
Pelvic bone injury	16	55
Pelvic vessel injury	6	6
Spine		
Lumbar spine injury	4	52

Table 4. Yields of abdominal and pelvis computed tomography (N = 689).

Injury detected	Yield for CSI-- # (% [95%CI])	Yield for any injury-- # (% [95% CI])
Injury in abdomen	15 (2.2 [1.3 -3.6])	50 (7.3 [5.6– 9.4])
Injury in pelvis	20 (2.9 [1.9 –4.4])	64 (9.3 [7.3-11.7])
Injury in LS spine	4 (0.6 [0.2 - 1.5])	52 (7.5 [5.8 - 9.8])
Injury in abdomen and pelvis	2 (0.3 [0.1 - 1.1)]	12 (1.7 [1.0 – 3.0])
Injury in abdomen and LS spine	4 (0.6 [0.2 - 1.5])	4 (0.6 [0.2 - 1.5])
Injury in pelvis and LS spine	1 (0.1 [0.0 - 0.8])	13 (1.9 [1.1 - 3.2])
Injury in abdomen, pelvis, and LS spine	1 (0.1 [0.0 - 0.8])	4 (0.6 [0.2 - 1.5])

LS, lumbosacral; *CSI,* clinically significant injury; *CI,* confidence interval.

anatomic region was associated with an increased likelihood of finding any injury in another region (OR [3.6], 95% CI [1.8-7.2]).

DISCUSSION

In this study, we investigated the yield of paired A/P CTs for detecting injuries in multiple anatomic regions in patients who had received blunt trauma. We found that less than 1% of paired A/P CTs revealed a CSI to both the abdomen and pelvis, to both the abdomen and lumbosacral spine, or to both the pelvis and lumbosacral spine and that less than 2% of these scans revealed any concomitant injury, clinically significant or insignificant, to those regional combinations. These low yields, which indicate approximately 345 CTs to detect CSI and 57 CTs to detect any injury in both the abdomen and pelvis, suggest little diagnostic benefit to reflexively pairing CTs of the abdominal and pelvic regions. We also demonstrated that there was a higher chance of seeing injury to either the abdomen or pelvis if there was an injury detected in the other region, a finding similar to that of other studies in which pelvic fractures were shown to be associated with injury in the abdomen.[19-21]

Table 5. Frequency of concomitant pelvic and abdominal injury.

Category	CSI frequency (% [95% CI])	Any injury frequency (% [95% CI])
Pelvic injury if has injury to abdomen	2/15 (13.3 [3.7 - 37.9])	12/50 (24.0 [14.3 – 37.4])
Pelvic injury if no injury to abdomen	18/674 (2.7 [1.7 - 4.2])	52/639 (8.1 [6.3 - 10.5])
Abdominal injury if has injury to pelvis	2/20 (10.0 [2.8 – 30.1])	12/64 (18.8 [11.1 – 30.0])
Abdominal injury if no injury to pelvis	13/669 (1.9 [1.1 - 3.3])	38/625 (6.1 [4.5 - 8.2])

CI, confidence interval.

CT imaging is not benign and by automatically pairing pelvic CT to an abdominal CT, patients are receiving increased radiation. A typical CT abdomen/pelvis exposes the patient to 15 millisievert (mSv), as opposed to 10 mSv of a CT abdomen alone.[22] The abdomen and pelvis, including digestive and reproductive organs, are particularly radiosensitive. Exposure to radiation increases the risk of developing malignancies later in life, especially in younger patients.[7-9, 22,23]

Several authors have reported that liberal head-to-pelvis CT imaging has significant utility in the critically ill, poly-trauma patient, and such pan-scan protocols are increasingly used for the evaluation of all adult blunt trauma patients with a concerning mechanism.[3,24,25] However, this approach of reflexive head-to-pelvis CT has generated substantial controversy, as experts weigh the balance between not missing clinically significant injuries and attempts to limit costs and radiation exposure.[2,25,26] Considering these risks and costs, both the American College of Surgeons and the American College of Emergency Physicians have included the avoidance of reflexive head-to-pelvis CT as part of their Choosing Wisely campaigns.[27,28]

Several investigators have proposed guidelines for selective A/P CT in adult trauma patients. However, because

these rules require the use of laboratory tests that take time, such as liver function tests, none of these rules has gained wide acceptance in acute trauma evaluation.[29-31] In fact, the majority of trauma patients are not critically ill with multiple sites of severe trauma. The median injury severity score of the 11,477 patients in the NEXUS Chest CT study conducted at eight Level I trauma centers was five.[17] It is this less critically ill trauma patient population that may benefit the most from selective CT protocols.

Our prior study demonstrated that head-to-pelvis CTs have a low yield for detecting injuries in multiple anatomic regions in patients after blunt trauma, suggesting more selective use of reflexive head-to-pelvis CT.[14] We also have previously demonstrated that paired CT of the head and neck is common and is a similarly low-yield practice.[17] Taken with these prior studies, our current findings suggest the need for more selective imaging in certain populations. While the severely injured, poly-trauma patient may still benefit from liberal head-to-pelvis CT protocols, less injured (low-risk) trauma patients may benefit from selective, clinical decision rule-guided (precision) CT, as has been demonstrated by other investigators.[32,33]

Overall, our findings suggest that clinicians should consider the uncoupling of abdominal and pelvis CT in lower-risk trauma patients. Toward more selective imaging, clinicians could choose to forego either the pelvis or abdominal portion of CT, depending on trauma mechanisms, physical exam findings and validated clinical decision rules. If a patient's mechanism and exam suggest that injury is restricted to the abdomen (and not the pelvis), then the CT could be limited to the abdomen region (and vice versa if injury is only suspected in the pelvis). Under such a protocol, our finding that injury found on CT in one region indicates higher likelihood of injury in the other region would suggest that, in those few cases where injury is seen on CT (< 3% for CSI and < 10% for any injury), CT of the other non-imaged region should be enacted. Real-time readings of CT (while patient remains on the CT table) may help prevent back-and-forth trips to the scanner under this strategy. Implementation of such selective CT protocols would require demonstrations of safety (and efficacy) in large multi-center trials.

LIMITATIONS

The primary limitation of this study is that it was conducted at a single site. Our results may not generalize to other institutions with different patient populations and different trauma CT-ordering practice. We only examined patients over 14 years of age; therefore, our results are not applicable to pediatric populations.

Our retrospective method prevented us from determining the reasons for CT; clinicians may have had strong clinical indicators to order both abdomen and pelvis CT concomitantly. Nevertheless, all CTs were ordered as paired, and it is unlikely that all of these patients had signs of dual abdomen and pelvis trauma.

Regarding the analysis of CT findings, some may question our anatomical location of injuries that may cross from the abdomen into the pelvis (i.e., injuries to the great vessels or sigmoid colon). There is also potential to miss extended injuries to parts of an organ if one were to perform isolated abdominal or pelvic CT.

Finally, clinicians may not agree with our classification of clinical significance and may believe that it is important to detect all (or nearly all) injuries, irrespective of whether these injuries change patient management. Even when considering all injuries, however, the rates of concomitant injury in both the abdomen and pelvis remained very low.

CONCLUSION

The yield of the current practice of automatically paired A/P CT is low for CSI in more than one anatomic region. When injury is seen in one anatomic region, there is a higher likelihood of having injury in one of the other regions. These data suggest a role for selective imaging protocols instead of the automatic pairing of CT of the abdomen and pelvis.

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Sepsis Bundle Adherence Is Associated with Improved Survival in Severe Sepsis or Septic Shock

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Introduction: There have been conflicting data regarding the relationship between sepsis-bundle adherence and mortality. Moreover, little is known about how this relationship may be moderated by the anatomic source of infection or the location of sepsis declaration.

Methods: This was a multi-center, retrospective, observational study of adult patients with a hospital discharge diagnosis of severe sepsis or septic shock. The study included patients who presented to one of three Los Angeles County Department of Health Services (DHS) full-service hospitals January 2012 to December 2014. The primary outcome of interest was the association between sepsis-bundle adherence and in-hospital mortality. Secondary outcome measures included in-hospital mortality by source of infection, and the location of sepsis declaration.

Results: Among the 4,582 patients identified with sepsis, overall mortality was lower among those who received bundle-adherent care compared to those who did not (17.9% vs. 20.4%; p=0.035). Seventy-five percent (n=3,459) of patients first met sepsis criteria in the ED, 9.6% (n=444) in the intensive care unit (ICU) and 14.8% (n=678) on the ward. Bundle adherence was associated with lower mortality for those declaring in the ICU (23.0% adherent [95% confidence interval{CI} {16.8-30.5}] vs. 31.4% non-adherent [95% CI {26.4-37.0}]; p=0.063), but not for those declaring in the ED (17.2% adherent [95% CI {15.8-18.7}] vs. 15.1% non-adherent [95% CI {13.0-17.5}]; p=0.133) or on the ward (24.8% adherent [95% CI {18.6-32.4}] vs. 24.4% non-adherent [95% CI {20.9-28.3}]; p=0.908). Pneumonia was the most common source of sepsis (32.6%), and patients with pneumonia had the highest mortality of all other subsets receiving bundle non-adherent care (28.9%; 95% CI [25.3-32.9]). Although overall mortality was lower among those who received bundle-adherent care compared to those who did not, when divided into subgroups by suspected source of infection, a statistically significant mortality benefit to bundle-adherent sepsis care was only seen in patients with pneumonia.

Conclusion: In a large public healthcare system, adherence with severe sepsis/septic shock management bundles was found to be associated with improved survival. Bundle adherence seems to be most beneficial for patients with pneumonia. The overall improved survival in patients who received bundle-adherent care was driven by patients declaring in the ICU. Adherence was not associated with lower mortality in the large subset of patients who declared in the ED, nor in the smaller subset of patients who declared in the ward. [West J Emerg Med. 2018;19(5)774-781.]

INTRODUCTION

The Surviving Sepsis Campaign (SSC) has established internationally endorsed guidelines for the management of patients with severe sepsis or septic shock (referred to as "sepsis" throughout this article).[1] These guidelines are distilled into bundles, which combine various components of sepsis care such as fluid resuscitation, timely and appropriate antibiotics, blood cultures, and the use of serum lactate levels. These components have evolved into core measures put forth by the Centers for Medicare & Medicaid Services (CMS) in October 2015. As hospital compensation from CMS is partially dependent on quality measure performance, hospital administrative efforts and resources have been directed toward improved compliance and accurate reporting. Due to the complexity of requirements and data verification procedures, it is estimated that hundreds of thousands to millions of dollars per year per hospital are spent on meeting and reporting these measures.[2]

The clinical benefit of adherence should be clearly demonstrated to justify this costly effort, but there are reasons for skepticism. In fact, some CMS quality metrics related to acute infections have had undesired negative effects. For example, the quality measure "blood cultures performed in the ED prior to initial antibiotics received in the hospital" for pneumonia[3-5] has been shown to be costly, results in high false-positive blood culture rates, and rarely results in antibiotic changes while simultaneously prolonging hospital length of stay.[4,6]

To date, experiences with the sepsis bundles have been mixed. Some studies have demonstrated an improvement in overall mortality with sepsis-bundle adherence,[1,7,8] but some of the most prominent recent studies examining sepsis treatment, including the ProCESS, ProMISe and ARISE trials, failed to show a similar benefit.[9-13] These contradictory findings may be due to smaller sample sizes, heterogenous effects of bundle adherence based on the source of infection (e.g., bundle adherence may matter more for pneumonia than urinary tract infection [UTI]), or variability in the site of sepsis declaration in the hospital (ED vs. intensive care unit [ICU]).

Using best practices from the SSC, the the Los Angeles County Department of Health Services (DHS) implemented an initiative to improve sepsis management through the use of bundles at its public hospitals. The strategy developed by DHS to improve sepsis care included implementation of a resuscitation bundle, measuring and assuring adherence with the bundle, and tracking mortality for patients with sepsis. Using data archived throughout this process, the current study sought to achieve the following: 1) characterize the association between bundle adherence and mortality for patients with sepsis; 2) examine whether the location of declaration in the hospital (ED vs. ward vs. ICU) impacts the relationship between bundle adherence and mortality; and 3) explore how the source of infection influences the relationship between bundle adherence and mortality.

Population Health Research Capsule

What do we already know about this issue?
Resources are being expended by hospitals on sepsis-bundle quality measures. It is unclear which patients with sepsis benefit from adherence to these bundles.

What was the research question?
Is sepsis-bundle adherence associated with improved mortality? Does location of declaration or source of infection matter?

What was the major finding of the study?
Sepsis-bundle adherence was associated with lower mortality in intensive care unit declarations, but not in cases declaring in the emergency department or ward.

How does this improve population health?
Focusing resource-intensive treatments on patients who benefit improves the value of care. This study explores which hospitalized patients benefited from sepsis-bundle adherence.

METHODS

This was a multi-center, retrospective, observational study of adult patients (≥ 18 years old) with a hospital discharge diagnosis of either severe sepsis or septic shock (ICD-9). The study included patients who presented to one of three Los Angeles County DHS full-service inpatient hospitals following implementation of a sepsis improvement initiative. Beginning in 2011, the sepsis program was implemented in phases across these sites. Excluding this staggered roll out, the study period encompasses January 2012 through December 2014. This study was approved by the DHS institutional review board.

We included in the dataset patients meeting severe sepsis or septic shock clinical criteria (Table 1) within the ED or inpatient setting. The inclusion criteria for severe sepsis was suspected or confirmed infection, two or more systemic inflammatory response syndrome (SIRS) criteria, and evidence of acute organ dysfunction. SIRS criteria included the following: body temperature > 38 ºC or < 36 ºC; heart rate > 90 beats per minute; respiratory rate > 20

respirations per minute or partial pressure of carbon dioxide in arterial blood ($PaCO_2$) < 32 mmHg, and white blood cell count > 12,000 per mm^3 or < 4,000 per mm^3 or a bandemia of > 10%. Organ dysfunction was defined as a new-onset ventilator requirement, vasopressor requirement, new-onset creatinine elevation > 2 mg/dL, new-onset INR > 1.5 in the absence of warfarin, FiO_2 > 30%, or new-onset thrombocytopenia of < 100,000 per µL. Septic shock was defined as severe sepsis plus lactate ≥ 4 mmol/L and/or systolic blood pressure < 90 mmHg or mean arterial pressure < 65 mmHg after 20 mL/kg of crystalloid fluid. Patients receiving comfort care were excluded.

Bundle adherence metrics were adapted from the SSC bundles from 2012.[1] For the purposes of this research project, bundle adherence was defined as the following: 1) lactate levels drawn within four hours pre-declaration or six hours post-declaration; 2) blood cultures prior to antibiotic administration; 3) a minimum of 20mL/kg of crystalloid fluids administered within six hours pre-declaration or six hours post-declaration (Patients with documented evidence of fluid overload were exempt from the intravenous fluid administration requirement. Fluid overload was defined as pulmonary edema on chest radiograph, an elevated B-natriuretic peptide level, or documentation of a plethoric inferior vena cava on bedside ultrasound.); 4) antibiotics administered within three hours of declaration in the ED setting or within one hour of declaration in the inpatient setting. Bundle adherence for patients in septic shock included the above components plus the administration of vasopressors.

Trained, utilization-review nurses recorded location of sepsis declaration (ED vs. ICU vs. ward) and timestamps associated with administration of antibiotics, completion of target fluid administration, and measurement of serum lactate levels. They determined the source of infection by reviewing the admission and discharge diagnoses and reviewing laboratory and radiographic data. These event data were used by the researchers to assess for adherence to the bundle.

The primary outcome analyzed was in-hospital mortality. Secondary outcome measures included in-hospital mortality by source of infection and location of declaration. Descriptive statistics were generated for all variables with appropriate confidence intervals. We used chi-square and Mann-Whitney U-tests of statistical significance for categorical and continuous variables, as appropriate.

RESULTS

Demographics of the study population are listed in Table 2. The mean age was 54.8 years and the median age was 55.5. Further, 75.5% (n=3,459) declared in the ED, 9.6% (n=444) declared in the ICU, and 14.8% (n=678) declared on the ward. Pneumonia was the most common source of infection (32.6%; n=1,494) followed by UTI (20.3%; n=929). Overall in-hospital mortality was 18.9% (n=867) and overall bundle adherence was 60.1% (n=2,755).

Table 1. Definitions of severe sepsis, septic shock and bundle adherence.

Severe sepsis	Septic shock	Bundle adherence
Suspected or confirmed infection	Severe sepsis plus lactate ≥ 4 mmol/L	Lactate levels drawn within 4 hours pre-declaration or 6 hours post-declaration
Two or more SIRS criteria[A]	AND/OR systolic blood pressure < 90 mmHg or mean arterial pressure < 65 mmHg after 20 mL/kg of crystalloid fluid	AND blood cultures prior to antibiotic administration
Evidence of acute organ dysfunction[B]		AND a minimum of 20mL/kg of crystalloid fluids administered within 6 hours pre-declaration or 6 hours post-declaration[C]
		AND antibiotics administered within 3 hours of declaration in the ED setting, or within 1 hour of declaration in the inpatient setting
		AND administration of vasopressors, if in septic shock

SIRS, systemic inflammatory response syndrome; *mmol/L*, millimoles per liter; *mmHg*, millimeters of mercury; *mL/kg*, milliliters per kilogram; *ED*, emergency department; *mm*^{3}, millimeters cubed.

[A]SIRS criteria included temperature > 38 ºC or < 36 ºC, heart rate > 90 beats per minute, respiratory rate > 20 respirations per minute or partial pressure of carbon dioxide in arterial blood ($PaCO_2$) < 32 mmHg, and white blood cell count > 12,000 per mm3 or < 4,000 per mm^3 or a bandemia of > 10%.

[B]Acute organ dysfunction was defined as new-onset ventilator requirement, vasopressor requirement, new-onset creatinine elevation > 2 mg/dL, new-onset INR > 1.5 in the absence of warfarin, FiO_2 > 30%, new-onset thrombocytopenia of < 100,000 per µL.

[C]Patients with documented evidence of fluid overload were exempt from the intravenous fluid administration requirement. Fluid overload was defined as pulmonary edema on chest radiograph, an elevated B-natriuretic peptide level, or documentation of a plethoric inferior vena cava on bedside ultrasound.

Table 2. Demographic characteristics of patients (N=4,582).

Patient demographics	N	%
Gender		
Male	2451	53.8
Female	2106	46.2
Race		
Asian	416	9.1
African American	593	13
White	3017	66.2
Other	389	8.5
Unknown	143	3.1
Ethnicity		
Hispanic or Latino	2783	61
Not Hispanic or Latino	1623	35.6
Unknown	153	3.4
Language		
English	2259	49.6
Spanish	2042	44.8
Other	256	5.6
Marital status		
Married	1280	27.9
Single	2332	50.9
Widowed/divorced/separated	720	15.7
Unknown	206	4.5
Location of declaration		
Emergency department	3459	75.50%
Intensive care unit	444	9.60%
Ward	678	14.80%
Facility		
LAC+USC	1965	42.90%
HUCLA	1447	31.60%
OVMC	1170	25.50%
Source of infection		
Pneumonia	1494	32.60%
Urinary tract infection	929	20.30%
Abdominal/gynecologic	606	13.20%
Bone/soft tissue/wound	481	10.50%
Multiple sources	317	6.90%
Unknown source	755	16.50%
Bundle adherent care	2755	60.10%
Mortality	867	18.90%

LAC+USC, Los Angeles County + USC Medical Center; *HUCLA*, Harbor-UCLA Medical Center; *OVMC*, Olive View Medical Center.

Overall, sepsis-bundle adherence was associated with improved mortality. Mortality among patients with bundle adherence care was 17.9% (95% CI [16.5-19.4]), whereas it was 20.4% (95% CI [18.6-22.3]) for those who did not receive bundle-adherent care. The relative increase in mortality rate for bundle non-adherence as compared with bundle adherence was 14.0% as is shown in Table 3. In general, regardless of the anatomic origin of sepsis, mortality was improved for patients who received bundle adherent care. Pneumonia had a relative increase in mortality rate for non-adherence of 36.3% ($p<0.001$), followed by multiple sources (33.2%; p=0.165), intra-abdominal/gynecologic (16.6%; p=0.347), and UTI (6.6%; p=0.804).

The mortality improvement for bundle-adherent care was not consistent across all sites of sepsis declaration (as shown in Table 4). Bundle adherence was associated with a trend toward improved mortality for patients whose sepsis declared in the ICU (23.0% adherent [95% CI {16.8-30.5}] vs. 31.4% non-adherent [95% CI {26.4-37.0}]; p=0.063), but was similar in ED declarations (17.2% adherent [95% CI {15.8-18.7}] vs. 15.1% non-adherent [95% CI {13.0-17.5}]; p=0.133) and in ward declarations (24.8% adherent [95% CI {18.6-32.4}] vs 24.4% non-adherent [95% CI {20.9-28.3}]; p=0.908).

Figure 1 depicts the relative rate of mortality for bundle adherent and bundle non-adherent patients per quarter from January 2012 to December 2014. The mortality over time of patients receiving bundle adherent care is generally lower than the mortality of those receiving non-adherent care.

A locally-weighted scatterplot smoothing comparing month-to-month sepsis cases vs. mortality rate is depicted in Figure 2. Although there was some fluctuation in the number of sepsis cases from month-to-month, overall the number of sepsis cases remained relatively stable from January 2012 through December 2014 (ranging from 104 to 140) while the mortality rate decreased. We saw an initial trend toward more sepsis cases from January 2012 through July 2013 with a high of 140 cases for the month of July 2013. The mortality rate remained relatively stable from January 2012 through September 2013 with an average rate of 25.3%. The rate then steadily decreased from 26.2% in September 2013 to 13.6% by December 2014.

DISCUSSION

CMS implemented the Severe Sepsis and Septic Shock Management Bundle in 2015, thus establishing a significant financial incentive for adherence, despite conflicting scientific evidence on its clinical impact. In this large study of a major urban healthcare system, we found that bundle-adherent care was, in fact, associated with lower mortality overall. Interestingly, the effect of bundle adherence varied markedly depending on the location of declaration. In the ICU, a 7% absolute decrease in mortality was associated with bundle adherence. Conversely in the ward and ED, bundle adherence was not associated with any improvement in mortality. This finding merits careful exploration as the great majority (75.5%) of sepsis patients were diagnosed in the ED.

Table 3. Mortality rate by bundle adherent vs. non-adherent, per infection source.

		Bundle adherent		Bundle non-adherent			
Source of infection	Total cases (n, %)	% Mortality	95% CI	% Mortality	95% CI	Relative increase in mortality rate for non-adherence	P value
Overall	4582	17.9%	16.5, 19.4	20.4%	18.6, 22.3	14.0%	0.035
Pneumonia	1494 (32.6%)	21.2%	18.7, 23.9	28.9%	25.3, 32.9	36.3%	<0.001
Urinary tract infection	929 (20.3%)	6.1%	4.3, 8.4	6.5%	4.4, 9.4	6.6%	0.804
Abdominal/gynecologic	606 (13.2%)	18.7%	14.8, 23.3	21.8%	17.3, 27.0	16.6%	0.347
Bone/soft tissue/wound	481 (10.5%)	13.0%	9.5, 17.6	11.7%	7.9, 16.9	-10.0%	0.661
Multiple sources	317 (6.9%)	20.2%	15.0, 26.7	26.9%	20.0, 35.1	33.2%	0.165
Unknown source	755 (16.5%)	26.5%	22.7, 30.7	25.1%	20.4, 30.5	-5.3%	0.672

CI, confidence interval.

Table 4. Mortality rate by site and bundle adherence.

		Died during hospitalization		Survived hospitalization		
Location of sepsis declaration	Bundle adherence	n, %	95% CI	n, %	95% CI	P value
Emergency department						
	(+) Bundle adherence	422 (17.2%)	15.8, 18.7	2031 (82.8%)	81.3, 84.2	0.133
	(-) Bundle adherence	152 (15.1%)	13.0, 17.5	854 (84.9%)	82.5, 87.0	
Ward						
	(+) Bundle Adherence	38 (24.8%)	18.6, 32.4	115 (75.2%)	67.6, 81.4	0.908
	(-) Bundle adherence	128 (24.4%)	20.9, 28.3	397 (75.6%)	71.7, 79.1	
Intensive care unit						
	(+) Bundle adherence	34 (23.0%)	16.8, 30.5	114 (77.0%)	69.5, 83.2	0.063
	(-) Bundle adherence	93 (31.4%)	26.4, 37.0	203 (68.6%)	63.0, 73.6	
Overall						
	(+) Bundle adherence	494 (17.9%)	16.5, 19.4	2,260 (82.1%)	80.6, 83.5	0.036
	(-) Bundle adherence	373 (20.4%)	18.6, 22.3	1,454 (79.6%)	77.7, 81.4	

CI, confidence interval.

It is unclear why bundle adherence did not have an association with improved mortality for ED patients but did for ICU patients (though not statistically significant). One possibility is that patients presenting to the ED with severe sepsis or septic shock had been suffering from the condition for many hours to days but could only "declare" once they arrived for medical attention. As a result, the marginal advantage of "timely care" per bundle requirements as compared with the timeline of disease evolution outside of the hospital was lost. For patients declaring in the ICU, it may be that they truly developed sepsis contemporaneous with the declaration of sepsis and that, therefore, early intervention was possible. Another factor may be that patients declaring in the ICU had higher illness severity, making treatment effects more easily observed. A final possibility is that "non-adherent" care in the ED may have been *almost* adherent care, perhaps only missing quality goals by a few minutes or few milliliters. In such circumstances, any mortality differences between adherent and non-adherent subjects would have been muted.

We found only two other studies that specifically examined the relationship between sepsis-bundle adherence and mortality in ED patients that yielded conflicting results. One small study (N=117) from Singapore found no statistically significant relationship between bundle compliance and mortality for ED patients,[14] while another study (N=330) observed a very large difference in mortality between bundle adherent and non-adherent ED patients

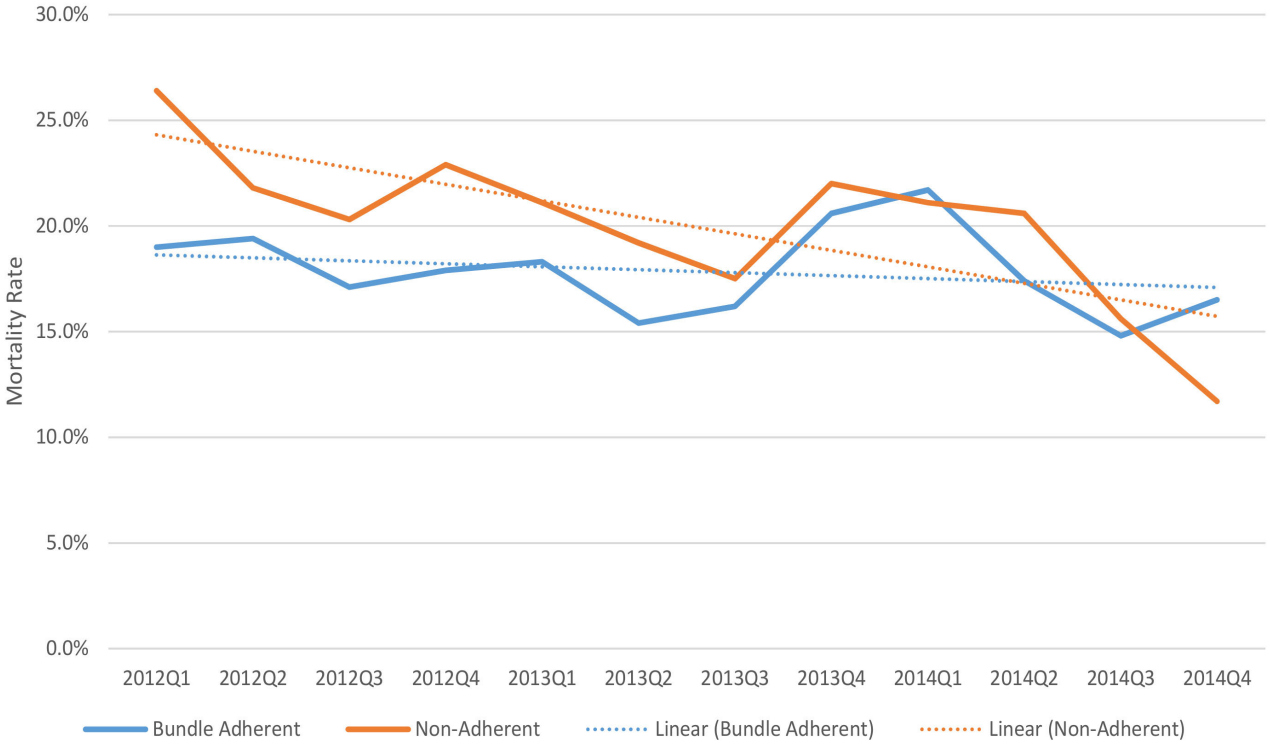

Figure 1. Mortality rates by bundle adherence, overall, 2012-2014.

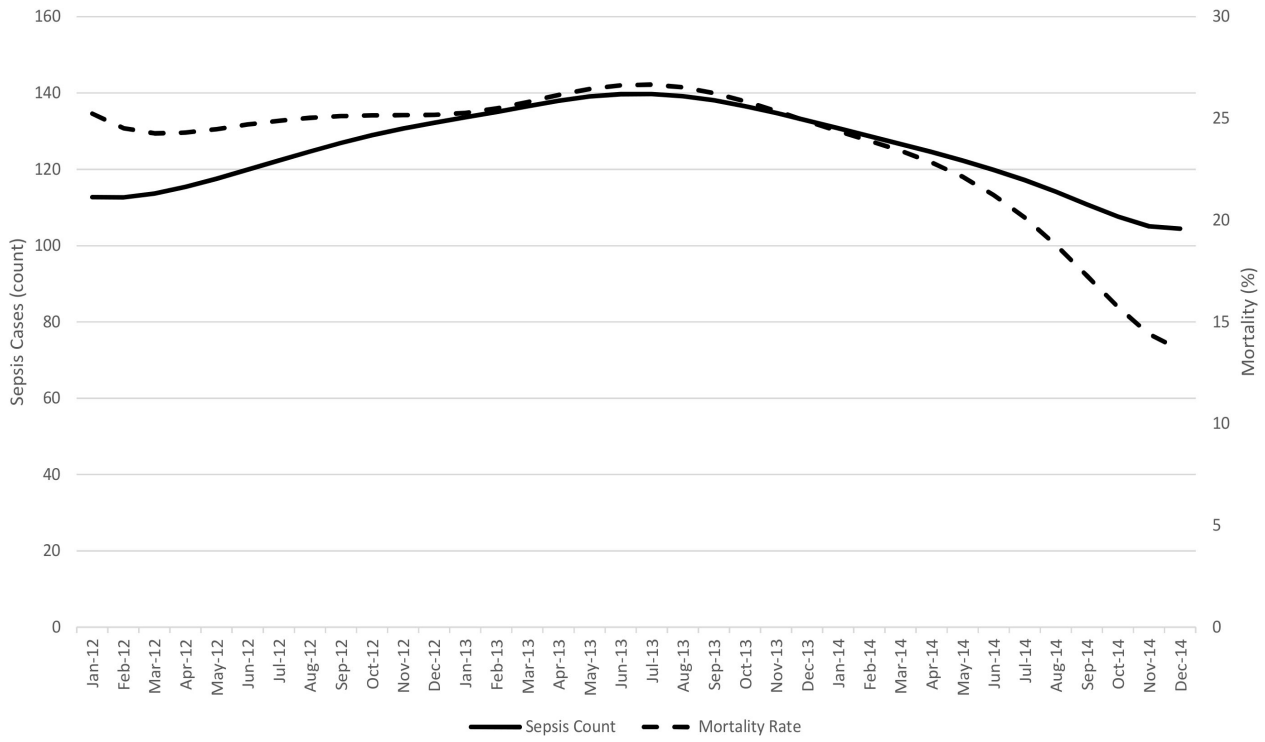

Figure 2. Sepsis cases (count) vs. mortality rate over time, LOWESS* smoothing trend lines.
LOWESS, locally weighted scatterplot smoothing.

with sepsis.[15] It should be noted that the current study is roughly 10 times larger than these previous two combined. Determining whether bundle adherence in the ED leads to improved patient outcomes is a matter of urgent importance. Between 50-75% of all sepsis cases declare in the ED, and consequently, a major emphasis of clinical and administrative work is geared toward ensuring bundle adherence in this area of care. These are efforts that could perhaps be better focused on the ICU setting for greater clinical impact. Future research should attempt to replicate our findings across a broad array of ED settings.

Another goal of this investigation was to explore whether the anatomic source of infection influenced the effect of sepsis-bundle adherence. We found that pneumonia was the most common source of sepsis (32.6%), and bundle-adherent care was associated with lower mortality in such cases (28.9% non-adherent vs. 21.2% adherent), a relative increase in mortality rate for non-adherence of 36.3%. This finding aligns with other investigations demonstrating an association between timely antibiotic treatment and improved mortality in pneumonia cases.[16] Interestingly, we observed a non-significant trend toward a reduction in relative mortality for other anatomic sources of infection (e.g. UTI, intra-abdominal/gynecologic, and multiple sources) with the exception of sepsis due to bone/soft tissue/wound infections and unknown sources. This may reflect the small number of patients within these subgroups rather than a true difference in the impact of bundle adherence across different sources of infection. Ultimately, our findings support the practice of attempting to provide bundle-adherent care for all patients with sepsis regardless of the suspected anatomic site of infection.

One notable observation in our study was the relative lack of increased sepsis cases over time. A criticism of existing sepsis literature is that increasing sensitivity of diagnosis over a study period may artificially lower mortality calculations. With an increasing awareness of sepsis, there should be an increase in the diagnosis of marginal or early sepsis cases. If such marginal cases (presumably of lower acuity) were incorporated into the data pool while bundle adherence was generally improving over time, one would expect to observe an association between compliance and mortality that would be confounded by severity.[17,18] In our study, however, a decreased absolute patient mortality was noted while the number of sepsis cases remained relatively stable over time. This supports the observation that improving bundle adherence is associated with decreased mortality and is not simply a result of enhanced documentation.

LIMITATIONS

This study is subject to limitations inherent in a retrospective study design. Though our abstractors were blinded to study objectives, it is possible that they were influenced by administrative pressure to meet bundle-adherence goals. To minimize this limitation, we used timestamps at the patient level and recalculated intervals and bundle adherence. Even if these biases influenced the documentation of events, they likely would not have impacted mortality rates substantially. It should also be noted that there are intrinsic differences between public and community hospitals. Decreased access to preventative care, prolonged ED wait times and increased ED boarding times is an unfortunate but constant reality in today's public hospitals.[19,20] It is possible that a greater percentage of patients declare in the ED when their disease course is in a more advanced stage due to lack of insurance.

The CMS SEP-1 Core Measure requirements at the time of the publication of this study[21] are different from the severe sepsis and septic shock criteria used during this study. Significant differences include the following: increasing the fluid administration requirement from 20mL/kg crystalloid to 30mL/kg; the current lack of an exemption from fluid boluses in the context of clinical evidence of fluid overload; and the inclusion of lactate >2 as a criteria for acute organ dysfunction (and therefore severe sepsis). The data presented in this study may not reflect the effects of the SEP-1 interventions.

Another potential limitation is that the source of infection was established through chart review by the abstractors. Patients with confounding laboratory, radiographic or diagnosis codes may have been mis-categorized into source of infection. Finally, we did not have the clinical detail to calculate severity indices (e.g. APACHE scores). Without these clinical data, it was impossible to discern whether there were differences in severity of illness in the bundle adherence and bundle non-adherence groups. As such, more severely ill patients could have been managed differently than those who were less severely ill. This possibility limits the conclusions of the study. Further prospective analysis using severity indices is warranted.

CONCLUSION

In a large public healthcare system, adherence with severe sepsis/septic shock management bundles was associated with an overall improvement in survival. This was generally true regardless of the anatomic site of infection. Interestingly, the mortality benefit of bundle-adherent care was concentrated in ICU patients; and we did not observe any benefit to bundle-adherent care for patients with sepsis in the ED or in those who declared on the hospital ward. Further study to determine the importance of sepsis-bundle adherence is especially needed in the ED setting, given that the great majority of sepsis cases are declared there.

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Emergency Department Computed Tomography Use for Non-traumatic Abdominal Pain: Minimal Variability

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Introduction: Variability in the use of computed tomography (CT) between providers in the emergency department (ED) suggests that CT is ordered on a provider rather than a patient level. We aimed to evaluate the variability of CT ordering practices for non-traumatic abdominal pain (NTAP) across physicians in the ED using patient-visit and physician-level factors.

Methods: We conducted a retrospective study among 6,409 ED visits for NTAP from January 1 to December 31, 2012, at a large, urban, academic, tertiary-care hospital. We used a two-level hierarchical logistic regression model to estimate inter-physician variation. Intraclass correlation coefficient (ICC) was calculated.

Results: The hierarchical logistic regression analyses showed that patient-visit factors including younger age, arrival mode by ambulance, prior CT, >79 ED arrivals in the previous four hours, and ultrasound had statistically significant negative associations with physician CT ordering, while surgical team admission and white blood count (WBC) >12.5 K/millimeter cubed (mm^3) had statistically significant positive associations with physician CT ordering. With physician-level factors, only physicians with >21 years experience after medical school graduation showed statistical significance negatively associated with physician CT ordering. Our data demonstrated increased CT ordering from the mean in only one out of 43 providers (2.3%), which indicated limited variation across physicians to order CT. After adjusting for patient-visit and physician-level factors, the calculated ICC was 1.46%.

Conclusion: We found minimal physician variability in CT ordering practices for NTAP. Patient-visit factors such as age, arrival mode, admission team, prior CT, ED arrivals in previous four hours, ultrasound, and WBC count were found to largely influence CT ordering practices. [West J Emerg Med. 2018;19(5)782–796.]

INTRODUCTION

Computed tomography (CT) utilization in the emergency department (ED) has increased significantly in the past 30 years.[1] A 330% rise was observed from 1996 to 2007 in a retrospective study of the National Hospital Ambulatory Medical Care Survey, with utilization for non-traumatic abdominal pain (NTAP) representing the highest growth rate in CT use.[2] During this period, abdominal pain composed 6.5% of total ED visit chief complaints, with related CT usage increasing from 1.4% in 1996 to 33% in 2005-2007.[2-4] However, rates can be as high as 45%-50% when considered in high-risk groups.[1]

Studies measuring CT use and associated outcomes and ordering practices for NTAP have not been in agreement. Rates of change in diagnosis and change in disposition for NTAP in five studies have been as high as 54% and 40%, respectively.[5-9] Yet three studies describe an increase in diagnostic specificity for NTAP but with no change in admission rates, missed surgical diagnoses, or six-month mortality.[10-12] One study showed minimal variability in physician ordering practices when examining overall CT use, while another showed significant variability when examining exclusively NTAP CT use.[13-15]

Increased CT use adds additional costs to clinical evaluation and treatment. Furthermore, concerns related to radiation exposure and the risks of benign, incidental findings are legitimate.[16,17] Within this context of equivocal risk-benefit and cost-benefit understanding, examination of variability in CT ordering practices across physicians, as well as against physician level and patient-visit level predictive factors will contribute to the identification of appropriate use[18-20] and may suggest guideline modifications that could result in decreased imaging with similar or improved outcomes. We examined the variability of CT ordering practices for NTAP across physicians in the ED using both patient-visit and physician-level factors. This focus adds to previously published literature, which has predominantly examined physician-level factors only or overall CT use, respectively.

Population Health Research Capsule

What do we already know about this issue?
Studies examining computed tomography (CT) use among emergency physicians for overall use and non-traumatic abdominal pain (NTAP) have demonstrated minimal and significant variability, respectively.

What was the research question?
This study evaluated the variability of CT ordering practices for NTAP among emergency physicians.

What was the major finding of the study?
The use of CT by emergency physicians for NTAP showed minimal variability and was influenced by patient-visit factors.

How does this improve population health?
Findings contribute to evidence to further clarify CT appropriate use to optimize resource utilization.

METHODS

Study Design and Data Collection

We conducted a retrospective cohort design, reviewing the electronic medical records (EMR) of patients visiting the ED at a large, urban, academic, tertiary-care hospital. EMR patient visit-level data included demographics, dates and times of ED registration, discharge and admission, diagnosis, attending physician, dates and times of image order, test name and results. The physician's gender and education background was extracted from the public-access hospital website. This study was approved by the institutional review board with informed consent waiver and was compliant with the Health Insurance Portability and Accountability Act (HIPAA).

We included all patient visits from January 1 to December 31, 2012, with a chief complaint of abdominal pain. We excluded patient visits from the trauma unit as well as those with pregnancy, patients less than 18 years old, with attending physician's annual NTAP visits < 50 (similar to Levine et al.),[15] with incomplete radiology data, without attending physician, or any visit associated with trauma. See Figure 1 for the detailed exclusions.

Outcome Measure and Predictor Variables

The primary outcome was whether a physician ordered a CT during a patient's ED visit for NTAP. We investigated both patient-visit and physician-level factors as predictor variables. Patient-visit factors included patient gender; age; arrival mode (walk-in, ambulance, or indeterminate); acuity (determined using Emergency Severity Index [ESI] – most severe, more severe, severe, less severe, or least severe); arrival time (weekday vs. weekend, and by shift – day, evening, or night); disposition (discharge, admit, observation, against medical advice/absent without leave/ left without being seen, or indeterminate); admission team (surgical team, non-surgical team, or not admitted);whether or not the patient had a prior CT abdomen/pelvis; current ED volume (evaluated by counting the number of ED arrivals in the previous four hours); whether or not there was use of diagnostic ultrasound; first white blood count (WBC) count; first hemoglobin count; and first hematocrit count. Physician-level predictor variables included gender, years since completing medical school, whether or not a physician completed a fellowship, whether or not there was involvement of advanced triage (a provider with ability to initiate orders prior to full evaluation), and annual ED visit volume (sum of patient visits supervised by each physician throughout 2012). The numeric variables (i.e., ED arrivals in previous four hours, WBC count, hemoglobin count, hematocrit count, and physician's annual ED visit volume) were all categorized into quartiles.[13]

Data Analysis

We conducted preliminary analyses to summarize patient-visit and physician-level characteristics by CT ordering status. Univariate and multivariate generalized linear models with repeated measures were performed to investigate the associations of patient-visit and physician-level factors, respectively. We applied the iterative fitting algorithm for repeated measures in modeling to avoid the violation of the assumption of independence due to the multiple patient visits cared for by the same physician. We used a two-level hierarchical logistic regression model with physician-specific random intercepts developed by Dr. Sistrom[13] to study the association of CT ordering with patient-visit and physician-level factors. The estimated physician-specific intercepts and associated standard errors were transformed by exponentiation to get the adjusted odds ratios with 95% confidence intervals (CI) for each physician.

To estimate the proportion of total variation attributable to the physician level after adjusting for the patient-visit and physician covariates, we calculated the intraclass correlation coefficient (ICC) by using the estimated variance of the physician-specific intercepts from the two-level hierarchical logistic regression model and an estimate of the standard logistic function variance of $\pi^2/3$. We also calculated a reliability estimate for each physician using the formula, OIV/(OIV+SEPI)^2, where OIV is the overall intercept variance, SEPI is the standard error for each physician, and both are produced directly from the multilevel model. The aggregate reliability with 95% CI was produced by averaging the reliability estimate for each physician. We performed all analyses using SAS v.9.4 (SAS Institute, Carry, NC, USA), and statistical significance was evaluated at the 0.05 level.

RESULTS

Of 95,153 total ED patient visits from January 1 to December 31, 2012, 8,222 visits were for NTAP by chief complaint. After the exclusions of 418 visits with pregnancy by chief complaint and 468 by positive beta-human chorionic gonadotropin (ß-hCG), 56 visits from patients less than 18 years old, 232 visits with incomplete radiology data, 457 visits without an attending physician, 19 visits associated with trauma, and another 163 visits supervised by seven providers with less than 50 annual visits, the final study population comprised 6,409 patient visits. Figure 1 shows the flow chart of sampling in detail.

Table 1 shows the demographic and clinical characteristics of the sampled patient visits. The majority were female (67.2%), 23−63 years old (73.6%), walk-ins (77.6%), during weekdays (74.9%), with moderate acuity (70.5%), were discharged from the ED (72.2%), and with no/intermediate advanced triage (76.2%). Overall, the percentage of CT ordering was 27.6% (1,770 of 6,409). After the stratification of CT ordering status, the patient visits with an ordered CT compared to those without a CT showed higher percentages in the older age group ≥ 44 years (62.9% vs. 45.0%), severe or higher acuity (95.0% vs. 81.5%), admit or observation disposition (42.1% vs. 19.6%), and admission by surgical team (15.6% vs. 4.5%).

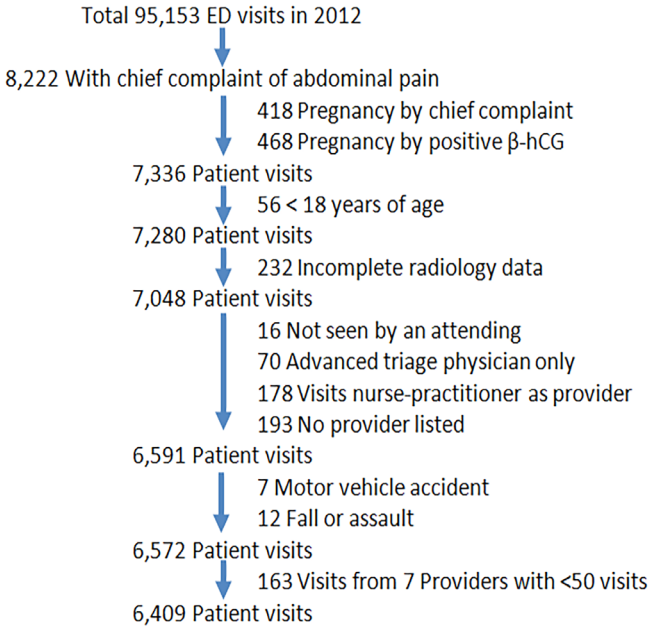

Figure 1. Flow chart of sampling procedure for excluding patient visits from a study on use of computed tomography for chief complaint of non-traumatic abdominal pain.

In addition, over one third of patient visits without CT did not have the lab/record of a WBC count, hematocrit, and hemoglobin, while over 96% among the patient visits with CT ordering had these records. During the study period, 43 physicians saw the sampled ED visits. Table 2 shows the characteristics of these physicians. Over 50% of them had 10 years or longer experience after completing medical school. Over 70% of the physicians did not complete a fellowship. These physicians provided care with the median annual NTAP visit volume of 138 (interquartile range [IQR]: 97−209), and median CT ordering rate of 27.1% (IQR: 22.9−30.5%).

Table 3 shows the unadjusted and adjusted odds ratios of CT ordering for the patient-visit variables. The univariate analyses showed that CT ordering was statistically significantly higher in the patients who were male, older, with severe or higher acuity, admitted by surgical team, had a WBC count >12.5 K/mm^3, hematocrit count >45%, and hemoglobin count >17.1 g/dL. In the multivariate model, compared to the patients aged 44-63 years old, the odds of CT imaging for younger patients significantly decreased 16-36%, but increased over 35% for older patients; the patients who arrived by ambulance (vs. walk-in) (odds ratio [OR] [0.75]; 95% CI

Table 1. Characteristics of 6,409 patient visits at emergency departments for non-traumatic abdominal pain.

Characteristic (n [%])	Without CT (n = 4639)	with CT (n = 1770)	Total (n = 6409)
Gender			
Male	1467 (31.6)	633 (35.8)	2100 (32.8)
Female	3172 (68.4)	1137 (64.2)	4309 (67.2)
Age			
18-22 yrs	581 (12.5)	89 (5.0)	670 (10.5)
23-30 yrs	936 (20.2)	220 (12.4)	1156 (18.0)
31-43 yrs	1034 (22.3)	348 (19.7)	1382 (21.6)
44-63 yrs	1490 (32.1)	689 (38.9)	2179 (34.0)
64-74 yrs	313 (6.8)	228 (12.9)	541 (8.4)
≥ 75 yrs	285 (6.1)	196 (11.1)	481 (7.5)
Arrival mode			
Walk-in	3621 (78.0)	1351 (76.3)	4972 (77.6)
Ambulance	1005 (21.7)	417 (23.6)	1422 (22.2)
Indeterminate	13 (0.3)	2 (0.1)	15 (0.2)
Acuity (Emergency Severity Index)			
Most/more severe	615 (13.3)	329 (18.6)	944 (14.7)
Severe	3164 (68.2)	1353 (76.4)	4517 (70.5)
Least/less severe	808 (17.4)	64 (3.6)	872 (13.6)
No record	52 (1.1)	24 (1.4)	76 (1.2)
Arrival time			
Monday-Friday daytime	1496 (32.2)	578 (32.7)	2074 (32.4)
Monday-Friday evening	1278 (27.6)	484 (27.3)	1762 (27.5)
Monday-Friday nighttime	688 (14.8)	274 (15.5)	962 (15.0)
Saturday-Sunday daytime	483 (10.4)	178 (10.0)	661 (10.3)
Saturday-Sunday evening	450 (9.7)	173 (9.8)	623 (9.7)
Saturday-Sunday nighttime	244 (5.3)	83 (4.7)	327 (5.1)
Disposition of patient visit			
Discharge	3617 (78.0)	1013 (57.2)	4630 (72.2)
Admit	794 (17.1)	646 (36.5)	1440 (22.5)
Observation	114 (2.5)	99 (5.6)	213 (3.3)
Against medical advice/absent without leave/left without being seen	104 (2.2)	8 (0.5)	112 (1.8)
Indeterminate	10 (0.2)	4 (0.2)	14 (0.2)
Admission team			
Non-surgical team	723 (15.6)	488 (27.6)	1211 (18.9)
Surgical team	209 (4.5)	277 (15.6)	486 (7.6)
Not admitted	3707 (79.9)	1005 (56.8)	4712 (73.5)
Advanced triage physician?			
No/indeterminate advanced triage	3588 (77.3)	1293 (73.1)	4881 (76.2)
Advanced triage	1051 (22.7)	477 (26.9)	1528 (23.8)
Prior CT abdomen/pelvis	103 (2.2)	25 (1.4)	128 (2.0)

CT, computed tomography; *ED*, emergency department.

Table 1. Continued.

Characteristic (n [%])	Without CT (n = 4639)	with CT (n = 1770)	Total (n = 6409)
ED arrivals in previous 4 hours			
≤42	1078 (23.2)	451 (25.5)	1529 (23.9)
>42 and ≤62	1187 (25.6)	440 (24.8)	1627 (25.4)
>62 and ≤79	1214 (26.2)	460 (26.0)	1674 (26.1)
>79	1160 (25.0)	419 (23.7)	1579 (24.6)
Ultrasound abdomen/pelvis evaluation	520 (11.2)	186 (10.5)	706 (11.0)
First white blood cell count, K/mm3			
≤3.9	143 (3.1)	68 (3.8)	211 (3.3)
>3.9 and ≤12.5	2510 (54.1)	1297 (73.3)	3807 (59.4)
>12.5 and ≤15.5	164 (3.5)	196 (11.1)	360 (5.6)
>15.5	133 (2.9)	169 (9.5)	302 (4.7)
No labs/no record	1689 (36.4)	40 (2.3)	1729 (27.0)
First hematocrit count, %			
≤35	694 (15.0)	367 (20.7)	1061 (16.5)
>35 and ≤40	1164 (25.1)	664 (37.5)	1828 (28.5)
>40 and ≤45	851 (18.3)	537 (30.4)	1388 (21.7)
>45	240 (5.2)	161 (9.1)	401 (6.3)
No labs/no record	1690 (36.4)	41 (2.3)	1731 (27.0)
First hemoglobin count, g/dL			
≤7	22 (0.5)	7 (0.4)	29 (0.5)
>7 and ≤10.4	341 (7.3)	172 (9.7)	513 (8.0)
>10.4 and ≤17.1	2538 (54.7)	1514 (85.5)	4052 (63.2)
>17.1	18 (0.4)	19 (1.1)	37 (0.6)
No labs/no record	1720 (37.1)	58 (3.3)	1778 (27.7)

CT, computed tomography; *ED*, emergency department.

[0.65-0.87]; P < 0.001), having prior CT imaging (OR [0.44]; 95% CI [0.30-0.65]; P < 0.001), receiving an ultrasound evaluation during visit (OR [0.71]; 95% CI [0.58-0.87]; P < 0.001), and arrived during the busiest ED periods (OR [0.82]; 95% CI [0.68-0.99]; P = 0.04) were less likely to have a CT.

The patients admitted by a surgical team were more likely to have a CT (OR [1.84]; 95% CI [1.43-2.37]; P < 0.001). WBC count was positively associated with CT ordering, where a first WBC count of > 15.5 K/mm^3 demonstrated increased odds of CT ordering (OR, [2.24]; 95% CI [1.66-3.03]; P < 0.001). Table 4 shows that physicians who had >21 years of experience (vs. 10-21 years) after medical school (OR [0.60]; 95% CI [0.39-0.93]; P = 0.02), or completed fellowship training (OR [0.70]; 95% CI [0.53-0.92]; P = 0.01) were significantly less likely to order a CT.

In the final multilevel model, we included all patient-visit and physician-level factors together with physician-specific random effect. Table 5 shows the results of each of the patient-visit and physician-level variables; Table 6 shows only those variables that were statistically significant. The patient-visit variables showed similar associations as those in the multivariate analysis above, whereas among physician-level variables, only physicians who had >21 years of experience after graduation from medical school showed statistical significance and these physicians were less likely to order CT (OR [0.68]; 95% CI [0.48-0.96]; P = 0.03) compared to those with 10-21 years experience.

Figure 2A shows the observed and predicted CT ordering rates for individual physicians plotted in ascending observed order. The predicted CT ordering rates accounted for fixed patient-visit and physician-level variables, but not for the random physician-specific intercepts. Figure 2B shows the corresponding physician-specific odds with 95% CIs for CT ordering. ORs less than one indicated the physician was less likely to order a CT; and ORs greater than one indicated higher tendency. There was only one out of 43 physicians

Table 2. Characteristics of emergency physicians who saw sampled patient visits.

Characteristic (n [%])	n=43
Physician gender	
Male	23 (53.5)
Female	20 (46.5)
Years since completing medical school	
≤5 yrs	8 (18.6)
>5 and ≤10	13 (30.2)
>10 and ≤21	16 (37.2)
>21 and ≤35	6 (14.0)
Fellowship?	
No fellowship	33 (76.7)
Completed a fellowship	10 (23.3)
Annual visit volume for NTAP	
<95	9 (20.9)
95-124	11 (25.6)
125-204	11 (25.6)
≥205	12 (27.9)
% of CT among annual visits for each physician (n [%])	
≤ 10%	2 (4.7)
>10% and ≤20%	2 (4.7)
>20% and ≤25%	12 (27.9)
>25% and ≤30%	14 (32.5)
>30% and ≤30%	5 (11.6)
>35% and ≤40%	6 (13.9)
> 40 %	2 (4.7)

NTAP, non-traumatic abdominal pain; *CT*, computed tomography.

(2.3%) with the 95% CI of OR not intersecting one, which indicated limited variation across physicians to order CT.

In the reduced model including physician-specific random intercept only, the calculated ICC was 4.73%. After adding the patient-visit and physician-level variables, the ICC was reduced to 1.46%. The estimate of reliability of the physician-specific intercepts was 0.62 (95% CI [0.61-0.64]).

DISCUSSION

Our study found minimal physician variability in CT utilization. Moreover, numerous patient-visit factors were statistically significantly associated with CT use. While the identification of patient factors related to CT utilization is not new, our study adds to previous literature by demonstrating the overwhelming magnitude that patient-visit factors (and the minimal role that physician factors) contribute to CT ordering variability within the context of NTAP.

Both the calculated ICC and estimated reliability in our study suggested minimal physician variability in CT ordering practice, which was in accordance with the results reported by Wong et al.[13] Specifically, "for provider profiling purposes, when reliability is above 70%, meaningful difference between some physicians (called 'outliers') and the mean are discernible; at 90% reliability, difference between pairs of physicians are meaningful."[13] Therefore, considering that our reliability was below 70%, no meaningful difference between physicians was discernible in our study. Specifically, the ICC in this study represents the percent of variability in CT ordering that could be attributed to a particular physician.

Thus, given the ICC was reduced from 4.7% to 1.46% after controlling for patient-visit factors and physician factors, two points should be highlighted. First, consideration should be given to controlling for patient-visit factors when examining resource utilization. Second, given that physicians contribute ostensibly only 1.46% to total CT use variability, care should be used when identifying outliers for overuse or underuse. Our data demonstrated increased CT ordering from the mean in one out of 43 providers. That being said, we have

Table 3. Patient-visit characteristics and computed tomography (CT) ordering odds ratios (ORs).

	Univariate model		Multivariate model	
Characteristic	Unadjusted OR	P value	Adjusted OR	P value
Gender				
Male	Reference		Reference	
Female	0.83 (0.72, 0.96)	0.01	0.99 (0.85, 1.16)	0.95
Age				
18-22 yrs	0.33 (0.26, 0.43)	< 0.001	0.64 (0.52, 0.80)	< 0.001
23-30 yrs	0.51 (0.42, 0.61)	< 0.001	0.74 (0.60, 0.91)	0.005
31-43 yrs	0.73 (0.64, 0.82)	< 0.001	0.84 (0.73, 0.97)	0.02
44-63 yrs	Reference		Reference	
64-74 yrs	1.58 (1.29, 1.93)	< 0.001	1.39 (1.12, 1.73)	0.003
≥ 75 yrs	1.49 (1.23, 1.79)	< 0.001	1.35 (1.10, 1.66)	0.004
Arrival mode				
Walk-in	Reference		Reference	
Ambulance	1.11 (0.95, 1.30)	0.17	0.75 (0.65, 0.87)	<0.001
Indeterminate	0.41 (0.10, 1.68)	0.22	0.33 (0.07, 1.56)	0.16
Acuity (Emergency Severity Index)				
Most/more severe	6.75 (5.05, 9.04)	< 0.001	0.87 (0.59, 1.29)	0.48
Severe	5.40 (3.99, 7.31)	< 0.001	1.15 (0.81, 1.63)	0.45
Least/less severe	Reference		Reference	
No record	5.83 (3.15, 10.76)	< 0.001	1.500 (0.68, 3.31)	0.32
Arrival time				
Monday-Friday daytime	Reference		Reference	
Monday-Friday evening	0.98 (0.79, 1.22)	0.86	1.08 (0.89, 1.33)	0.43
Monday-Friday nighttime	1.03 (0.80, 1.33)	0.82	1.01 (0.80, 1.28)	0.95
Saturday-Sunday daytime	0.95 (0.79, 1.16)	0.63	1.00 (0.84, 1.19)	0.96
Saturday-Sunday evening	0.99 (0.79, 1.26)	0.97	1.14 (0.92, 1.40)	0.24
Saturday-Sunday nighttime	0.88 (0.71, 1.09)	0.25	0.83 (0.65, 1.06)	0.13
Disposition of patient visit				
Discharge	0.34 (0.28, 0.42)	< 0.001	1.21 (0.65, 2.23)	0.55
Admit	Reference		Reference	
Observation	1.07 (0.77, 1.48)	0.69	1.25 (0.91, 1.73)	0.17
Against medical advice/absent without leave/left without being seen	0.09 (0.04, 0.20)	< 0.001	0.48 (0.16, 1.51)	0.21
Indeterminate	0.49 (0.18, 1.36)	0.17	0.67 (0.24, 1.87)	0.44
Admission team				
Non-surgical team	Reference		Reference	
Surgical team	1.96 (1.55, 2.49)	< 0.001	1.84 (1.43, 2.37)	< 0.001
Not admitted	0.40 (0.33, 0.49)	< 0.001	0.67 (0.35, 1.29)	0.23
Advanced triage physician?				
No/indeterminate advanced triage	Reference		Reference	
Advanced triage	1.26 (1.09, 1.46)	0.002	0.97 (0.82, 1.15)	0.74
Prior CT abdomen/pelvis				
No	Reference		Reference	
Yes	0.63 (0.44, 0.91)	0.01	0.44 (0.30, 0.65)	< 0.001

Table 3. Continued.

Characteristic	Univariate model		Multivariate model	
	Unadjusted OR	P value	Adjusted OR	P value
ED arrivals in previous 4 hours				
≤42	1.10 (0.90, 1.36)	0.35	1.09 (0.83, 1.42)	0.54
>42 and ≤62	0.98 (0.80, 1.19)	0.83	0.97 (0.77, 1.24)	0.83
>62 and ≤79	Reference		Reference	
>79	0.95 (0.80, 1.14)	0.59	0.82 (0.68, 0.99)	0.04
Ultrasound abdomen/pelvis evaluation				
No	Reference		Reference	
Yes	0.93 (0.77, 1.13)	0.46	0.71 (0.58, 0.87)	< 0.001
First white blood cell count, K/mm3				
≤3.9	Reference		Reference	
>3.9 and ≤12.5	1.09 (0.82, 1.44)	0.56	1.06 (0.80, 1.42)	0.67
>12.5 and ≤15.5	2.51 (1.76, 3.58)	< 0.001	2.33 (1.61, 3.38)	< 0.001
>15.5	2.67 (1.96, 3.65)	< 0.001	2.24 (1.66, 3.03)	< 0.001
No labs/no record	0.05 (0.03, 0.08)	< 0.001	0.03 (0.002, 0.71)	0.03
First hematocrit count, %				
≤35	Reference		Reference	
<35 and ≤40	1.08 (0.91, 1.28)	0.40	1.00 (0.79, 1.25)	0.97
<40 and ≤45	1.19 (0.99, 1.44)	0.07	1.06 (0.87, 1.29)	0.55
>45	1.27 (1.03, 1.56)	0.02	1.07 (0.86, 1.33)	0.54
No labs/no record	0.05 (0.03, 0.07)	< 0.001	2.03 (0.12, 35.08)	0.63
First hemoglobin count, g/dL				
≤7	Reference		Reference	
>7 and ≤10.4	1.59 (0.67, 3.76)	0.30	1.75 (0.63, 4.88)	0.28
>10.4 and ≤17.1	1.87 (0.77, 4.57)	0.17	2.17 (0.78, 6.08)	0.14
>17.1	3.32 (1.08, 10.16)	0.04	3.26 (1.09, 9.74)	0.03
No labs/no record	0.11 (0.05, 0.24)	< 0.001	1.89 (0.52, 6.89)	0.34

ED, emergency department; *OR*, odds ratio.

not overstated the provider's difference in utilization given the minimal physician influence over CT use found in this study.

When examining physician factors separately we found years after completing medical school, fellowship, and advanced triage physician to be statistically significantly negatively associated with CT ordering. However, in the fixed-effects model considering physician and patient-visit factors jointly, only the subset of physicians with the longest period of time from completing medical school was statistically significantly negatively associated with imaging ordering, while patient-visit factors were shown to have a larger magnitude of association over CT imaging-ordering practices.

Some studies have shown that physician factors have minimal predictive value on ordering practices,[4,13] which were in accordance with our results. After considering all patient-visit and physician-level factors in our multilevel analyses, most physician factors were not statistically significantly associated with CT ordering. Notwithstanding, our findings contrast with studies that have shown physician age, board certification, and risk-tolerance to have statistical significance with respect to CT ordering.[15,21-24] Differences in population, sampling, predictors considered, and/or the sample source may explain discordance among these studies. For example, shared decision-making in academic settings may serve to dampen image-ordering provider variability, and chief complaints such as trauma or head injury may carry unique considerations related to mechanism when compared to NTAP.[21] Conversely, elderly patient visits are associated with increased CT use due to their increased risk for abdominal pathology and their less-reliable physical exams.[25]

We found that older patients were more likely to have CT as a part of their work-up. This is consistent with the benefits

Table 4. Physician characteristics and computed tomography (CT) ordering odds ratios (ORs).

	Univariate model		Multivariate model	
Characteristic	Unadjusted OR	P value	Adjusted OR	P value
Physician gender				
Male	Reference		Reference	
Female	1.23 (0.93, 1.63)	0.14	1.23 (0.93, 1.64)	0.15
Years since completing medical school				
≤5 yrs	0.89 (0.68, 1.17)	0.41	0.82 (0.63, 1.08)	0.16
>5 and ≤10	1.01 (0.73, 1.40)	0.93	0.99 (0.74, 1.32)	0.95
>10 and ≤21	Reference		Reference	
>21 and ≤35	0.55 (0.31, 0.96)	0.04	0.60 (0.39, 0.93)	0.02
Fellowship?				
No fellowship	Reference		Reference	
Completed a fellowship	0.62 (0.45, 0.85)	0.003	0.70 (0.53, 0.92)	0.01
Annual visit volume for NTAP				
<95	1.02 (0.75, 1.38)	0.91	1.19 (0.86, 1.65)	0.30
95-124	Reference		Reference	
125-204	0.93 (0.72, 1.19)	0.54	1.04 (0.76, 1.43)	0.82
≥205	1.11 (0.80, 1.54)	0.53	1.18 (0.87, 1.61)	0.28

NTAP, non-traumatic abdominal pain.

of CT in diagnosing the source for NTAP in the elderly, whose clinical presentation is a diagnostic challenge.[11] For the elderly, the etiology of NTAP often presents atypically, and abdominal tenderness or lack thereof may not be representative of the underlying pathology.[5, 26]

A prior CT was negatively associated with CT ordering in our study. Ostensibly, if a patient was already known to have an abdominal pathology, they may have been managed under the assumption of an acute flare of this condition, which did not require repeat imaging, in so far as their presentation is not overtly suggestive of severe progression. For example, a patient with a recently diagnosed renal or ureteral stone on CT would be unlikely to have a repeat scan as it has been shown that repeat CT in this setting does not provide additional benefit but potentially increases risk.[27, 28] Moreover, if a recent CT is available, this may influence the provider to weigh concerns of radiation exposure against possible minimal added-benefit from repeat imaging in a patient with a previously negative scan or with chronic abdominal disease (e.g., a patient with inflammatory bowel disease may not receive a CT if they have recently had imaging).[29-31]

In our study, a radiology ultrasound performed during the patient-visit was negatively associated with CT ordering. This is consistent with previous studies, which demonstrated the ability of ultrasound to rule in or rule out pathology.[20,32] While our study did not explicitly examine other imaging modalities, ultrasound potentially could make CT unnecessary in the setting of acute appendicitis or cholelithiasis.[33,34] We did not evaluate emergency physician-performed bedside ultrasound. However, a bedside ultrasound that is clearly positive for cholecystitis could obviate the need for a CT.[35] Moreover, bedside ultrasound in the setting of renal colic could similarly influence CT use.[36]

Using ED arrivals in the previous four hours as a surrogate for ED "busyness" or crowding, we found a busier ED negatively associated with CT imaging, which was different from the findings by Wong et al.[13] This may have been due to the time required to perform a CT and obtain results. Moreover, during high-volume periods in the ED, prioritization of CT use may have taken place (consciously or unconsciously) and disposition decisions may have been based more on clinical presentation. The varying effect of ED volume and crowding has been investigated,[37-40] and so impact on imaging ordering stands to reason.

Elevated WBC count was positively associated with ordering of CT. This further demonstrates the notion that patient severity would drive CT imaging. However, lack of significance of acuity represented by the ESI, while an imperfect metric,[41] makes this picture less clear. Moreover, sensitivity and specificity of WBC counts have unclear clinical significance in isolation so clinical decision scores such as the Alvarado score and the pediatric appendicitis score take into account multiple predictors.[42, 43] It should be noted that our analysis of WBC count did not examine whether the WBC count resulted before or after a CT was ordered or deferred.

Table 5. Results of fixed effects from the multilevel model.

Variable type	Variable name	F value	Adjusted OR	P value
Patient-visit	Patient's gender	0.03		
	Male		Reference	
	Female		0.99 (0.86, 1.14)	0.87
	Age	9.64		
	18-22 yrs		0.65 (0.50, 0.86)	0.003
	23-30 yrs		0.73 (0.60, 0.89)	0.002
	31-43 yrs		0.84 (0.71, 0.99)	0.04
	44-63 yrs		Reference	
	64-74 yrs		1.42 (1.15, 1.76)	0.001
	≥ 75 yrs		1.37 (1.10, 1.71)	0.006
	Arrival mode	7.90		
	Walk-in		Reference	
	Ambulance		0.75 (0.65, 0.88)	<0.001
	Indeterminate		0.31 (0.06, 1.59)	0.16
	Acuity (Emergency Severity Index)	3.89		
	Most/more severe		0.82 (0.57, 1.18)	0.29
	Severe		1.08 (0.78, 1.51)	0.63
	Least/less severe		Reference	
	No record		1.48 (0.78, 2.81)	0.23
	Arrival time	0.90		
	Monday-Friday daytime		Reference	
	Monday-Friday evening		1.04 (0.88, 1.24)	0.64
	Monday-Friday nighttime		0.88 (0.70, 1.12)	0.30
	Saturday-Sunday daytime		0.99 (0.78, 1.25)	0.91
	Saturday-Sunday evening		1.12 (0.88, 1.42)	0.37
	Saturday-Sunday nighttime		0.79 (0.58, 1.09)	0.15
	Disposition of patient visit	2.30		
	Discharge		1.17 (0.65, 2.09)	0.60
	Admit		Reference	
	Observation		1.21 (0.89, 1.64)	0.23
	Against medical advice/absent without leave/left without being seen		0.41 (0.15, 1.08)	0.07
	Indeterminate		0.68 (0.19, 2.39)	0.54
	Admission team	16.76		
	Non-surgical team		Reference	
	Surgical Team		1.88 (1.49, 2.38)	<0.001
	Not admitted		0.71 (0.39, 1.27)	0.24
	Advanced triage physician?	0		
	No/indeterminate advanced triage		Reference	
	Advanced triage		0.99 (0.82, 1.21)	0.95
	Prior CT abdomen/pelvis	12..34		
	No		Reference	
	Yes		0.43 (0.27, 0.70)	0.001

OR, odds ratio; *CT*, computed tomography.

Table 5. Continued.

Variable type	Variable name	F value	Adjusted OR	P value
	ED arrivals in previous 4 hours	2.73		
	≤42		1.10 (0.88, 1.37)	0.39
	>42 and ≤62		0.98 (0.81, 1.18)	0.82
	>62 and ≤79		Reference	
	>79		0.80 (0.66, 0.97)	0.02
	Ultrasound abdomen/pelvis evaluation	12.59		
	No		Reference	
	Yes		0.70 (0.58, 0.86)	0.001
	First white blood cell count, K/mm3	19.04		
	≤3.9		Reference	
	>3.9 and ≤12.5		1.05 (0.77, 1.43)	0.77
	>12.5 and ≤15.5		2.28 (1.57, 3.32)	<0.001
	>15.5		2.25 (1.52, 3.33)	<0.001
	No labs/no record		0.03 (0.002, 0.62)	0.02
	First hematocrit count, %	0.33		
	≤35		Reference	
	>35 and ≤40		0.98 (0.79, 1.21)	0.86
	>40 and ≤45		1.06 (0.84, 1.32)	0.62
	>45		1.06 (0.78, 1.44)	0.69
	No labs/no record		2.11 (0.13, 35.44)	0.60
	First hemoglobin count, g/dL	1.57		
	≤7		Reference	
	>7 and ≤10.4		1.75 (0.69, 4.44)	0.24
	>10.4 and ≤17.1		2.19 (0.86, 5.57)	0.10
	>17.1		3.33 (1.01, 10.9)	0.047
	No labs/no record		1.87 (0.62, 5.68)	0.27
Physician	Physician gender	0.46		
	Male		Reference	
	Female		1.08 (0.86, 1.36)	0.50
	Years since completing medical school	2.22		
	≤5 yrs		0.89 (0.65, 1.20)	0.43
	>5 and ≤10		1.03 (0.82, 1.30)	0.79
	>10 and ≤21		Reference	
	>21 and ≤35		0.68 (0.48, 0.96)	0.03
	Fellowship?	1.39		
	No fellowship		Reference	
	Completed a fellowship		0.85 (0.65, 1.12)	0.25
	Annual visit volume for NTAP	1.86		
	<95		1.18 (0.85, 1.65)	0.31
	95-124		Reference	
	125-204		0.97 (0.71, 1.34)	0.87
	≥205		1.28 (0.97, 1.69)	0.08

OR, odds ratio; *ED*, emergency department; *NTAP*, non-traumatic abdominal pain.

Table 6. Statistically significant results of fixed effects from the multilevel model.

Variable type	Variable name	F value	Adjusted OR	P value
Patient-visit	Age	9.64		
	18-22 yrs		0.65 (0.50, 0.86)	0.003
	23-30 yrs		0.73 (0.60, 0.89)	0.002
	31-43 yrs		0.84 (0.71, 0.99)	0.04
	44-63 yrs		Reference	
	64-74 yrs		1.42 (1.15, 1.76)	0.001
	≥ 75 yrs		1.37 (1.10, 1.71)	0.006
	Arrival mode	7.90		
	Walk-in		Reference	
	Ambulance		0.75 (0.65, 0.88)	<0.001
	Indeterminate		0.31 (0.06, 1.59)	0.16
	Admission team	16.76		
	Non-surgical team		Reference	
	Surgical team		1.88 (1.49, 2.38)	<0.001
	Not admitted		0.71 (0.39, 1.27)	0.24
	Prior CT abdomen/pelvis	12..34		
	No		Reference	
	Yes		0.43 (0.27, 0.70)	0.001
	ED arrivals in previous 4 hours	2.73		
	≤42		1.10 (0.88, 1.37)	0.39
	>42 and ≤62		0.98 (0.81, 1.18)	0.82
	>62 and ≤79		Reference	
	>79		0.80 (0.66, 0.97)	0.02
	Ultrasound abdomen/pelvis evaluation	12.59		
	No		Reference	
	Yes		0.70 (0.58, 0.86)	0.001
	First white blood cell count, K/mm3	19.04		
	≤3.9		Reference	
	>3.9 and ≤12.5		1.05 (0.77, 1.43)	0.77
	>12.5 and ≤15.5		2.28 (1.57, 3.32)	<0.001
	>15.5		2.25 (1.52, 3.33)	<0.001
	No labs/no record		0.03 (0.002, 0.62)	0.02
Physician	Years since completing medical school	2.22		
	≤5 yrs		0.89 (0.65, 1.20)	0.43
	>5 and ≤10		1.03 (0.82, 1.30)	0.79
	>10 and ≤21		Reference	
	>21 and ≤35		0.68 (0.48, 0.96)	0.03

OR, odds ratio; *CT*, computed tomography; *ED*, emergency department.

It bears mentioning that the presence of an advanced triage physician did not show statistical significance. Thus, whether order sets were initiated at triage or by the physician providing direct care to the patient did not impact CT utilization. Moreover, as in other studies[13,15] we did not evaluate the presence or absence of registered nurse-initiated order sets nor the possibility of resident CT ordering prior to attending consultation.

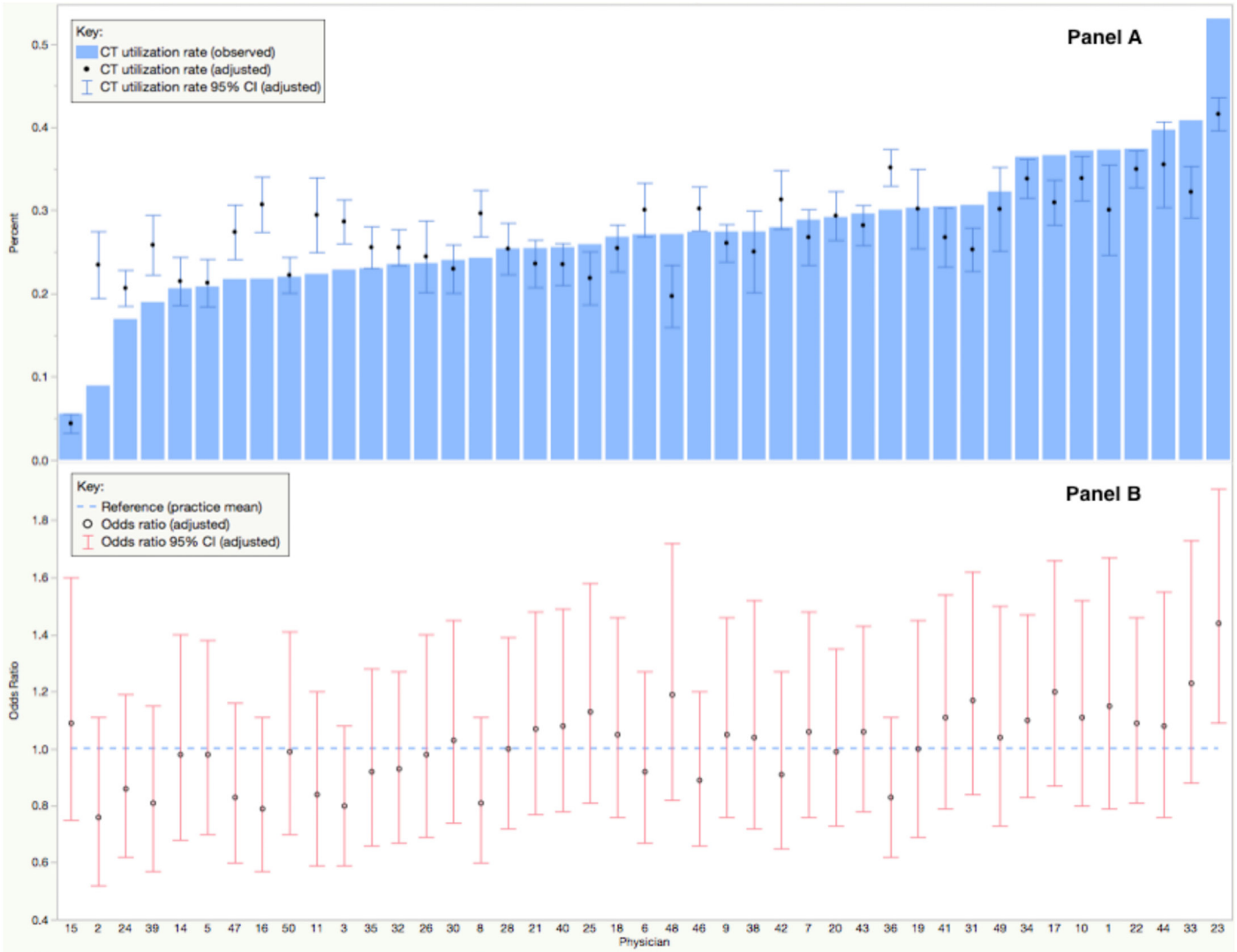

Figure 2. A) Observed and predicted computed tomography (CT) ordering percentage for each physician; B) Estimated odds ratio of each physician for the tendency to order CT. (All predicted and estimated values were from the hierarchical model.)
CI, confidence interval.

Admission to a surgical team was positively associated with CT imaging. This finding suggests that patients admitted to surgery are surgical candidates and, therefore, likely to have more severe pathology. Thus, CT imaging may be used to confirm this acuity and contribute to surgical planning.[5, 44, 45]

Arrival mode via ambulance was negatively associated with CT imaging. This was different from Wong et al.[13] who found that arrival via ambulance was positively associated with CT imaging. Moreover, the 2010 National Hospital Ambulatory Medical Care Survey demonstrated that 73% of ambulance ED visits are for patients > 65 years old,[46] an age group where increased use of CT was expected. While our arrival mode findings seemed contrary to that of severity driving CT imaging, one hypothesis could be that patients arriving by ambulance may have represented a disproportionate number of repeat visitors and may have had a recent CT in their medical records, which in our study was a negative predictor for CT use.

Our sample of 6,409 ED visits for NTAP was extracted from 95,153 ED visits. This is comparable to Wong et al. [13] who examined 88,851 ED visits for all types of imaging but did not provide subgroups by complaint. The subgroup of abdominal pain for Levine et al.[15] included 18, 614 ED visits for abdominal pain, and while this robust study was three times the size of our sample, they did not account for a number of statistically significant, patient-visit factors such as prior CT, prior ultrasound, surgical admitting team, WBC count, arrival mode, and ED volume. Thus, while our study sample was smaller by comparison, our examination and identification of strongly predictive patient-visit factors adds value to current evidence.

LIMITATIONS

Limitations to our study include error associated with data collection during patient-visits; as this was a retrospective study, we were unable to monitor the accuracy of this process. Additionally, as a single-center study within an academic setting, including resident-ordering effects, generalizability is limited beyond this context. Our study demonstrated limited variability for CT use related to NTAP exclusively. However, examination of use by all complaints may be of importance, as variability by CT modality has been observed.[15] Furthermore, analysis of a one-year study period did not permit detection of annual trends or control of incoming or outgoing physicians. Lastly, given this was a single-center study within a single year our sample size was too small to reliably detect meaningful differences among physicians. Future research should be multicenter and multiyear to investigate the influence of patient-visit and physician-level factors on CT use.

CONCLUSION

We found minimal physician variability in CT ordering practices for NTAP, similar to the findings by other researchers. Patient-visit factors such as age, arrival mode, admission team, prior CT, ED arrivals in previous four hours, ultrasound, and WBC count were found to largely influence CT ordering practices whereas physician-factor contributions were minimal. This study adds to previous research by uniquely quantifying the magnitude of patient-visit and physician-level factors.

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Emergency Department Visits for Sexual Assault by Emerging Adults: Is Alcohol a Factor?

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Introduction: Emerging adults (18-25 years of age) are at increased risk for sexual assault. There is little Emergency Department (ED) data on sexual assaults that involve alcohol among this population. The purpose of this study was to analyze ED visits for sexual assault and determine if alcohol consumption by the patient was noted.

Methods: This study was a retrospective chart review of patients aged 18-25 presenting to an ED in a college town over a four-year period. Extracted variables included age, gender, delay in seeking care, sexual assault nurse examiner (SANE) evaluation, and alcohol consumption by the patient. For analysis of alcohol use, cases were categorized as ages < 21 and ≥ 21.

Results: There were 118 patients who presented to the ED from 2012 to 2015. The mean age of the cohort was 20 years, and almost 70% of visits were among those < 21. Of those aged < 21, 74% reported alcohol consumption, in contrast to 48% of those ≥ 21 (p = 0.055). Of those reporting alcohol use, 36% were evaluated on the day of the assault compared to 61% of those not reporting alcohol (p=0.035).

Conclusion: This study found that ED visits for sexual assault in emerging adults were more common in younger patients. Alcohol use occurred more frequently with patients under the legal drinking age, and presentation was also more likely to be delayed. The relationship between sexual assault and alcohol use should underscore primary prevention efforts in emerging adult populations. [West J Emerg Med. 2018;19(5)797-802.]

INTRODUCTION

Sexual assault is a complex public health and medical problem. The vast majority of sexual assaults against females occur before age 25.[1] Approximately 38% of victims of completed rape, which includes forced penetration and completed alcohol- or drug-facilitated rape, first experience this form of sexual assault between the ages of 18 and 24.[1] The term "emerging adulthood" has been recently used to describe the developmental period between ages 18 and 25.[2] This phase is characterized by significant life transitions such as entry into the workforce and/or college attendance as well as sharp increases in experimentation and unsafe behavior, making this age group vulnerable to violence and substance use.[3-5] Because over one-third of emerging adults in the United States (U.S.) attend college, the disproportionate impact of sexual assault among this population is a growing concern.[6] Sexual assault on college campuses is an issue that has recently caught the attention of national leaders in the U.S., as evidenced by the creation of the "It's On Us" and White House Task Force to Protect Students from Sexual Assault initiatives.[7,8] Studies have found that as many as 1 in 5 women on college

campuses experience sexual assault, and a high percentage of these are facilitated by alcohol.[9] Few studies have focused on the relationship between alcohol and sexual assault among emerging adult populations that do not attend college.[8]

Most prior research has focused on the relationship between sexual assault and alcohol consumption by the perpetrator, yet recent studies estimate that up to 70% of young adult victims report alcohol consumption prior to the incident.[10-14] Being under the influence of alcohol can impair both parties' abilities to give and recognize active consent to engage in sexual activity.[15] Furthermore, individuals who were intoxicated during an incident of sexual assault were less likely to report the incident because they were "unclear if crime had been committed" or "didn't think incident was serious enough" to report.[16-19] Alcohol use by the victim might also have an impact on help and healthcare seeking, with individuals using alcohol at the time of the assault being less likely to call law enforcement or seek medical treatment.[17] Although several studies have reported that alcohol intoxication was associated with less frequent reporting to law enforcement and medical evaluation, little research has examined delayed presentation to the emergency department (ED) after assault.[19] Delayed care may significantly impact patients' abilities to have forensic evidence collected during sexual assault nurse examiner (SANE) exams.[20]

Most previous research on the relationship between sexual assault and alcohol consumption among emerging adults: 1) aims to establish directionality and causal explanations (i.e. how does alcohol influence the likelihood sexual assault occurrence?); 2) utilizes self-report/ self-administered surveys; and/or 3) focuses on college-attending samples.[15, 21-24] However, fewer studies have utilized healthcare data to describe characteristics of medical treatment received by emerging adults who have experienced sexual assault and report alcohol use at the time of victimization. The ED is a frequent point of entry for patients experiencing sexual assault. EDs play a critical role by providing immediate care, facilitating forensic data collection through the use of SANE exams, and connecting patients with community resources such as sexual assault advocacy services and counselors.[25] This makes medical record data a valuable, yet underutilized resource for gleaning information on characteristics associated with sexual assault. To our knowledge, no prior study has specifically examined patient- and visit-level characteristics of emerging adults presenting to the ED following a report of sexual assault. The purpose of this study was to conduct a medical record review of patients between the ages of 18-25 who presented to our ED after sexual assault victimization. We sought to examine reported alcohol use at the time of the incident as well as various demographic and clinical characteristics among these patients.

Population Health Research Capsule

What do we already know?
The majority of sexual assaults occur before the age of 25 years. Patients commonly seek care following a sexual assault in the emergency department (ED).

What was the research question?
How commonly is alcohol use reported in young adults presenting to the ED following a sexual assault?

What was the major finding of the study?
Alcohol use at the time of the assault was reported in 60% of patients, and the majority of patients were under 21 years of age.

How does this improve public health?
Primary prevention efforts, including those on college campuses, should address and incorporate the relationship between sexual assault and alcohol use.

METHODS

This was a retrospective medical record review of all patients ages 18-25 presenting to the ED of a tertiary care, academic hospital in the mid-Atlantic region of the U.S. between January 1, 2012 and December 31, 2015. The hospital resides in a college town where over half of the population is comprised of college students. The undergraduate student enrollment is approximately 22,500, of which 54% are male. The first author (AT) reviewed medical records for all patients with ICD-9-CM codes of E960.1 (rape) or V71.5 (observation following alleged rape or seduction) present in the discharge diagnosis during the study period. The following information was extracted from each relevant case: age, gender, delay in seeking care (patient not presenting the same day as the incident), evaluation by the SANE nurse, prophylaxis for human immunodeficiency virus (HIV), sexually transmitted infections (STI) and pregnancy, and if alcohol consumption by the patient was recorded in the medical record. Female patients with an intrauterine device, implanted contraception device, or taking oral contraceptives as prescribed were considered to be on reliable contraception. Descriptive statistics (i.e. frequencies and percentages) were used to describe all study variables. Chi-square tests were used to examine bivariate associations between age (grouped as <21 and ≥ 21) and alcohol use as well as delay

in presentation to the ED (<24 hours vs. ≥ 24 hours) and alcohol use. Statistical significance was set to $p < 0.05$ for all analyses. Data was analyzed using SPSS 22.0. This study was approved by our institution's Institutional Review Board.

RESULTS

There were a total of 121 emerging adult patients presenting for evaluation after sexual assault during the study period, 98% (n=118) of which were female. To minimize the risk of inadvertent disclosure of private information, no further characteristics of the three male patients are reported here. Thus, the subsequent findings presented reflect data from the 118 female patients. Almost 70% (n=82) were 21 years or younger, with a mean age of 20 (Figure 1). Other demographic information (e.g. race, socioeconomic status) is not routinely recorded in our electronic medical record and was unavailable for inclusion in our analyses. Almost 60% (n=69) of cases involved reported alcohol use by the patient. Of these, 74% were under age 21 and 26% were age 21 and over ($p < 0.0002$; Figure 2). Significantly more patients under 21 reported alcohol use than not (73.9% vs. 63.3%, $p < 0.0018$). A significantly greater proportion of patients reporting alcohol use at the time of the incident had a delay in presentation (of at least 24 hours) to the ED compared with those not disclosing alcohol use (62.3% vs. 37.7%, $p < 0.0038$). The number of patients seeking care for sexual assault also differed by the time of year, with almost 40% of visits occurring during late summer/early fall (Figure 3). Fewer visits occurred in winter and summer months. The table presents various clinical characteristics associated with ED visits for patients presenting after sexual assault. Prophylaxis for gonorrhea and chlamydia was accepted by 85.6% of patients. In contrast, less than a quarter of patients accepted HIV prophylaxis. Of those not already on reliable contraception, 83% accepted pregnancy prevention medication. An examination by a SANE nurse was accepted by 84% of patients.

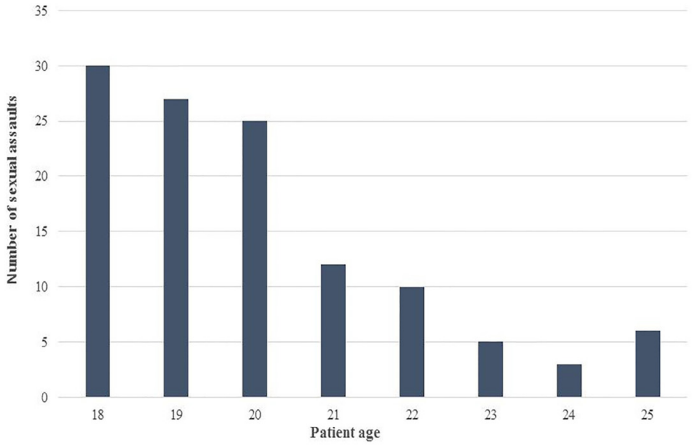

Figure 1. Number of sexual assaults by age among emerging adults.

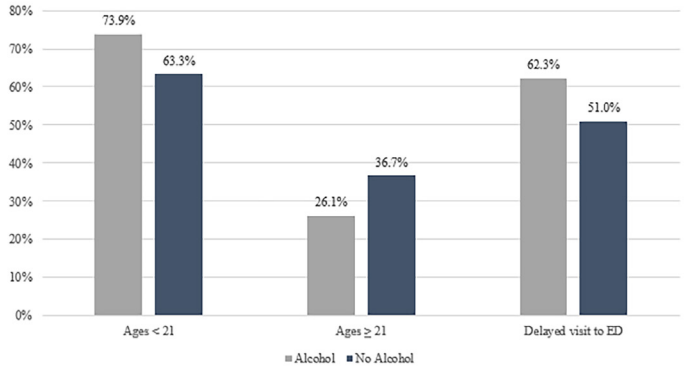

Figure 2. Percentage of sexual assault cases with reported alcohol use by age group among emerging adults.

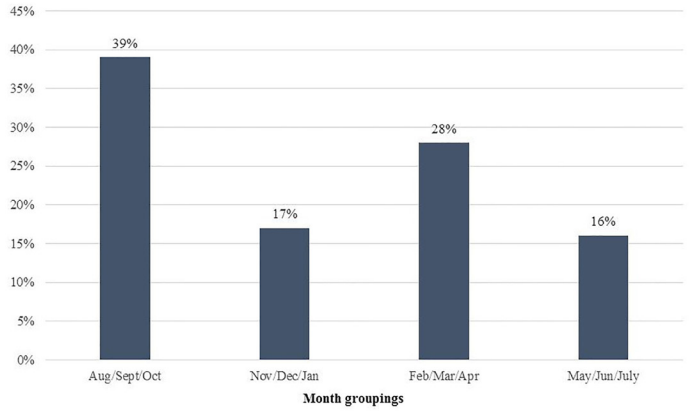

Figure 3. Percentage of sexual assault cases presenting to the ED by month groupings among emerging adults.

Table. Clinical characteristics of sexual assault cases by age group among emerging adults.

Characteristics	<21 years n (%)	≥ 21 years n (%)	TOTAL n (%)
Total visits	82 (69.5)	36 (30.5)	118
Prophylaxis			
Gonorrhea/chlamydia	69 (84.1)	32 (88.9)	101 (85.6)
HIV	20 (24.4)	9 (25.0)	29 (24.6)
Plan B*	49 (83.1)	24 (82.8)	73 (83.0)
Alcohol involved	51 (62.2)	18 (50.0)	69 (58.5)
SANE evaluation	67 (81.7)	32 (88.9)	99 (83.9)

HIV, human immunodeficiency virus; *SANE*, sexual assault nurse examiner.
*Out of 88 eligible.

DISCUSSION

Alcohol use was prevalent in our sample of emerging adult patients presenting to the ED after sexual assault victimization, especially among those under 21 years of age. College students and other young adults—many of whom are

under the legal drinking age of 21 in the U.S.—frequently participate in the practice of binge drinking (defined as 4 or more drinks an hour for women and 5 or more an hour for men), making them particularly susceptible to sexual assault.[26,27] This finding is supported by previous research; a study by Lawyer and colleagues examining forcible, drug-facilitated, and incapacitated sexual assault and rape among undergraduate women found the average age among assault victims to be 19.[21]

In our study, alcohol use was also associated with a delay in presentation for ED care of at least 24 hours. Alcohol use may lead to delays in seeking healthcare after an assault due to incapacitation at the time of the incident or less certainty over what transpired during the assault due to the effects of alcohol. A seasonal variation in the number of sexual assaults presenting to the ED was observed, with the highest number occurring in the first three months of the academic year (August, September, and October). These months coincide with an influx of approximately 5,000 incoming freshmen as well as the beginning of football season, fraternity and sorority events, and many other on- and off-campus social gatherings. In fact, many notes in the patients' medical records made specific mention of these types of events. Additionally, academic loads are often lighter at the beginning of the semester, giving students more free time to attend social events and engage in binge drinking behavior. College freshman new to campus may be particularly vulnerable to the effects of alcohol and may not yet have an established, trusted social network. Not surprisingly, the lowest number of assaults occurred during the months when students would be on holiday and summer breaks. Administrators and others involved in the education and prevention of sexual assaults should be aware of these variations.

A large portion of our population did elect to have SANE evaluations, emergency contraception, and prophylaxis for Gonorrhea and Chlamydia. Prophylaxis for pregnancy, Gonorrhea, and Chlamydia can be completed while in the ED. Lower rates of HIV prophylaxis were likely related to side effects, length of treatment, cost, and the lower prevalence of the disease in our catchment area.[28]

Given that emerging adulthood is a time when young persons are at increased risk for sexual assault and are also likely to engage in risky behaviors, such as binge drinking, sexual assault prevention efforts should begin early and integrate information about binge drinking and alcohol-related sexual assault into their curricula.[30] Ideally this education would occur before emerging adults reach college age, as some individuals do not seek higher education but still may be vulnerable. Our data also support the notion that prevention efforts should occur prior to college, as the majority of sexual assaults in this study occurred during the beginning of the academic year among younger (>21 years of age) patients. Programs to encourage responsible drinking should also have a focus on alcohol's role in sexual assault, and emphasize that alcohol impairs a partner's ability to consent to sexual activity.[30] In a survey of college students, over 40% of respondents believed a woman was responsible for the rape if she was intoxicated at the time.[31] This misconception may add to feelings of guilt by the victim. Widely promoted risk reduction tactics to reduce the likelihood of sexual assault while engaging in drinking behavior include protecting drinks from possible alteration, staying in groups, being aware of alcohol limits, and not accepting rides from or going home with strangers. Still, prevention programs that primarily target the victim and emphasize awareness and sexual assault risk reduction alone have not demonstrated reductions in rates of sexual assault over time.[28,32] Bystander-based prevention programs that focus on changes in social norms have shown promise for reducing sexual violence.[23, 33-35]

LIMITATIONS

As many women do not report a sexual assault after it occurs, this study likely represents only a fraction of the total number of sexual assaults occurring in our community.[29] In addition, because this study included all patients aged 18-25 presenting for evaluation of sexual assault, we were not able to differentiate which patients were college students and which were other young adults in the community. This may limit the applicability of our data to other student populations. Patients may have also reported to other health care settings, such as student health services. However, the protocol is to send patients to our ED from this clinic so this is not thought to be a common mechanism for missing patients.

This study was conducted in a retrospective fashion, and therefore, it was at the discretion of the provider as to whether or not they obtained and recorded information on the victim's use of alcohol at the time of the incident. In addition, the patient may have intentionally not mentioned that they were using alcohol, especially as most of our victims were under the legal drinking age. Therefore, it is likely that alcohol consumption at the time of the sexual assault was even higher than what is represented in our data. Furthermore, lack of information about ethnicity, socioeconomic status, and other important demographic variables is a known limitation of using medical record data. Thus, we were unable to extract these data for our study. The characteristics of the three male patients included in our sample are not presented here, due to privacy and HIPAA concerns. Healthcare data on males receiving medical care after sexual assault is scarce and is an important area for future research.

CONCLUSION

This study found that ED visits for sexual assault in emerging adults were more common in younger patients. Alcohol use occurred more frequently with patients under the legal drinking age; among this group, ED presentation was also more likely to

be delayed. The relationship between sexual assault and alcohol use should underscore primary prevention efforts in emerging adult populations. Primary prevention efforts, including those on college campuses where a large portion of this population is present, should address and incorporate the relationship between sexual assault and alcohol use.

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Conflicts of Interest: By the *West*JEM article submission agreement, all authors are required to disclose all affiliations, funding sources and financial or management relationships that could be perceived as potential sources of bias. No author has professional or financial relationships with any companies that are relevant to this study. There are no conflicts of interest or sources of funding to declare.

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Emergency Medicine Physician Assistant (EMPA) Postgraduate Training Programs: Program Characteristics and Training Curricula

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Introduction: A growing number of formal postgraduate training programs have been established to provide emergency medicine physician assistants (EMPA) with the unique skills and knowledge to work in the emergency department (ED). The objective of this study was to provide an overview of the current state of EMPA postgraduate training and to describe program characteristics and curriculum components.

Methods: We conducted a cross-sectional study of EMPA postgraduate training programs using data from websites and contacting individual programs to provide program characteristics and curriculum components. Variables collected included length of program, curriculum (e.g., clinical rotations, didactic experience, and research opportunities), size of program/number of trainees, affiliation with emergency medicine (EM) residency, geographic location, and salary.

Results: We identified 29 EMPA postgraduate training programs in 17 states, with at least one additional program in development. The mean length of EMPA training programs is 15 months (range 12-24 months). The most common non-ED/elective rotations are orthopedics, ultrasound, anesthesiology, and trauma. The mean number of trainees per class is 3.46 (median 3, range 1-16 trainees); 27 of 29 (93%) programs were in institutions that also had an EM residency program. The mean annual salary is $58,566 (range $43,000-90,000).

Conclusion: EMPA postgraduate training programs have common characteristics and curriculum components despite a lack of a specialty-specific accrediting organization or certifying examination. The overall growth and current number of these programs merits further research focusing on whether standardized curricula, formal recognition, and accreditation should be developed. [West J Emerg Med. 2018;19(5)803–807.]

INTRODUCTION

Physician assistants (PAs) have been integrated into clinical practice in emergency departments (ED) since the early 1970s,[1] predating the recognition of emergency medicine (EM) as a specialty by the American Board of Medical Specialties. According to the National Commission on the Certification of Physician Assistants (NCCPA), there are over 12,000 certified PAs working in EM, representing 13% of all certified PAs.[2]

There are currently more than 225 Accreditation Council for Graduate Medical Education-accredited EM residencies,[3] yet workforce projections suggest that fully staffing emergency departments (ED) with residency-trained, board-certified

emergency physicians (EP) will continue to be a challenge for the foreseeable future.[4,5] The workforce mismatch is particularly pronounced in rural settings. For example, in Iowa less than 12% of all EDs are staffed exclusively with EPs.[6] Many EDs, including pediatric and academic EDs, use PAs to augment the EP workforce.[7-11] Emergency medicine physician assistants (EMPAs) play an increasingly important part of the EM patient care team for a variety of presentations,[12]and can positively impact department productivity[13] and throughput.[14]

Unlike EPs, EMPAs are not required to complete formal postgraduate training programs in EM, and currently there are no EM-specific standards, competencies, or continuing education requirements for EMPAs. Almost 80% of EMPAs cite "on-the-job training" as the method by which they receive EM training.[15] Increasing EM training and educational opportunities is beneficial to the development of the EMPA workforce and has been cited as critical to the future of EM.[16]

EMPA postgraduate training programs offer an opportunity to formalize training in EM for PAs and to provide a foundation for lifelong learning and practice improvement. Completion of specialty-specific postgraduate training by PAs has been identified as an alternative to on-the-job training, and might enhance competitiveness in the job market and decrease onboarding time for newly hired PAs.[17] However, there is variability in the definition of the training and in the structure and standardization of these clinical training experiences.[18]

Postgraduate training programs for PAs have existed in multiple specialties since the early 1970s, and since at least the 1980s for EMPAs.[19,20] An early, prototype EMPA program began in the late 1980s at the University of Southern California/Los Angeles County Hospital. This program offered the opportunity for PAs to develop specialized training in the knowledge and skills that are unique to the practice of EM, and helped lead to the formation of the Society for Emergency Medicine Physician Assistants (SEMPA).[21] Over the past three decades, EMPA training programs developed and evolved along with the specialty of EM. The objective of this study was to provide an overview of the current state of EMPA postgraduate training and to describe program characteristics and curriculum components.

METHODS

We performed a cross-sectional study to identify EMPA postgraduate training programs and to describe their characteristics and curriculum components. The study received exempt status approval from the University of Missouri-Columbia School of Medicine Institutional Review Board. Between October 2016 and January 2017, we collected data by searching individual program websites, the SEMPA website, and the Association of Postgraduate PA Programs website. Where incomplete, and to verify information, these public data were supplemented by contacting EMPA programs by telephone and/or email for additional information.

All three authors extracted data using a data form based on an initial review of common program features using a standardized electronic data form (see online appendix). Variables collected included the following: length of program; curriculum (e.g., clinical rotations, didactic experience, and research opportunities); size of program/number of trainees; affiliation with EM residency; geographic location; and salary. We performed descriptive statistical analyses using Excel (Microsoft Corporation, Redmond, Washington).

RESULTS

We identified a total of 29 EMPA postgraduate training programs, with at least one additional program in development. EMPA programs are found in 17 states (Figure). The mean length of EMPA training programs is 15 months (range 12-24 months). In addition to ED experiences, most programs have a curriculum that includes non-ED (i.e., off-service) required or elective rotations (Table). The most common of these were orthopedics (19/29, 66%), ultrasound (19/29, 66%), anesthesiology (18/29, 62%), and trauma (15/29, 52%). A dedicated pediatric ED experience was offered by 25/29 (86%) of programs. Twenty-two (76%) programs offer or require scholarly activity or research projects. Simulation experience is included in 18/29 (62%) of programs. All programs had didactic conferences that EMPA trainees attended with resident physicians, and most programs (21/29, 72%) had journal club. Additionally, 26/29 (90%) of programs award certificates/ diplomas, and 27 of 29 (93%) programs are in departments or divisions of EM or institutions that also had an EM residency program.

The mean annual salary is $58,566 (range $43,000-90,000). The mean number of trainees per class is 3.46 (median 3, range 1-16 trainees). All programs require a formal application process that includes letters of recommendation and an interview. Programs uniformly require certification by the National Commission on Certification of Physician Assistants (NCCPA) prior to beginning the postgraduate EMPA training.

DISCUSSION

EMPAs are now an important part of the EM workforce and will continue to be in the coming decades. Postgraduate EMPA training programs focused on EM knowledge, skills, and abilities can play a significant role in creating this workforce. EM is a unique practice environment for PAs, featuring a vast knowledge base and procedural competency in a high-risk environment.[22] EPs gain experience, expertise, and clinical mastery through rigorous residency training and board certification and re-certification examinations and lifelong learning through maintenance of certification activities. A majority of EMPAs develop their EM knowledge, skills, and abilities through on-the-job experiences.

There is an opportunity for the development of standardized curricula, training programs, and a certification process for EMPAs that could be like EP training, with a focus on the unique and collaborative practice needs of EMPAs. This formalized

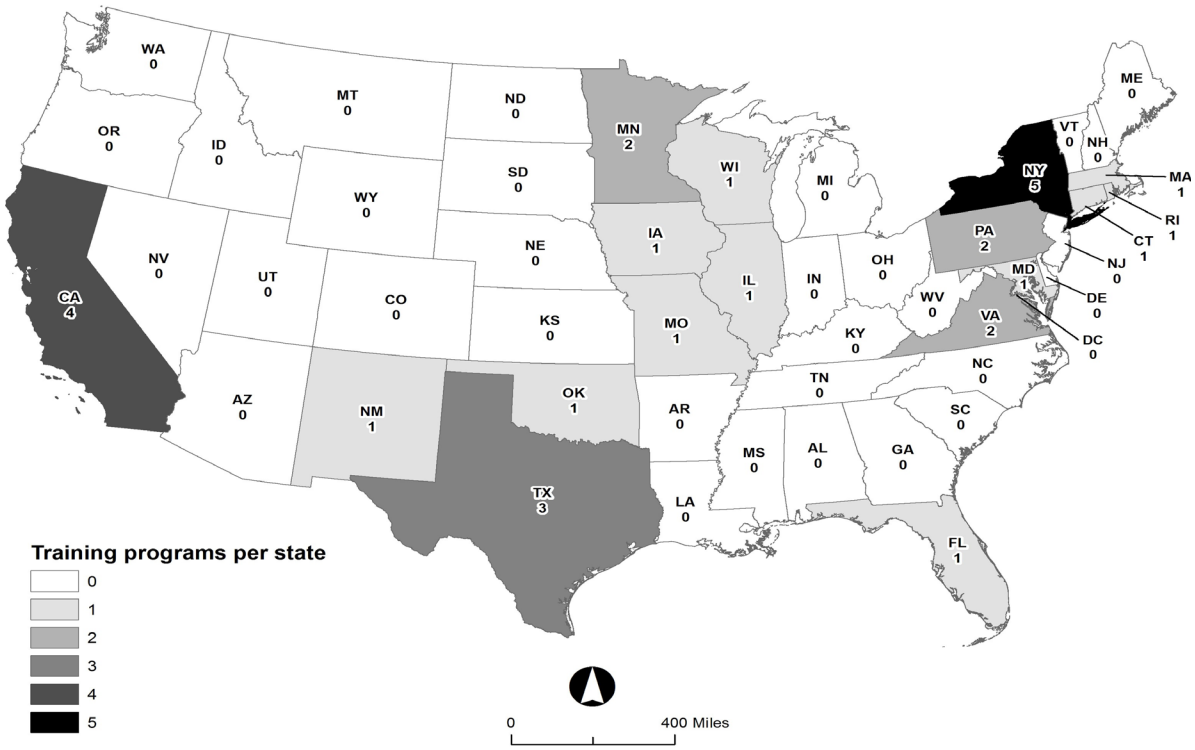

Figure. Geographic distribution of emergency medicine physician assistant (EMPA) postgraduate programs.

training in EM knowledge and skills would prepare PAs to work in a variety of ED settings. Postgraduate EMPA training programs, when partnered with an EM residency training program, might enhance the understanding of all members of the EM team about the key role of EMPAs in providing emergency care. Further standardization of basic curricula, with the ability to tailor specific program and institutional needs and resources, could accelerate the growth of EMPA training programs by encouraging existing EM residencies to develop co-existing EMPA postgraduate training programs. In 2007, there were five postgraduate EMPA training programs.[23]

Our study identified 29 programs, an increase of 24 programs in a decade. The rapid growth of these programs suggests a need for specialized EM training and is analogous to the increased number of EM residency programs over the past decade. When EM residencies were first developed and board certification adopted as the standard for EPs, the American College of Emergency Physicians (ACEP) played a significant role. Similarly, SEMPA has been at the forefront of education and advocacy for EMPAs, and as a close partner of other EM organizations, including ACEP, could be a catalyst for formalizing EMPA education and certification.

Our study shows curricular similarities among EMPA postgraduate training programs. The curricular similarities that already exist provide a foundation for standardizing EMPA postgraduate training and for the future development of board certification or another similar recognition for EMPAs who have completed these training programs. This formal recognition, whether via board certification or another mechanism would underscore the unique role and commitment of EMPAs to patient care in the ED. Accreditation and certification processes would need to be developed and implemented. One existing example is the availability of voluntary accreditation through the Accreditation Review Commission on the Education for the Physician Assistant (ARC-PA).[24]

Finally, the geographic distribution of EMPA postgraduate programs and EM residency programs are similar, consistent with the affiliation of most EMPA programs in departments and/or institutions with existing EM residencies. EMPA programs are likely found in these settings because of the educational infrastructure and ED volume and acuity that provide the necessary training environment for both EMPA and EM residency training programs. The co-existence of EMPA and emergency physician training programs in the same institution offers an opportunity for interdisciplinary learning and is critical to developing a workforce of EMPAs and EPs who will work collaboratively to provide high quality, patient-centered emergency care.

Our study does not evaluate potential barriers to EMPA training programs or explore outcome measures related to the

Table. Clinical experiences (elective or required outside of adult emergency department).

	Number of programs	% of all programs (N = 29)
Pediatrics		
Emergency medicine	25	86
General	3	10
Pediatric intensive care unit	1	3
Orthopedics	19	66
Ultrasound	19	66
Anesthesia	18	62
Medical intensive/critical care unit	17	59
Trauma	15	52
Radiology	13	45
Cardiology (including cardiac intensive care)	12	41
Ophthalmology	11	38
Emergency medical services (ground and/or aeromedical)	10	34
Toxicology	10	34
Obstetrics-gynecology	8	28
General internal medicine	4	14
Neurology	3	10
Other surgical		
Surgical intensive care unit	8	28
Burn	5	17
General surgery	4	14
Oral/maxillofacial	2	7
Wound care	1	3
Miscellaneous		
Wilderness medicine	2	7
Rural medicine	2	7
Disaster medicine	2	7

training. For example, we did not evaluate whether EMPAs who completed postgraduate training provided higher quality, higher value emergency care, or are more desirable as job applicants compared to those who did not have these experiences. We also did not evaluate the potential funding barriers to EMPA programs, especially at a time when government and institutional funding for graduate medical education and postgraduate training is limited, and entering a training program means deferred income for a PA. Future research should explore the cost-effectiveness of EMPA postgraduate training programs in recruiting, training, and retaining EMPAs. Additionally, future investigation into outcomes associated with EMPA postgraduate training is merited.

LIMITATIONS

Our methodology relied primarily on publicly available data and on responses by individual programs to requests for information. It is possible that the data about existing programs are incomplete or missing. Not all postgraduate EMPA programs have websites or other easily accessible information. Because there is no single accreditation body or database for EMPA programs, there might be programs for which data were not included in our study. Our results might underestimate the number of training programs and under-report some of the characteristics of the programs identified. However, the data that are readily available and included in our study suggest similarities among EMPA postgraduate programs from which broad inferences might be drawn about the overall state of EMPA training.

CONCLUSION

Our results provide a foundation for further investigation of curricular best practices and standardized curricula for EMPA postgraduate training. EMPA postgraduate training programs have common characteristics and curriculum components despite a lack of a specialty-specific accrediting organization or certifying examination. The overall growth and current number of these programs merits further research focusing on whether standardized curricula, formal recognition, and accreditation should be developed specifically for EMPA training programs. Additionally, best practices for program components and educational methods should be evaluated and disseminated among existing programs. EMPA postgraduate training programs can provide an important foundation for expanding the PA workforce in emergency medicine.

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Ultrasound-guided Placement of Single-lumen Peripheral Intravenous Catheters in the Internal Jugular Vein

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Introduction: The peripheral internal jugular (IJ), also called the "easy IJ," is an alternative to peripheral venous access reserved for patients with difficult intravenous (IV) access. The procedure involves placing a single-lumen catheter in the IJ vein under ultrasound (US) guidance. As this technique is relatively new, the details regarding the ease of the procedure, how exactly it should be performed, and the safety of the procedure are uncertain. Our primary objective was to determine the success rate for peripheral IJ placement. Secondarily, we evaluated the time needed to complete the procedure and assessed for complications.

Methods: This was a prospective, single-center study of US-guided peripheral IJ placement using a 2.5-inch, 18-gauge catheter on a convenience sample of patients with at least two unsuccessful attempts at peripheral IV placement by nursing staff. Peripheral IJ lines were placed by emergency medicine (EM) attending physicians and EM residents who had completed at least five IJ central lines. All physicians who placed lines for the study watched a 15-minute lecture about peripheral IJ technique. A research assistant monitored each line to assess for complications until the patient was discharged.

Results: We successfully placed a peripheral IJ in 34 of 35 enrolled patients (97.1%). The median number of attempts required for successful cannulation was one (interquartile range (IQR): 1 to 2). The median time to successful line placement was 3 minutes and 6 seconds (IQR: 59 seconds to 4 minutes and 14 seconds). Two lines failed after placement, and one of the 34 successfully placed peripheral IJ lines (2.9%) had a complication – a local hematoma. There were, however, no arterial punctures or pneumothoraces. Although only eight of 34 lines were placed using sterile attire, there were no line infections.

Conclusion: Our research adds to the growing body of evidence supporting US-guided peripheral internal jugular access as a safe and convenient procedure alternative for patients who have difficult IV access. [West J Emerg Med. 2018;19(5)808–812.]

INTRODUCTION

When patients with difficult intravenous (IV) access present to the emergency department (ED), they may experience significant delays in care.[1] A recently described technique – the peripheral internal jugular (IJ) or "easy IJ" – provides a novel means to establish IV access on these patients. This technique, first described in 2009, involves placement of a peripheral IV catheter in the IJ vein under ultrasound (US) guidance.[2] Subsequently, several small studies have concluded that this is a fast and safe procedure.[3-8] Moreover, a recent review article

calculated that the literature has reported 154 patients in whom peripheral IJs have been attempted, and it concluded that peripheral IJs are fast, effective, and have low complication rates. However, it also concluded that further data are needed.[9]

With the above-mentioned studies as support, several physicians in our hospital have begun placing peripheral IJs; however, a number of other physicians, nurses, administrators, and support staff have questioned the safety of placing a central line without following all the typical precautions associated with an IJ central line (full sterile barrier precautions, BIOPATCH® placement, post-procedure chest radiograph, etc.). Indeed, it may be argued that a peripheral IJ is a central line as the Centers for Disease Control and Prevention defines it – "an intravascular catheter that terminates at or close to the heart or in one of the great vessels" – and clarifies that the type of device inserted does not determine if the line qualifies as a central line.[10]

Therefore, as a relatively new technique, a number of details regarding how peripheral IJs should be placed and the safety of the procedure are uncertain. Thus, we believe it is important to add to the existing literature more information about the speed and, especially, the safety of US-guided IJ vein peripheral cannulation. We performed a prospective evaluation of peripheral IJ placement on a convenience sample of ED patients who required IV access and had difficult IV access.

Population Health Research Capsule

What do we already know about this issue?
The peripheral internal jugular (IJ) is an alternative means of obtaining vascular access in patients with difficult vascular access, but some details regarding the procedure and its safety are uncertain.

What was the research question?
Can a heterogeneous group of emergency physicians with minimal training safely and efficiently place peripheral IJ lines?

What was the major finding of the study?
Peripheral IJs were successfully and rapidly placed on 34 of 35 patients with only one complication – a local hematoma.

How does this improve population health?
This study provides additional data that peripheral IJs are a reasonable option for patients with difficult vascular access.

Study Aims and Objectives

Our primary outcome was to determine the rate at which attempted peripheral IJs are successful in a heterogeneous group of operators. Secondarily, we sought to determine mean time to successful line placement and the frequency of complications.

METHODS

This was a prospective case series at a single, urban, academic emergency department (ED) with an annual census of about 77,000. We evaluated the placement of peripheral IJs on a convenience sample of adult ED patients with difficult IV access who required IV access for medical management. Our hospital's institutional review board (IRB) approved this study, and we registered it on clinicaltrials.gov (NCT03231345). All patients on whom a peripheral IJ was attempted signed written, informed consents.

Inclusion criteria were at least two unsuccessful attempts at peripheral IV access by ED nursing staff and age >18. We excluded patients if they were critically ill with clinical indications for emergent triple-lumen catheter access, had an overlying skin infection, had an external jugular vein that was easily visible for cannulation, were in law enforcement custody, were pregnant, or were unable to give consent. Emergency medicine (EM) residents who had placed at least five central lines in the IJ vein were eligible to place peripheral IJs for this study after watching a 15-minute lecture about the technique. Five EM attending physicians who had previous experience placing peripheral IJs were also eligible to place the lines for this study.

The technique for peripheral IJ placement for this study was as follows. The skin was prepped with an alcohol swab or chlorhexidine. Direct US guidance with a linear transducer was required, and a sterile probe cover was recommended. Gloves were required, but sterile gloves were not mandated. The catheter used for the study was the Introcan Safety® catheter (Braun, Kronberg, Germany), a single-lumen 18-gauge, 2.5-inch catheter. Standard catheter-over-needle method was used, and the catheter was secured in typical fashion as for a standard IV start. We also requested that all providers order a chest radiograph (CXR) after line placement to rule out pneumothorax.

As described in more detail in the discussion section below, about halfway through enrollment, although no line infections had occurred, our institution's patient safety committee mandated that we place peripheral IJs as if they were central lines with sterile technique, using full sterile barrier precautions, a sterile dressing, and a BIOPATCH®. Thus, there was an abrupt change in the means by which peripheral IJs were placed during the course of study. This change occurred despite prior IRB approval of a protocol that did not require sterile technique.

After consent, a trained observer watched the physician place the peripheral IJ, and the observer filled out a standard data collection form. The data collection form included location of the attempt (left or right IJ), the level of training of the physician placing the line, the equipment used, number of attempts, time to successful placement, post-procedure portable

CXR results, immediate complications (arterial puncture, neck hematoma, or pneumothorax), equipment used, time to discontinuation of catheter, reason for catheter removal, and delayed complications (thrombus or line infection). Basic demographic information including age, gender, race, and body mass index were also recorded.

The number of "attempts" was defined as the number of times the needle punctured the skin. The time to successful placement began when the US probe touched the patient's skin, and the time stopped when either blood was successfully withdrawn from the line or when the line was successfully flushed. A "line failure" occurred when a line that was initially successfully placed could no longer draw blood or be flushed. For patients who ended up getting admitted, a research assistant checked on the line once per day until the patient was discharged from the hospital. If the line had any problems or was discontinued, the research assistant would determine what the problem was or why it was removed. Two weeks after patients were discharged, a research assistant reviewed the medical records to determine if there was a positive blood culture that may not have been known about at the time of discharge.

At the time this study was conceived, the largest study about peripheral IJs included just 33 patients,[6] so our goal was to enroll 50 patients in an attempt to make this the largest peripheral IJ study to date.

The primary outcome was successful cannulation of the IJ with a peripheral venous catheter. Secondary outcomes included time to placement, number of attempts, and complications.

Table 1. Baseline characteristics of patients who received peripheral internal jugular line placement.

Characteristic	Number
Gender	
Female	25 (71.4%)
Male	10 (28.6%)
Age, mean (SD)	48.2 (15.6)
BMI, median (IQR)	25.7 (22.2, 31.0)
Race	
Caucasian	14 (40%)
African American	14 (40%)
Hispanic	6 (17.1%)
Asian	1 (2.9%)
Side of catheterization	
Left/right	16/19
Disposition	
Admitted	29 (82.9%)
Discharged	5 (14.3%)
Eloped	1 (2.9%)

SD, standard deviation; *BMI*, body mass index; *IQR*, interquartile range.

RESULTS

We enrolled 35 patients between August 2016 and September 2017. We did not achieve our goal of 50 patients because enrollment dramatically decreased after our hospital mandated that peripheral IJs be placed using full sterile barrier precautions, and the study was stopped early. Table 1 shows the baseline characteristics of the 35 enrolled patients.

With regard to the primary outcome, a peripheral IJ was successfully placed in 34 of 35 enrolled patients (97.1%; 95% confidence interval [CI] [85.1-99.9]). On first attempt, the line was successfully placed in 22 of 35 patients (62.8%; 95% CI [44.9-78.5]). The median number of attempts was one (interquartile range [IQR]:1 to 2), and the mean number of attempts was 1.41 (95% CI [1.24-1.58]). The median time to successful cannulation was 3 minutes and 6 seconds (IQR: 59 seconds to 4 minutes and 14 seconds). Line failure occurred in two cases, and both occurred within one hour of line placement. In one of those cases, the line failure occurred because the line was dislodged due to cardiopulmonary resuscitation. The appendix lists the number of attempts and time it took for successful cannulation for each of the 35 enrolled patients.

Of the 35 peripheral IJs attempted, 25 (71.4%) were attempted by a resident, and 10 (28.6%) were attempted by an attending physician. The difference in first-attempt success rates for residents and attending physicians was not statistically significant: 60% (95% CI [38.7 to 78.9]) for residents and 70% (95% CI [34.8 to 93.3]) for attendings, but the median time to cannulation was shorter for attendings. Table 2 shows a more detailed breakdown of success rates by level of training.

We tracked the equipment used by physicians for the placement of peripheral IJs. Although the catheter that was supposed to be used for this study was a 2.5-inch, 18-gauge catheter, in one instance a 1.25-inch, 18-gauge catheter was used. This occurred on the second attempt on subject 34, and this was the only subject on whom a peripheral IJ was not successfully placed. In addition, there was significant variability in the equipment used for peripheral IJ placement, in part, because of physician preference and in part, because our hospital mandated sterile technique after the study had already started (as described further below). Table 3 outlines the equipment used by physicians in our study for peripheral IJ placement.

One of the 34 successfully placed peripheral IJ lines (2.9%; 95% CI [0.1-15.3]) had a complication: a small hematoma that resolved spontaneously without incident. There were no arterial punctures, pneumothoraces, or line thrombi. In 30 of 35 cases, the absence of pneumothorax was confirmed by a post-procedure CXR. Although we told providers to order a CXR after attempting a peripheral IJ, in five cases this was not done. Upon a review of the medical records, all five of those patients were discharged from the hospital without incident, and there was no indication that anyone of those five was suspected to have a

Table 2. Success rates of peripheral internal jugular line placement stratified by level of emergency physician training.

Level of training	Peripheral IJs attempted	Successful, n (%)	Successful on first attempt, n (%)	Median time to cannulation
PGY1	1	1, (100%)	1, (100%)	186 seconds
PGY2	12	12, (100%)	8, (66.7%)	197 seconds
PGY3	12	11, (91.7%)	6, (50%)	224 seconds
Attending	10	10, (100%)	7, (70%)	64 seconds

PGY, postgraduate year; *IJ*, internal jugular.

Table 3. Equipment used for peripheral internal jugular line placement.

Equipment	Frequency of use
Gloves	
Sterile	9 (25.7%)
Nonsterile	26 (74.3%)
BIOPATCH®	7 (20.6%)
Probe cover	30 (85.7%)

pneumothorax. Although the provider only used sterile attire in eight of 34 successfully placed lines, there were no line infections or cases of bacteremia in any of the enrolled patients. Lines were left in for an average of 58 hours, with a maximum of 339 hours.

Through the course of the study, it came to our attention that some technicians in the radiology department and some radiologists in our hospital were concerned that it might not be safe to give IV contrast through peripheral IJ lines because extravasation could be particularly harmful. Therefore, although we did not prospectively assess for contrast extravasation, we found through retrospective analysis that 13 enrolled patients (37.1%) had an IV-contrast radiologic study including seven computed tomography (CT) with IV contrast, two magnetic resonance images with IV contrast, and three nuclear medicine studies. One CT angiogram of the chest was done. There were no instances of contrast extravasation, but of note, the CT angiogram of the chest was read as having "suboptimal opacification of the pulmonary arteries."

DISCUSSION

The results of this study are consistent with other recent literature,[3-8] suggesting that a peripheral IJ can be placed on the majority of patients with only one attempt. Our study was unique in that residents with minimal training placed the majority of lines, and they had high success rates with this procedure. Our study also adds to the growing body of literature that suggests that peripheral IJs are safe. Although our study was not large enough to estimate the rate at which serious complications such as pneumothoraces or line infections occur after the placement of peripheral IJs, the fact that none occurred in our study or other observational studies examining this technique[3-8] suggests that these complications are very rare.

Despite the data in favor of the use of peripheral IJs for patients with difficult IV access, our study also demonstrates some of the difficulties that providers may have when trying to use what will be an unfamiliar line to others in the hospital. In particular, our hospital's patient safety committee expressed concerns that we were not using full sterile barrier precautions for the central lines we were placing. Consequently, our IRB requested that we suspend the study until our principal investigator could talk to the physician in charge of the patient safety committee. This resulted in a protocol change in which we mandated that our physicians place the lines using sterile gloves and "sterile technique." Subsequently, enrollment dropped and the study was stopped before meeting our goal enrollment of 50 patients.

Regarding whether peripheral IJs should be considered central lines, we maintain that they should not. The infection rate noted in studies about US-guided IJ central lines is about 10%.[11] In our study there were zero cases of suspected line infections even without consistent sterile barrier precautions and even with some lines staying in place for a number of days. In previous studies,[3-8] there have also been no reported line infections. Thus, while more data are needed to definitively determine the infection rate, the infection rate of peripheral IJs seems to be very low.

As to whether or not a CXR should be ordered after a peripheral IJ attempt, we would also argue that a CXR may not necessarily be required. The authors of some prior studies argue that routine CXRs are not needed after US-guided IJ central lines because the rate of complications is exceedingly low.[12] Moreover, in our study and in previous studies[3-8] there have been zero reported pneumothoraces from a peripheral IJ. Overall, it is difficult to see why it would be necessary for a provider to treat a peripheral IJ like a central line with full sterile barrier precautions and a post-procedure CXR when peripheral IV catheters placed in the external jugular vein (which is immediately adjacent to the internal jugular vein) are treated like any other peripheral IV lines.

LIMITATIONS

This study had several limitations to consider. First, the study size was small and limited by selection bias. Therefore, our data

are best interpreted by looking at our data along with the results from other studies about peripheral IJs. Second, as described above, our hospital patient safety committee compelled us to change our protocol during the course of data collection. This resulted in a change in the technique used for the procedure from nonsterile to sterile. Ideally, the entire study would have been done with nonsterile attire to provide more evidence that sterile attire is unnecessary.

Although we were more diligent about assessing for complications than some of the previous peripheral IJ studies, our protocol for assessing for complications could have resulted in some missed complications, such as delayed presentations of bacteremia. Also, in five cases the provider who attempted the peripheral IJ did not order a CXR after the procedure. It is thus possible (but unlikely) that we missed a pneumothorax. Finally, this study had no comparison group. A randomized trial comparing peripheral IJs to other US-guided peripheral IVs would help elucidate when peripheral IJs should be used in patients with difficult IV access.

CONCLUSION

This study adds to the growing body of literature that suggests that peripheral IJs are a fast, safe, and easy alternative means for establishing IV access on patients with difficult IV access.

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Accuracy of Height Estimation Among Bystanders

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Introduction: High-risk mechanisms in trauma usually dictate certain treatment and evaluation in protocolized care. A 10-15 feet (ft) fall is traditionally cited as an example of a high-risk mechanism, triggering trauma team activations and costly work-ups. The height and other details of mechanism are usually reported by lay bystanders or prehospital personnel. This small observational study was designed to evaluate how accurate or inaccurate height estimation may be among typical bystanders.

Methods: This was a blinded, prospective study conducted on the grounds of a community hospital. Four panels with lines corresponding to varying heights from 1-25 ft were hung within a building structure that did not have stories or other possibly confounding factors by which to judge height. The participants were asked to estimate the height of each line using a multiple-choice survey-style ballot. Participants were adult volunteers composed of various hospital and non-hospital affiliated persons, of varying ages and genders. In total, there were 96 respondents.

Results: For heights equal to or greater than 15 ft, less than 50% of participants of each job description were able to correctly identify the height. When arranged into a scatter plot, as height increased, the likelihood to underestimate the correct height was evident, having a strong correlation coefficient (R=+0.926) with a statistically significant p value = <0.001.

Conclusion: The use of vertical height as a predictor of injury severity is part of current practice in trauma triage. This data is often an estimation provided by prehospital personnel or bystanders. Our small study showed bystanders may not estimate heights accurately in the field. The greater the reported height, the less likely it is to be accurate. Additionally, there is a higher likelihood that falls from greater than 15 ft may be underestimated. [West J Emerg Med. 2018;19(5)813-819.]

INTRODUCTION

Trauma from falls is an important cause of both morbidity and mortality in children and adults. High-level falls (>15 feet [ft]) are a source of blunt trauma that can be difficult to evaluate and are characterized by multiple injuries across different body areas. Falls are the most common cause of admission to the emergency department during childhood and are the fourth leading cause of trauma deaths.[1] Multiple trauma resulting from a high-level fall requires laborious investigation. To date, there are no current data to evaluate how closely heights are estimated by those at the scene of a fall.

Currently, emergency medical services' (EMS) guidelines use fall height estimation as a criterion to determine the disposition of a patient to a trauma center or closest non-trauma center. The current height referenced as an indication

for transfer to a trauma center is a fall from 20 ft for an adult and 10 ft for a child, or three times the height of the child.[4] Most trauma centers and prehospital personnel use these guidelines to set trauma team activation protocols as well, determining the resources made available to the patient upon arrival and how quickly the patient is evaluated by the trauma team.

Demetriades et al. in 2005 evaluated injury patterns in falls from > 15 ft and found a higher rate of spinal injuries among patients over 14 years of age. This study also showed a range of mortality from 5.5% in the pediatric population to 24.3% in those over 65 years old.[1] For adults, trauma from falls is associated with alcohol use in more than half of cases, and has a male predominance.[5,13,14] The injuries sustained in adults from falls from a height vary from those of children, as adults tend to suffer axial loads from landing with their feet on the ground. Because of this, the most common injuries in adults tend to be fractures of the spine and lower limbs, particularly calcaneal fractures, and the most common spinal injuries tended to be in the lumbar region.[6] Aside from skeletal injuries from falls, soft tissue injuries are also prevalent, the most common being brain injuries, followed by liver and lung injuries.[15]

Trauma continues to be the most common cause of death in the U.S. pediatric population. In pediatric populations, high-level falls show a predominance of head and soft-tissue injuries as demonstrated in Figure 1.[18] Another small study of 70 patients showed that 100% of children who fell from a height of two stories or fewer survived, but the mortality increased in falls from fifth- and sixth-story heights.[2]

Computed tomography (CT) imaging of head-injured children after a fall can carry a risk of radiation-induced malignancy. To identify children at very low risk of clinically-important traumatic brain injuries, for whom CT might involve unnecessary radiation exposure, the *Pediatric Emergency Care Applied Research Network* (PECARN) clinical decision tool is often used. Part of this tool incorporates the height of the fall. A severe mechanism is considered a fall of five ft for children over two years old and three ft for children under two years old.[9] With regard to blunt abdominal trauma, PECARN clinical decision rules considered a height of 10 ft a severe mechanism.[21]

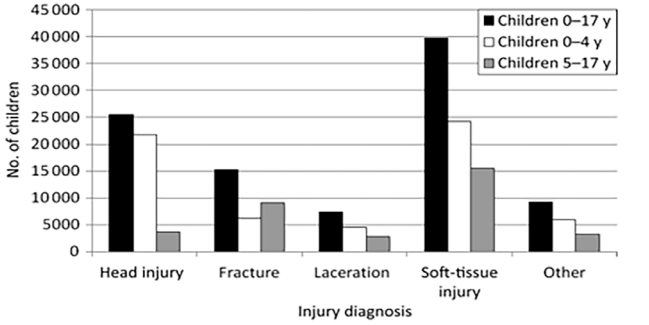

Figure 1. Distribution of pediatric injuries from falls.[18]

A notable limitation of many studies involving high-level falls is the actual measurement of the heights involved.[1] Previous studies that focused on high-level falls used various methods of obtaining the height from which the patient fell. Some of these methods include speaking with first responders, medical chart review, or self-report by the patient or bystanders, with and without reliable height reference points, such as storied buildings.[7,19]

Population Health Research Capsule

What do we already know about this issue?
The height of a fall is considered relevant mechanistic information for trauma triage and evaluation; it is typically provided by prehospital personnel or bystanders.

What was the research question?
How accurate are height estimations in the absence of reference points (such as a storied building)?

What was the major finding of the study?
Most people inaccurately underestimate heights greater than 15 feet in the absence of reference points.

How does this improve population health?
Fall reported from a height of >15 feet without a reference point such as a storied building may be at risk for more significant injuries.

METHODS

We recruited volunteer participants varying in age, gender, and educational background to estimate height in feet of 16 horizontal lines. Large fabric panels pre-marked with four different lines corresponding to various heights were suspended from a ceiling of an indoor site, which did not have visible stories or other reference points as confounders. The first fabric panel was labeled on one side as panel 1A, which contained four lines labeled A through D. The alternate side of this panel was labeled 1B, containing four lines labeled E through H. A second fabric panel was labeled on one side

as panel 2A, containing four lines labeled I through L. The alternate site of this panel was labeled 2B, containing lines labeled M through P (Figure 2).

We created an answer key showing corresponding heights to the lines labeled A through P. This was not shared with study participants and was maintained only for data analysis.

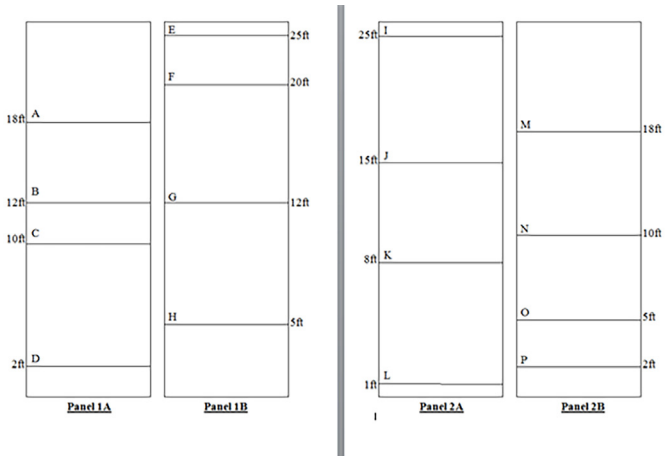

Figure 2. Schematic of fabric panels used by study participants to estimate height.

A ballot form (Appendix) was given to participants while viewing the panels. Each line, labeled A through P, had four possible answers in a multiple-choice format from which to select as an estimate.

Exclusion criteria for participants were those who could not participate for mental or physical disability, as well as those under the age of 18 years. Volunteers were given information regarding the study but not the objectives and were consented for participation. The ballot forms were sequentially numbered for purposes of tracking ballots and were otherwise anonymous. Participants were handed a ballot upon entering the room, given instructions on how to complete the survey, and the ballot was recollected upon completion.

Participants were monitored during the survey and not permitted to discuss their guesses with each other. They were positioned in the middle of the room, approximately 20 ft from the viewed panel. Participants first viewed Panel 1A and chose their answers. They then turned around to view Panel 2A and again chose their answer. They were not permitted to turn back around to look at the previous panel. While participants viewed Panel 2A, Panel 1A was pivoted to the 1B side to further prevent them from comparing heights to their previous guesses. Participants then turned around, viewed Panel 1B and chose their answers. While doing this, Panel 2A was pivoted to the 2B side. Finally, participants turned around to view Panel 2B and choose their answers. The initial goal was to obtain enrollment of 100 volunteers.

RESULTS

We enrolled a total of 96 participants. Figure 3 shows the distribution. Table 1 demonstrates the percentages of correct identifications for each line, broken down by job description (referred to as "groups"). These percentages were obtained by dividing the number of correct answers for the group by the total number of respondents in the group. Viewing these data in table form allows easy assessment for trends, showing that at lower heights, participants were more likely to correctly guess the height. For heights equal to or greater than 15 ft, less than 50% of participants in each group were able to correctly identify the height.

Job Description	Number of Participants
Ancillary hospital staff	17
EMS/EMT/paramedic	21
Medical student/PA student	17
Non-healthcare profession	11
Nurse	19
Physician/PA/NP	11
Total = 96 participants	

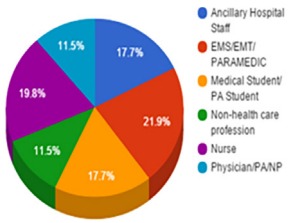

Figure 3. Distribution of study participants by job description. *EMS*, emergency medical service; *EMT*, emergency medical technician; *PA*, physician's assistant; *NP*, nurse practitioner.

We further evaluated the data to reveal any trend for predisposition toward overestimating or underestimating heights when guessed incorrectly. We can determine how height (on x axis) coincides with the number of responses (on the y axis) for each subset (underestimation, overestimation, and correct). We plotted a linear function based on these data and used www.statscrunch.com to calculate the correlation coefficient (R).

We completed an a priori power analysis for the bivariate correlation using the GPower 3.0 program (Faul, Erdfelder, Lang, & Buchner, 2007). Two-tailed p values were employed. Power was set to 0.80, meaning there would be an 80% probability of reaching statistical significance if the obtained sample differences were truly present in the population. The sample size for the current study was n=96. Results from the power analysis revealed that a sample size of 29 would be sensitive to differences

Table 1. Percentage of correct answers per line divided by job description.

	A (18ft)	B (12ft)	C (10ft)	D (2ft)	E (25ft)	F (20ft)	G (12ft)	H (5ft)	I (25ft)	J (15 ft)	K (8ft)	L (1ft)	M (18ft)	N (10ft)	O (5ft)	P (2ft)
Ancillary hospital staff	11.8	64.7	52.9	82.4	17.6	17.6	58.8	52.9	23.5	35.3	29.4	94.1	29.4	47.1	47.1	82.4
EMS/EMT/ paramedic	23.8	61.9	61.9	71.4	19.0	28.6	61.9	61.9	19.0	47.6	33.3	90.5	33.3	52.4	76.2	61.9
Medical student/PA student	23.5	82.4	58.8	82.4	35.3	35.3	52.9	58.8	17.6	35.3	52.9	94.1	17.6	23.5	82.4	82.4
Non-healthcare profession	36.4	45.5	45.5	81.8	9.1	27.3	36.4	36.4	18.2	45.5	63.6	81.8	0.0	18.2	36.4	63.6
Nurse	42.1	63.2	57.9	73.7	5.3	10.5	47.4	52.6	10.5	26.3	36.8	94.7	5.3	31.6	47.4	78.9
Physician/ PA/NP	27.3	45.5	63.6	100	9.1	36.4	72.7	54.5	18.2	45.5	27.3	100	36.4	45.5	81.8	90.9

ft, feet; *EMS,* emergency medical service; *EMT*, emergency medical technician; *PA,* physician's assistant; *NP,* nurse practitioner.

in ranks associated with large effect sizes (i.e., Cohen's [1988] f = 0.50, minimal n required by the power analysis = 29). Therefore, given an obtained sample size of 96, the study is sensitive to a large effect size.

In our panel design, there were repeated heights on different panels. The goal of this design was to evaluate if participants were able to correctly identify the same height line, but on different panels with varying surrounding lines as reference points (Figures 4-6). Table 2 demonstrates the heights that were duplicated and the lines corresponding to that height. The two lines for each height are referred to as a "pair." Each line of the pair was positioned on a panel to have either a "near" reference point or a "far" reference point. The distances between the "near" reference points and the height to be estimated ranged from 2-6 ft. The distances between the "far" reference points and the height to be estimated ranged from 5-10 ft.

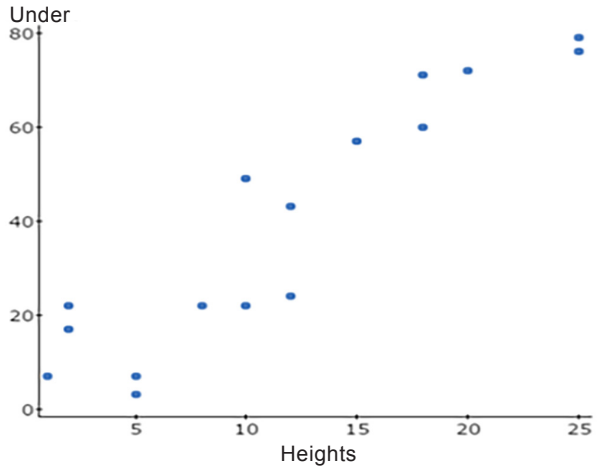

Figure 4. Scatter plot of heights vs. number of underestimations. For underestimation, R=+0.926, showing a strong positive correlation between the heights and number of underestimations. As the heights increased, more people consistently underestimated the correct height. Using a simple linear regression, the slope of R has a p-value=<0.001, suggesting that this trend is statistically significant. *R,* correlation coefficient.

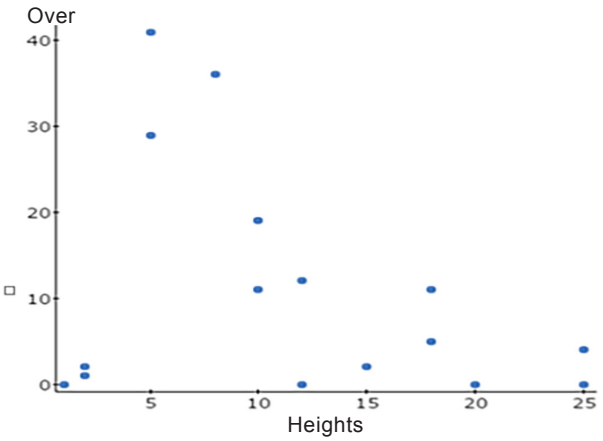

Figure 5. Scatter plot of heights vs. number of overestimations. For overestimation, R=-0.0331, showing a very weak negative correlation between the heights and number of overestimations. This data does not significatnly suggest that there was a prominent trend for respondents to overestimate with increasing height length,. Using a simple linear regression, the slope of R has a p-value=0.2111, suggestion that htis relationship is not statistically significant. *R,* correlation coefficient.

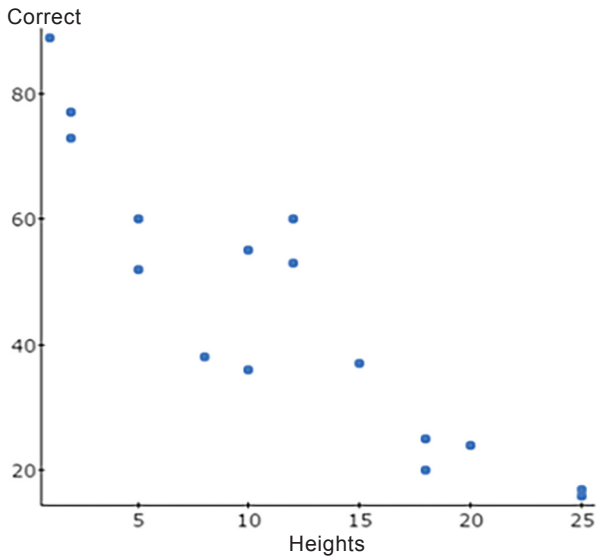

Figure 6. Scatter plot of heights vs number of overestimations. For correct estimation, R=-0.904 showing a strong negative correlation between the heights and number of correct responses. As the heights increased, the number of correct guesses from respondents reliably decreased. Using a linear regression, the slope of R has a p-value=<0.001, suggesting that this trend is statistically significant.
*R,*correlation coefficient.

Table 2. Lines assigned to "near" or "far" groups.

Height (feet)	Near	Far
2	P	D
5	O	H
10	C	N
12	B	G
18	A	M
25	E	I

We completed an a priori power analysis for the dependent samples t-test using the GPower 3.0 program (Faul, Erdfelder, Lang, & Buchner, 2007). Two-tailed *p* values were employed. Power was set to 0.80, meaning there would be an 80% probability of reaching statistical significance if the obtained sample differences were truly present in the population. The sample size for the current study was n=96. Results from the power analysis revealed that a sample size of 34 would be sensitive to differences in ranks associated with large effect sizes (i.e., Cohen's [1988] $f = 0.40$, minimal n required by the power analysis = 34). Therefore, given an obtained sample size of 96, the study is sensitive to a large effect size.

We calculated the average relative error for each panel in the pair sets. A paired t-test was used to calculate if the average relative error for the "near group," 11.5%, was a statistically significant difference from the average relative error for the "far group," 16.4%. With a p= 0.08, this is not a statistically significant difference, meaning that the proximity of possible reference points does not consistently influence the bystander's estimation of height.

DISCUSSION

Acute vertical deceleration is a major cause of significant morbidity and mortality in the urban trauma setting. Velmahos et al. performed a prospective study that evaluated 187 patients who presented after a fall from a height between 5-70 ft. This study found that fractures were the most common form of injuries. Spinal cord and intra-abdominal organ injuries were also very common with falls from any height. Injuries sustained after a higher than 60 ft free-fall are usually lethal. This study concluded that the height of the fall is a good predictor of injury severity and outcome prognosis.[5] Parreira et al. performed a retrospective study comparing the injuries sustained in falls vs. those in other mechanisms of blunt trauma, and found that those involved in falls had significantly higher rates of skeletal injuries.[20]

Multiple studies have postulated a correlation between height of fall and severity of injury.[5–8] The American College of Surgeons recommends that patients injured in falls from heights greater than 20 ft (1 meter = 3.2 feet) need to be taken to a trauma center.[3,4] The use of the height of a fall as a predictor of severe injury has been assessed as a part of several studies of trauma triage. Heights are factors that have been confounding in some studies.[1] These data are often an estimation provided by prehospital personnel, first-responders, or bystanders. Many studies disclose how height values were obtained in high-level fall patients. In prospective studies performed, the height of the falls was obtained from police, fire-rescuers, paramedics, witnesses or patients themselves.[5,7,13] Most retrospective studies assessing height injuries obtained height through medical records, chart reviews or national trauma registries.[1,3,6,14,16] Other studies that looked at falls from building, balconies or high-level vertical fall, calculated their heights as an estimation based on how many stories each patient fell.[2,13,17]

Due to the high costs involved in healthcare spending, and in trauma team activation and work-ups in particular, it is of great interest to reduce unnecessary ordering of CTs.[22, 23] Given the importance of fall height in clinical decision-making, the reliability of bystander-reported heights was investigated in this study, with the hypothesis that in the absence of a reference point such as a storied building, the estimated fall height may often be inaccurate. We found that at lower heights, participants were more likely to correctly estimate the height. In this study, the estimation was less reliable in heights greater

than 15ft. Furthermore, it was found that for greater heights, inaccurate estimations were more likely to be underestimated than overestimated. Without a frame of reference, bystanders may be less accurate in estimating heights greater than 15 ft, especially in the absence of a reference point. It may be useful, then, to ask whether a storied building was nearby or if the information has validity in some other way (i.e., known heights of our machines/ scaffolding/ladders). It is possible that underestimation may lead to missed injuries, and overestimation may lead to unnecessary work-up. Future studies with equal distribution of participants in each category would allow a proper analysis of variance that may reveal if one particular group of people is more accurate at estimating heights, or if additional historical factors can further vet these patients into a narrower pool in terms of work-up in protocolized trauma care. Overall, falls are a major cause of morbidity and mortality in the trauma patient and the heights estimated by those present at the scene may be inaccurate; nonetheless, it is still used as valid information pertaining to the mechanism.

LIMITATIONS

Our study has several limitations that we must acknowledge. Previous trauma studies that assessed injuries due to high-level falls included evaluation of victims who fell from heights up to 70 ft.[5] When planning on making fabric panels to this height, our greatest challenge was to find a location to accommodate such a height. The data collection period was between December and January, when having panels set up outdoors was a concern due to possibility of inclement weather. The location with the highest ceiling height at our institution was our hospital church, which allowed for setting up panels with the highest length of 25ft.

Our original goal was to recruit 100 prehospital respondents. Ideally, EMS participants were to be recruited at EMS stations/firehouses. However, because the logistics of assembling freestanding panels in these settings proved not to be feasible, we expanded our participant pool to include those listed in "Job Description" in Figure 6, as anyone could potentially estimate the height of a fall in the field. A degree of respondent bias must also be taken into account. Some variation in height estimation is inherent in the participant's own height, which can alter perception of viewed heights.

Additionally, participants were observed looking at their fellow co-participants, using the perceived height of their co-participant to estimate the height of the line on the panel. As each group varied in participants, this may have altered some of the participants' perceptions. Other limitations include number of respondents; if we could have had a greater power in the study, there might have been more noticeable differences in height accuracy between first responders vs. non-first responders. Also, we did not include age, which may also play a role in accuracy. Finally, estimating heights in a vacuum is not how it actually occurs in real life. Our aim was to determine accuracy in estimation in the absence of buildings; in an actual setting, this would include falls from a large piece of machinery, tree, or other structure without a clear height-reference point.

CONCLUSION

This small study from a community hospital showed that bystanders may not estimate heights accurately in the field. The greater the reported height, the less likely it is to be accurate. Additionally, there is a higher likelihood that falls from greater than 15 ft may be underestimated. Further studies are warranted to determine additional demographic and environmental factors that may affect the accuracy of bystander reports in the mechanism of traumatic injuries. Potential bystanders are more likely to underestimate the actual height of a fall. High-level falls are linked to more life-threatening injuries; therefore, it may be prudent to assume a more severe mechanism than inferred from the height provided via bystander report.

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Preparing Osteopathic Students for the Single Graduate Medical Education Accreditation System: Evaluating Factors for Match Success in Emergency Medicine

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Introduction: With the development of and progression toward a single graduate medical education accreditation system combining the current Accreditation Council for Graduate Medical Education (ACGME) and American Osteopathic Association (AOA) residency programs, the total number of students competing for the same postgraduate training spots will continue to rise. Given this increasing competition for emergency medicine (EM) residency positions, understanding factors that contribute to match success is important to ensure a successful match for osteopathic medical students.

Methods: Our anonymous survey to evaluate factors that led to a successful match was sent out to residents in current ACGME-, AOA-, and dually-accredited programs via the AOA program director listserv and the Council of Residency Directors (CORD) e-mail listserv in 2017.

Results: We had 218 responses. Responses showed that osteopathic graduates had less affiliation with EM residencies, their home institutions provided less information regarding standardized letters of evaluations (SLOE), and that successful osteopathic graduates seemed to learn about them while on EM elective rotations. These students also had less direct EM mentorship and were generally unsatisfied with the level of mentorship available. Osteopathic graduates in current ACGME programs were also more likely to have taken the United States Medical Licensing Examination compared to their AOA resident counterparts.

Conclusion: Osteopathic medical schools can improve their graduates' chances of successfully matching in EM by establishing mentorship programs and educating their students early about SLOEs. [West J Emerg Med. 2018;19(5)820-824.]

INTRODUCTION

The second semester of the fourth year of medical school is generally regarded as the least stressful in a medical school, with one notable exception: the match. Students hoping to obtain a residency position in emergency medicine (EM) face increasingly steep competition. The 2016 data from the National Resident Matching Program (NRMP) (allopathic) match showed 2,703 applicants for a total of 2,047 EM positions, with only four unfilled spots after the main match.[1] Of the 264 osteopathic applicants participating in this match, 60 went without a successful EM match. In the National Matching Services (NMS) (osteopathic) match, 310 positions were available in EM with again only four unfilled spots after the main match.[2] Osteopathic graduates have historically made up a small percentage of the total participants in the NRMP match – 8.4%[3] in 2017. As we move toward a single graduate medical education (GME) accreditation system, the number of osteopathic students competing with allopathic students will continue to rise. The failure in the past year of some osteopathic students to match was likely multifactorial. Given the increasing competition for

EM residency positions, understanding factors that contribute to match success is becoming increasingly important to ensure that strong osteopathic candidates are not overlooked.

Our objective was to query active EM residents and, by retrospectively reviewing the steps they took, to understand any potential limitations that current osteopathic students may face to achieve a successful match. We aimed to identify these limitations well in advance of the merger in order to guide students prospectively as they apply for EM residency positions. We hypothesized that osteopathic medical students are at a particular disadvantage compared with their allopathic peers, especially in terms of EM-specific mentorship at their respective undergraduate institutions.

Population Health Research Capsule

What do we already know about this issue?
Applying for residency has become increasingly competitive. Traditionally osteopathic medical students have made up a small percentage of participants in the National Resident Matching Program. As we move to a single graduate medical education accreditation system more osteopathic students will be compared to their allopathic counterparts.

What was the research question?
What potential limitations may osteopathic students face to achieve a successful match?

What was the major finding of the study?
Osteopathic graduates do not have the same level of pre-residency resources as allopathic students, particularly with fewer affiliated EM residency programs, and fewer mentorship opportunities.

How does this improve population health?
These data demonstrate that osteopathic medical schools can make their students more competitive for EM residency positions to ensure that no qualified applicant is overlooked in the future.

METHODS

With approval from our institution's institutional review board, we created an anonymous retrospective survey using Google Forms and distributed it to active, consenting residents in current Accreditation Council for Graduate Medical Education (ACGME)-, American Osteopathic Association (AOA)-, and dually-accredited programs, via the AOA program director listserv and the Council of Emergency Medicine Residency Directors Advances in Education Research and Innovations (CORD) listserv in the spring of 2017, just after the match.

We collected survey results using Google Forms and analyzed them with Microsoft Excel (Redmond, WA). We received a total of 218 responses, which we sorted into two groups to allow for comparison: respondents who graduated from an allopathic medical school and respondents who graduated from an osteopathic medical school. We did not differentiate responses based on postgraduate-year level. Survey questions highlighted multiple aspects of the match process including board scores, standardized letters of evaluation (SLOE) and mentorship, among others (Figure 1).

We tallied and calculated responses as a percentage of that group's (osteopathic/allopathic) responders. Percentages were rounded to nearest percentage for better visualization and comparison.

RESULTS

Of the 218 responses to our survey, 119 (54%) were from residents who graduated from an allopathic medical school and 99 (45%) from residents who graduated from an osteopathic medical school. The majority of responses, 64%, came from residents currently training at an ACGME program, 28% were at a dually-accredited program, and 7% were at an AOA program.

Of the 99 osteopathic resident responses, only 27% reported a medical school affiliation with an EM residency as compared to 73% noted by the allopathic graduates. Most allopathic graduates had an EM rotation offered by their home institution (80%), as compared to osteopathic graduates who reported only 35% of them came from programs that offered an EM rotation at their home institution. There was less of a contrast between groups when comparing numbers of total EM rotation opportunities they were allowed to schedule. Allopathic graduates reported that 44% were allowed to schedule >3 rotations in EM. Osteopathic graduates reported 56% were allowed to schedule >3 rotations in EM.

The responses were more varied regarding how students learned about SLOEs. The four most common responses were mentors, medical schools, sites such as the EM Residents' Association (EMRA)/CORD, and elective rotations. The osteopathic and allopathic groups again had differing responses to this question. Allopathic graduates most commonly learned about SLOEs from their medical schools (91%), followed by EMRA/CORD (10%), mentors (6%), and electives (4%). Osteopathic graduates more commonly learned about SLOEs while on their EM-elective rotation (29%), through EMRA/CORD (28%), school (14%), and mentors (10%) (Figure 2).

For osteopathic graduates in ACGME programs, 82% had taken the United States Medical Licensing Examination (USMLE) Steps 1 and 2 (7% did not take USMLE exams, and

Question 1	Selecting your graduate institution. (Osteopathic, Allopathic)
Question 2	If you are an osteopathic graduate, what match did you use?
Question 3	Are you currently training in an ACGME- or an AOA-accredited EM residency program?
Question 4	Did you have a designated EM faculty mentor at your medical school?
Question 5	Did your home institution offer an EM rotation?
Question 6	Was your home institution affiliated with an accredited EM training program?
Question 7	How many 4th-year elective EM rotations were you allowed to schedule?
Question 8	How many 4th-year elective EM rotations were you ABLE to schedule?
Question 9	How many of your 4th-year elective rotations were affiliated with a residency program or at an academic institution with residency programs but not EM?
Question 10	How did you learn about obtaining SLOEs?
Question 11	How many SLOEs did you obtain?
Question 12	If applicable, how may NMS programs did you apply to?
Question 13	If applicable, how many NRMP programs did you apply to?
Question 14	If an osteopathic graduate, did you take the USMLE?
Question 15	Overall, do you feel satisfied with the EM specific mentoring provided by your medical school?

Figure 1. Survey questions distributed to residents through Google forms.
ACGME, Accreditation Council for Graduate Medical Education; *AOA*, American Osteopathic Association; *EM*, emergency medicine; *SLOE*, standardized letter of evaluations; *NMS*, National Matching Services; *NRMP*, National Resident Matching Program; *USMLE*, United States Medical Licensing Examination.

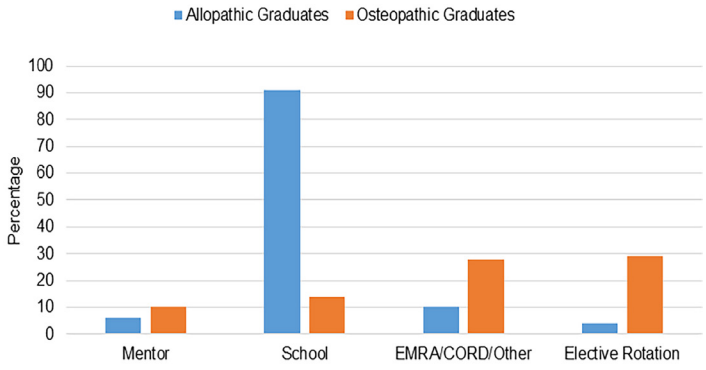

Figure 2. How survey respondents learned about the standardized letter of evaluation.
EMRA, Emergency Medicine Residents' Association; *CORD*, Council of Emergency Medicine Residency Directors Advances in Education Research and Innovations.

7% took either Step 1 or Step 2 only). In AOA programs, 37% took USMLE Steps 1 and 2 (25% did not take the USMLE, and 31% took either Step 1 or Step 2); and in dual programs 27% took USMLE Steps 1 and 2. Of note, 57% in dual programs did not take the USMLE at all (16% took either Step 1 or step 2) (Figure 3).

Regarding EM-specific mentoring, allopathic graduates predominantly had structured mentoring support; 70% of allopathic responders reported that their home institution had an EM faculty mentor, 30% did not have a mentor, and 4% were unsure. This was in stark contrast to osteopathic responders who reported that only 20% had an EM faculty mentor at their home institution, while 68% reported no mentor and 11% were unsure (Figure 4). Levels of satisfaction with available mentoring were also different between the two groups. Of the allopathic graduates, 65% reported they were overall satisfied, 12% were neutral, and 21% were dissatisfied. Of the osteopathic graduates, 17% were satisfied, 17% were neutral, and 65% were dissatisfied (Figure 5).

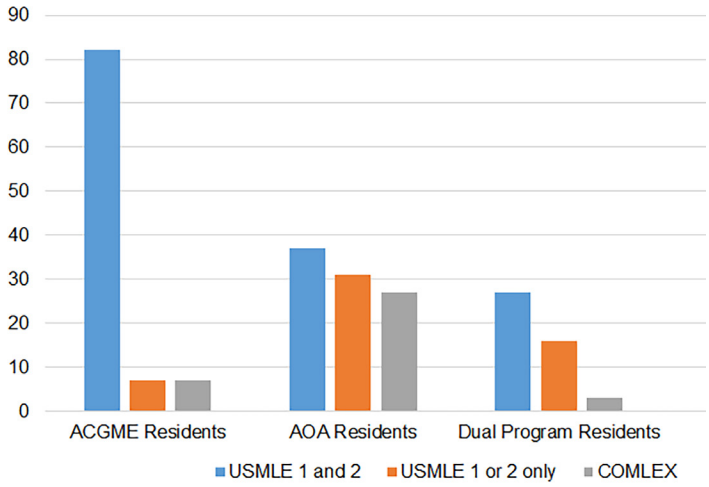

Figure 3. Board exams taken by allopathic and osteopathic residents in ACGME-, AOA-, and dually-accredited programs.

DISCUSSION

In reviewing the survey data, we found that our responses were almost evenly divided between the doctor of osteopathic medicine (DO) and doctor of medicine (MD) groups. Most of the graduates (DO and MD) who responded are currently training at ACGME programs, thus representing the population we most wanted to study. In the responses we received, the general theme appeared to be that osteopathic graduates do not have the same level of pre-residency resources or support as their allopathic colleagues. This is likely part of a multifactorial problem and a

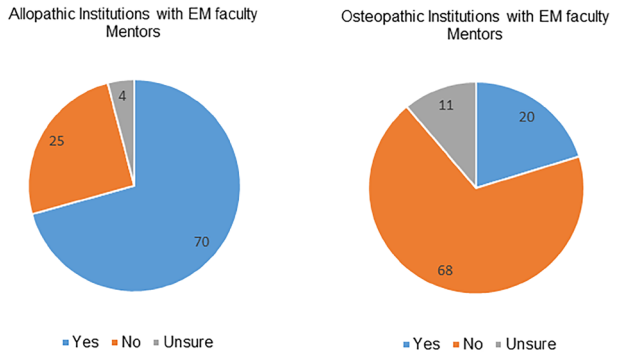

Figure 4. Availability of mentors at allopathic and osteopathic medical schools.
EM, emergency medicine.

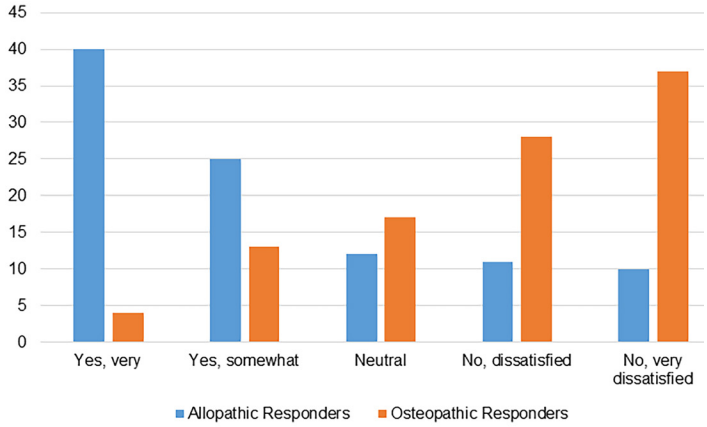

Figure 5. Satisfaction with available mentorship as reported by osteopathic and allopathic graduates.

product of the different environments between osteopathic and allopathic medical schools; however, our study did suggest some areas where improvement could be made.

Because osteopathic medical schools are typically not affiliated with a major academic institution, it was not surprising that the majority of osteopathic graduates did not have an affiliated EM residency with their school. Most medical schools regardless of type appear to be supportive in allowing their students to participate in EM electives. The majority of survey responders stated that their school allows >3 electives to be scheduled.

Students in ACGME-accredited programs primarily took USMLE Steps 1 and 2 based on survey responses. This could be multifactorial and our assumption would be that more students may have taken this exam due to a perceived preference by residency programs, or perhaps osteopathic students were attempting to appear more competitive by taking the additional exam. Graduates currently in dually-accredited programs seem to match well without taking the USMLE; this was also likely multifactorial. Again, we could assume that dual programs are likely more familiar with the Comprehensive Osteopathic Medical Licensing Examination (COMLEX), or perhaps these students had higher COMLEX scores and did not feel the need to take an additional exam. Further studies could be directed at ascertaining the reasons for this.

Obtaining SLOEs is something most allopathic students learn about from their medical schools. The majority reported that was where they learned about SLOEs, with the second highest number stating they learned from a source such as CORD/EMRA. Osteopathic students had a wider variety of responses but, notably, far fewer had learned about this vital part of the application process from their medical school. They seemed to learn about the necessity of getting SLOEs during their elective rotations rather than beforehand, which could have led to obtaining letters late in the application season.

The majority of allopathic responders reported having mentoring available to them directly from their medical school, as opposed to the osteopathic responders who reported the majority did not have EM-specific mentorship available to them. Osteopathic responders appeared to be dissatisfied overall with the level of mentorship available to them, as demonstrated by their responses.

LIMITATIONS

One limitation in our study was the low response rate to the survey. Based on an estimation of the current number of U.S. medical school graduates in EM training, excluding international graduates, our response rate was approximately 5%. While this low response rate likely limited the major conclusions that we could draw, the survey results do suggest an overall trend. Perhaps future studies could draw an improved response rate by direct communication with programs and residents. We did, however, have a nearly even number of responses between DO and MD residents and thus believe we obtained a representative sample of the population we were studying.

CONCLUSION

Osteopathic medical students face a disadvantage in the EM match in multiple areas. Fewer osteopathic graduates came from schools with EM residency affiliations or learned about SLOEs from their medical schools. They reported having less mentorship during their undergraduate studies and overall felt dissatisfied with the level of mentorship available to them. Our study suggests that osteopathic medical schools could improve their graduates' chances of successfully matching in EM by establishing mentorship programs and educating their students early about SLOEs. Obtaining affiliations with EM residency programs would be beneficial as well. As we move to a single match by 2020 under the single GME accreditation system, encouraging students to take the USMLE could also prove advantageous, given that the majority of osteopathic graduates at ACGME-accredited programs had taken that exam.

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Comment on "A Tactical Medicine After-action Report of the San Bernardino Terrorist Incident"

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Editor:

We noted several consequential factual errors in the after-action report written by Bobko et al[1] compared to the official after-action report of the San Bernardino terrorist incident.[2]

The authors[1] state law enforcement transported two deceased victims to a hospital. Before establishment of Triage A, probation officers (PO) transported one survivor to a hospital emergency department.[2] After establishment of Triage A, law enforcement officers (LEO) transported two victims from the Casualty Collection Point (CCP) to Triage A where paramedics determined death.[2] To prevent further transport of deceased victims, the Special Weapons and Tactics' (SWAT) medic wrapped tape around their wrists. No other deceased victims were moved from the scene.

The authors[1] place the CCP on the other side of the building from the conference room. Figure 2 shows Triage A, not the CCP. The CCP was directly outside the conference room adjacent to Parkcenter Dr. South.[2] This facilitated movement of victims from the conference room to the CCP, and then into law enforcement vehicles to Triage A.

The authors[1] state SWAT medics did not operate in the medical branch and that duplication of medical resources occurred. After the conference room was cleared, the SWAT medic separated from the SWAT operation to provide patient care.[2] Convergent POs and patrol LEOs initiated casualty treatment in the conference room and at the CCP under the direction of the SWAT medic. We found no law enforcement medical assets were dispatched. The fire department was the primary medical first responder and handled triage, treatment, and medical transport for victims.[3] The Air Rescue (AR) helicopter responded as a law enforcement asset to a crime in progress. (The county communications center must dispatch all EMS aircraft).[2] Two medics, SWAT and AR, rendered organized medical care in support of each other without duplication of efforts. Five minutes after LEOs first entered the conference room, LEOs and POs began evacuating victims to the CCP.[2]

The authors[1] state a designated law enforcement medical director (LEMC) would streamline processes and enable the SWAT medic to focus on medical aid in the hot zone. In this incident, the early arrival of a SWAT medic was incidental to a nearby training exercise. The SWAT medic became the acting LEMC operating at the point of contact and did focus solely on providing medical care within the hot zone. He accomplished this with volunteer LEOs and POs who received rapid instruction for immediate medical aid and methods for patient carry to the CCP.[2] These actions gave the SWAT medic time for the primary triage. The efforts of the AR medic enhanced patient treatment and assisted in secondary triage.[2] In this environment characterized by volatility, uncertainty, complexity, ambiguity, and threat (VUCA-T),[4] actions at the point of contact were more effective than streamlined processes. The first patient arrived at Triage A approximately 18 minutes after clearance of the room.[3]

The authors[1] describe "delay in treating patients." The deceased suffered non-survivable injuries from massive blood loss and extreme respiratory system or head injuries.[2] The majority of gunshot wounds were in the head, chest, and abdomen of which none were amenable to citizen first aid. Environment and time are independent comorbidities, with nonlinear contributions to death, converting a "potentially survivable injury" into a non-survivable injury.[2]

A public safety incident appears disorganized and inefficient from a distance, yet it is a response to local, immediately available, imperfect information not detectable from farther away. This results in improvisation and nonlinear self-organization to local information.[2,5] Top-down and

bottom-up sensemaking,[6] using cognitive and affective mental processes,[7] gives direction.

Public safety personnel engage novel, unstructured problems in an unstructured environment. We urge caution when translating operational methods and thinking from the stable hospital environment to situations characterized by uncertainty, time-compression, and threat in a VUCA-T environment.[4]

There is more to an active shooter incident than medical care and law enforcement activity. We identified elements of high reliability organizing; interactive, real-time risk assessment and management; leadership *in extremis* with leader-leader constructs; proactive critical incident stress management; visual communication with heedful interrelating; and self-organizing improvisation.[2]

Victim extraction began five minutes after LEO entry, completed in 18 minutes. Within 18 minutes the fire department triaged, treated, and initiated transport for 14 patients, none of whom died. Our analysis identified different lessons learned.[2]

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Serum Lactate and Mortality in Emergency Department Patients with Cancer

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Introduction: Patients with malignancy represent a particular challenge for the emergency department (ED) given their higher acuity, longer ED length of stay, and higher admission rate. It is unknown if patients with malignancies and hyperlactatemia are at increased risk of mortality. If serum lactic acid could improve detection of at-risk patients with cancer, it would be useful in risk stratification. There is also little evidence that "alarm" values of serum lactate (such as >/=4 mmol/L) are appropriate for the population of patients with cancer.

Methods: This was a continuous retrospective cohort study of approximately two years (2012-2014) at a single, tertiary hospital ED; 5,440 patients had serum lactic acid measurements performed in the ED. Of the 5,440 patients in whom lactate was drawn, 1,837 were cancer patients, and 3,603 were non-cancer patients. Cumulative unadjusted mortality (determined by hospital records and an external death tracking system) was recorded at one day, three days, seven days, and 30 days. We used logistic regression to examine the risk of mortality 30 days after the ED visit after adjusting for confounders.

Results: In an unadjusted analysis, we found no statistically significant difference in the mortality of cancer vs. non-cancer patients at one day and three days. Significant differences in mortality were found at seven days (at lactate levels of <2 and 4+) and at 30 days (at all lactate levels) based on cancer status. After adjusting for age, gender, and acuity level, 30-day mortality rates were significantly higher at all levels of lactic acid (<2, 2-4, 4+) for patients with malignancy.

Conclusion: When compared with non-cancer patients, cancer patients with elevated ED lactic acid levels had an increased risk of mortality at virtually all levels and time intervals we measured, although these differences only reached statistical significance in later time intervals (Day 7 and Day 30). Our results suggest that previous work in which lactate "cutoffs" are used to risk-stratify patients with respect to outcomes may be insufficiently sensitive for patients with cancer. Relatively low serum lactate levels may serve as a marker for serious illness in oncologic patients who present to the ED. [West J Emerg Med. 2018;19(5)827–833.]

INTRODUCTION

Cancer is a growing healthcare problem, and it is the second leading cause of death in the United States (U.S.).[1] There were 1,665,540 new cancer cases and 585,720 cancer deaths in the U.S. in 2014,[2] and this number is expected to rise by 70% over the next 20 years.[3] Importantly, cancer diagnoses tend to increase exponentially with age, and the fastest growing segment of the U.S. population is adults over age 65.[4] Cancer, therefore, is poised to play an increasingly

prominent role in emergency medicine (EM).

Previous work suggests that emergency department (ED) serum lactate has an association with mortality in a broad array of ED patients including those with suspected sepsis or meeting sepsis criteria, hemorrhagic shock, focal ischemic conditions, metabolic derangement, congestive heart failure, and low-flow states.[5-11] We sought to determine the role of lactate in predicting mortality specifically in ED patients with cancer. Vital signs and biological markers are typically used to risk stratify acutely ill patients in the ED. Patients with malignancies may have subtle presentations of acute disease, owing either to comorbid conditions or an immunosuppressed state from chemotherapy. If serum lactate could improve detection of at-risk patients with cancer, it would be useful in risk stratification. Furthermore, there is little evidence that "alarm" values of serum lactate (such as >/= 4 millimoles per liter [mmol/L]) are appropriate for the population of patients with cancer.

We report the association of serum lactate and unadjusted mortality at one, three, seven, and 30 days on patients with and without malignancy, and adjusted mortality (based on age, sex, and Emergency Severity Index [ESI] score) at 30 days. We analyzed these data in categorical fashion using lactate intervals of <2 mmol/L (normal), 2 to <4 mmol/L, or >\= 4 mmol/L.

Population Health Research Capsule

What do we already know about this issue?
Previous work suggests that emergency department (ED) serum lactate has an association with mortality in a broad array of ED patients but has not been well studied in cancer patients.

What was the research question?
What is the role of lactate in predicting mortality specifically in ED patients with cancer?

What was the major finding of the study?
Cancer patients with elevated ED lactic acid levels had an increased risk of mortality at day 7 and day 30.

How does this improve population health?
It alerts clinicians to the fact that relatively low serum lactate levels may serve as a marker for serious illness in oncologic patients who present to the ED.

MATERIALS AND METHODS

This was a continuous, retrospective cohort study of all ED visits from December 1, 2012, to August 31, 2014. The Mayo Clinic Arizona ED is a single, tertiary, teaching hospital located in Phoenix, Arizona. During the study period, annual ED volume was approximately 28,000 with substantial seasonal variation. The ED is staffed year-round by board-certified emergency physicians. The admission rate during the study period was approximately 30%. The Mayo Clinic institutional review board process approved this study and waived the requirement of informed consent.

All visits during the study period in which a serum lactate was drawn in the ED prior to patient disposition were eligible for analysis. We did not include admitted patients whose first serum lactate was drawn after admission (even if that blood draw occurred in the ED) or patients who did not have a serum lactate drawn. The decision to order a serum lactate was left to the discretion of the treating physician. At our facility, a serum lactate is typically ordered in patients with suspected sepsis or meeting sepsis criteria, hemorrhagic shock, focal ischemic conditions, metabolic derangement, and other low-flow states. During the study period, blood was collected by laboratory phlebotomists soon after ordering and immediately taken to the laboratory for quantitative analysis; the use of phlebotomists (vs. nurses) to draw blood samples did not produce significant delays in sample procurement. There were no changes during the study period in how laboratory personnel collected and processed samples.

From our electronic medical record (EMR) (Cerner®, Kansas City, MO), we extracted patient age, presence of cancer, race, acuity, and gender; ESI score; and serum lactate level. We defined age in integral years on the date of registration. The presence of cancer was determined by a field present on the past medical history portion of the nursing ED treatment record. This record was completed on each patient upon presentation to the ED. We defined gender and race based on patient declaration. We assessed race as white vs. non-white; we aggregated non-white responses due to the low number of non-white patients in our sample. We assessed ESI score in binary (1/2 vs. 3/4/5) fashion. Serum lactate was measured in mmol/L using a Roche Cobas 6000 serum-based assay (Indianapolis, IN) located in our central laboratory. We did not use point-of-care lactate testing during the study period. One author (RB) was responsible for all data abstraction from the EMR.

Cumulative mortality (determined by hospital records and an external death tracking system) was recorded at one day, three days, seven days, and 30 days.

We divided the cohort into patients who had active cancer or a history of cancer vs. those who did not. The primary outcome was patient mortality, and the primary comparison was cancer patients vs. non-cancer patients. Cumulative mortality was noted at one, three, seven, and 30 days. We

report unadjusted mortality by lactate level at one, three, seven, and 30 days, as well as adjusted mortality (adjusted via multivariable logistic regression in a model that included age, gender, ESI score, and race) at 30 days.

The limited number of events at one, three, and seven days precluded a meaningful regression analysis in these groups. The descriptive statistics consist of frequencies and proportions for categorical variables, and mean and standard deviation for continuous variables. We used the Pearson chi-square to test for univariate associations between categorical values and the Wilcoxon rank-sum for univariate comparisons of numerical variables between two groups where appropriate (Table 1). Statistical Analysis Software (SAS) (Version 9.4, SAS Institute, Cary, NC) was used for all analysis.

RESULTS

There were 47,136 ED visits during the study period; 5,440 had a serum lactate measurement performed in the ED and were eligible for analysis. Of the 5,440 patients in whom lactate was drawn, 1,837 were cancer patients, and 3,603 were non-cancer patients. The baseline characteristics of the 5,440 study visits are shown in Table 1.

Emergency Severity Index

Patients with cancer were more likely to be older, male, and have a more acute ED presentation (as evidenced by lower ESI scores). Unadjusted mortality results are presented in Table 2.

The information from Table 2 is represented graphically in Figure. When stratified by lactate level (<2 mmol/L, 2 to <4 mmol/L and >/= 4 mmol/L), there were no statistically significant differences in mortality at one day or three days at any level; differences in the <2 mmol/L and the >/= 4 mmol/L levels, but not in the 2 to <4 mmol/L level at seven days; and differences at every lactate level at 30 days. In all cases in which there were differences, mortality was higher in the cancer group.

Adjusted mortality results at 30 days are presented in Table 3. In the adjusted 30-day analysis, patients with cancer had a greater mortality than patients without cancer at every lactate level. A low number of mortality events precluded a determination of adjusted mortality results at the one-, three- or seven-day time points.

DISCUSSION

Serum lactate is a useful biomarker in EM. Elevations in lactate correlate with mortality in a broad array of ED patients, including those with suspected sepsis or meeting sepsis criteria, hemorrhagic shock, focal ischemic conditions, metabolic derangement, congestive heart failure, and low-flow states.[5-11] Specifically, a serum lactate ≥4 has been shown to be associated with significant mortality, regardless of the etiology of elevation.[12-14]

Patients with cancer are unique in many ways, in that they may be malnourished, chronically ill, and immunosuppressed. It is not surprising, therefore, that in-hospital septic cancer patients have a higher mortality, longer hospital length of stay, and higher total costs than septic non-cancer patients;[15,16] and they also have a higher mortality from invasive pneumococcal infections.[17] Our findings of elevated lactate levels correlating with mortality in patients with and without malignancy are consistent with previous work in this area. Of note, however,

Table 1. Patient information.

	Cancer n=1837	No cancer n=3603	Difference	95% CI of difference	P value
Age (years)	69.8(14.0)	62.4(19.2)	7.4	6.5-8.3	< 0.01
Gender					< 0.01
Female	845 (46.0%)	1933 (53.6%)			
Male	992 (54.0%)	1670 (46.4%)	7.7%	5.7% to 9.6%	
Race					< 0.01
Caucasian	1737 (94.6%)	3315 (92.0%)			
Other	100 (5.4%)	288 (8.0%)	-2.5%	-3.5% to -1.6%	
ESI					< 0.01
1 or 2	655 (35.9%)	1101 (30.6%)			
3, 4, or 5	1172 (64.1%)	2502 (69.4%)	-5.3%	-7.2% to -3.4%	
Lactate (mmol/L)					0.45
0-2	1337 (72.8%)	2690 (74.4%)	-1.6%	-4.1 to 0.8%	
2-4	421 (22.9%)	776 (21.5%)	1.4%	-0.1 to 3.7%	
4+	79 (4.2%)	147 (4.1%)	0.1%	-0.1% to 1.3%	

CI, confidence interval; *ESI*, Emergency Severity Index.

Table 2. Unadjusted mortality by cancer and lactate levels. Data presented as absolute mortality (mortality rate).

Lactate	Cancer n=1837	No cancer n=3603	Difference	95% CI of difference
1 day				
<2	0(0%)	1(0.04%)	-0.04%	NA
2-4	4(0.95%)	4(0.52%)	0.48%	-0.62% to 1.49%
4+	6(7.59%)	10(6.80%)	0.79%	-6.33% to 7.91%
3 days				
<2	10(0.75%)	13(0.49%)	0.26%	-0.27% to 0.79%
2-4	12(2.85%)	9(1.16%)	1.69%	-0.06% to 3.45%
4+	11(13.92%)	16(10.88%)	3.04%	-6.10% to 12.18%
7 days				
<2	30(2.24%)	30(1.12%)	1.12%	0.24% to 2.01%
2-4	22(5.23%)	22(2.84%)	2.39%	-0.03% to 4.82%
4+	22(27.85%)	22(14.97%)	12.88%	1.44% to 24.33%
30 days				
<2*	114(8.53%)*	80(2.99%)*	5.54%*	3.91% to 7.17%*
2-4	54(12.83%)	53(6.83%)	6.00%	2.34% to 9.65%
4+*	31(39.24%)*	32(21.77%)*	17.47%*	4.81% to 30.1%*

CI, confidence interval.
*Statistically significant differences.

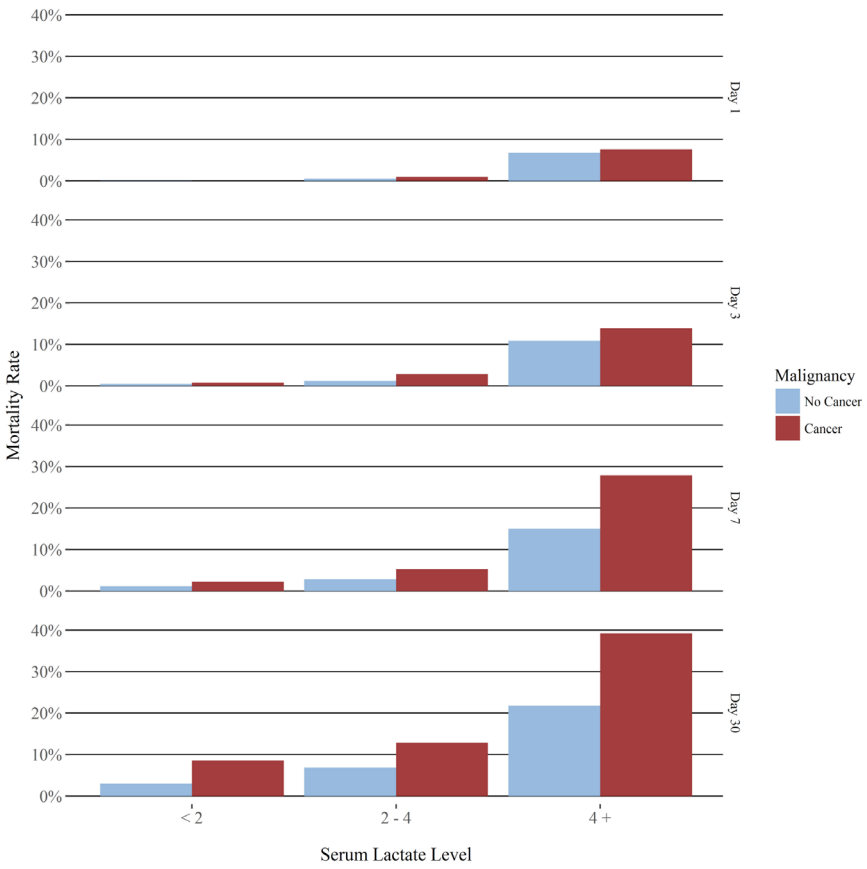

Figure. Mortality rate at day 1, 7, 30: cancer vs. no cancer.

Table 3. Adjusted mortality at 30 days. Mortality rates after adjusting for age, gender, and acuity level (ESI).

Lactate	Cancer n=1837	No cancer n=3603	Difference	95% CI of difference
1 day				
<2*	7.31%*	3.19%*	4.12%*	2.19%-4.85%*
2-4*	9.25%*	5.73%*	3.52%*	0.57%-5.49%*
4+*	27.4%*	16.1%*	11.3%*	4.06%-29.66%*

CI, confidence interval; *ESI*, Emergency Severity Index.
*Statistically significant differences.

many of the previous investigations of lactate and mortality have specifically focused on infection.[8,13,14,18-26] Our work does not attempt to categorize patients with respect to the reason why a lactate was determined, but rather seeks to understand the degree to which serum lactate can be used as a prognostic tool in patients with cancer.

In an unadjusted analysis, we found a consistent increase in mortality at almost all lactate levels in patients with cancer as compared to patients without cancer; however, at the earlier time points (day 1 and day 3) these findings were not statistically significant. By day 7, there was a statistically significant difference in mortality at two lactate levels (0-2 and >/= 4) that did not reach statistical significance for the lactate level of 2-4. At 30 days, there was a statistically significant difference at all levels. An analysis controlling for age, gender, and acuity confirmed the statistically significant difference in mortality at 30 days.

Our work builds upon that of others to establish that patients with malignancy represent a high-risk group in the ED. Oncology patients who present to the ED with sepsis and bacteremia have a higher 72-hour mortality, higher in-hospital mortality, and higher 28-day mortality than non-cancer patients.[27] In addition to the burden of chronic illness, cancer patients are more likely to be receiving immunosuppressive chemotherapy, which may predispose cancer patients to greater morbidity and mortality. This may be particularly true in disease states (such as infection or sepsis) that would predispose a physician to obtain a serum lactate level.

Our results suggest that previous work in which lactate "cutoffs" are used to risk-stratify patients with respect to outcomes may be insufficiently sensitive for patients with cancer. For example, at 30 days the unadjusted mortality rate of cancer patients with a lactate of 2-4 was 12.83%, almost double the 6.83% mortality of non-cancer patients with a level of 2-4. At 30 days the unadjusted mortality of patients with a lactate of four or greater in cancer vs. non-cancer was 39.24% vs. 21.77%. These findings also were significant at 30 days after adjusting for age, gender, and acuity. The 30-day adjusted mortality rates of cancer patients at the 2-4 and 4+ lactic acid levels were almost double that of non-cancer patients (9.25% vs. 5.73% and 27.4% and 16.1%, respectively).

We note that in the unique population of cancer patients, the prognostic value of serum lactate levels may serve another purpose. It may help guide end-of-life decisions in patients who are terminally ill. Such decisions are often difficult, and are particularly difficult to make in a fast-paced environment such as the ED. While the extrapolation of our work for this purpose is limited by the fact that we did not stratify cancer patients into those who were near end of life vs. those who were not, our findings may be of use in such cases, or at least provide a framework for further research and discussion in this area.

We found elevated rates of mortality at essentially every lactate level and time interval in cancer patients as compared with non-cancer patients, although many of those differences did not reach statistical significance in the earlier timeframes. While we acknowledge that there are limitations in our methodology, we nonetheless believe that our work suggests that relatively low serum lactate levels may serve as a marker for serious illness in oncologic patients who present to the ED. This may require a shift in clinical mindset, as many clinicians typically consider an "alarm" value of lactic acid to be at or above four. Since even the adjusted 30-day mortality of cancer patients nearly doubles at the 2-4 lactic acid level and then almost doubles again at the 4+ level, clinicians may need to pay special attention to this especially vulnerable population of cancer patients in the 2-4 lactic acid level range. Further prospective research is needed.

LIMITATIONS

Our data were from a single site at which the percentage of ED visits for patients with cancer (~20%) is quite likely higher than that of most EDs. Both of these factors limited generalizability. Additionally, we obtained mortality data from an internal database and external death tracking system, but did not attempt to contact patients (such as by phone); thus, we may have failed to identify deaths that occurred but were not recorded in either of our databases. We had no reason to believe, however, that missed events would have occurred in one group more than another.

We treated cancer categorically. We did not differentiate

patients by type of malignancy, did not determine if patients in the cancer group had an active malignancy or simply a history of cancer, and did not record the presence or absence of active chemotherapy or radiation. We believe that our decision to view cancer patients in the aggregate allowed for a high-level analysis of this group, but we concede that there are myriad details regarding lactate levels in each of the abovementioned subgroups that we cannot know.

We lack data necessary to characterize our findings of lactic acidosis as Type A (due to hypoperfusion) or Type B (related to mitochondrial dysfunction) or their relation to the Warburg effect. These limitations are particularly important given our focus on cancer patients, as Type B lactic acidosis is a rare, often-fatal complication in some patients with lymphoma, leukemia, and solid malignancies. In the Warburg effect, cancer cells produce additional energy through increased oxygen-dependent glycolysis followed by lactic acid fermentation with secretion of lactate.

We analyzed only mortality. There may have been significant differences in morbidity between the two groups (such as admission to a monitored bed, endotracheal intubation, or need for invasive monitoring), but we did not have data to ascertain this. And because our data are retrospective, we were able to determine correlation but not causation. While our data showed a strong correlation between patients with cancer and lactic acid elevation, a prospective trial would suggest causation.

Our relatively low event rate at earlier (one-day and three-day) time points limits our ability to draw conclusions in those timeframes. The fact that the higher mortality seen in cancer patients vs. non-cancer patients at almost every lactate level did not reach statistical significance may have been due to a relatively small sample size, not necessarily a lack of effect.

Our data suffer significantly from selection bias. Emergency physicians ordered a serum lactate at their discretion, without set criteria. For example, approximately 34% of our lactate samples were drawn in the 20% of our ED visits made by patients with cancer; this may have reflected the fact that patients with cancer were more systematically ill, or may have reflected an age-related bias in ordering lactate levels. We did not attempt to ascertain the clinical reasoning behind the decision to order a serum lactate; anecdotally, it appeared that providers ordered serum lactate preferentially in infected patients or those who were seriously ill. We have no reason to believe, however, that this pattern of ordering lactate is different to that of other EDs, or that ordering behavior was different in cancer vs. non-cancer patients.

As we lacked a robust mechanism to clearly delineate ED visits that were or were not related to other ED visits for the same patient, we treated each ED visit as an independent event. This is a limitation, as one ED visit may affect another, particularly if the visits are temporally proximate. Finally, our data may not adequately control for severity of illness. Although we incorporated ESI scores into our model, ESI may not fully reflect and differentiate patients with respect to illness severity.

CONCLUSION

In summary, cancer patients with elevated ED lactic acid levels had an increased risk of mortality at virtually all lactate levels and time intervals that we measured, although these differences only reached statistical significance in later time intervals (day 7 and day 30). These results suggest that previous work in which lactate "cutoffs" were used to risk-stratify patients with respect to outcomes may be insufficiently sensitive for patients with cancer. Relatively low serum lactate levels may serve as a marker for serious illness in oncologic patients who present to the ED.

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Left Ventricular Assist Device Management in the Emergency Department

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The prevalence of patients living with a left ventricular assist device (LVAD) is rapidly increasing due to improvements in pump technology, limiting the adverse event profile, and to expanding device indications. To date, over 22,000 patients have been implanted with LVADs either as destination therapy or as a bridge to transplant. It is critical for emergency physicians to be knowledgeable of current ventricular assist devices (VAD), and to be able to troubleshoot associated complications and optimally treat patients with emergent pathology. Special consideration must be taken when managing patients with VADs including device inspection, alarm interpretation, and blood pressure measurement. The emergency physician should be prepared to evaluate these patients for cerebral vascular accidents, gastrointestinal bleeds, pump failure or thrombosis, right ventricular failure, and VAD driveline infections. Early communication with the VAD team and appropriate consultants is essential for emergent care for patients with VADs. [West J Emerg Med. 2018;19(5)834–841.]

INTRODUCTION

Heart failure (HF) produces a significant disease burden in the United States, with over 5.1 million Americans suffering from HF and over $32 billion expended annually. Although survival from HF has improved, the mortality rate at five years is 50%.[1,2] Ventricular assist devices (VAD) have improved survival in patients with advanced HF.[3] Over 22,000 patients with advanced HF have received VADs in the last decade, and implantation rates are expected to increase with newer generation devices.[3] VADs may be used as "destination" (e.g. permanent) therapy or as a "bridge to transplant" (BTT). Patients implanted as "destination therapy" will remain on the VAD for the rest of their lives. BTT patients will remain on their VADs until they undergo heart transplantation.

Many patients with VADs are well informed about their devices and possess adequate VAD self-management skills. This includes contact information for VAD centers and instructions on obtaining assistance when needed. In addition, VAD patients are generally accompanied by a VAD-trained caregiver (e.g. family member). Despite precautionary measures, including close outpatient follow-up and detailed instructions on the device, the incidence of VAD patients presenting to the emergency department (ED) will likely increase due to rising rates of VAD implantation. Thus, emergency physicians must be proficient with the diagnoses and treatment of VAD-related emergencies and general management of VAD patients. Optimal treatment requires understanding of the associated anatomy and changes in cardiovascular physiology associated with VADs, and knowledge of the device itself. This article provides emergency physicians with an overview of the current U.S. Food and Drug Administration (FDA)-approved assist devices and provides a framework for patient assessment, including

common VAD-related complications, device troubleshooting, and the management of the unstable VAD patient.

Overview of Current Left Ventricular Assist Devices (LVAD) and VAD Components

LVADs are surgically implanted into the apex of the left ventricle of the heart (inflow cannula) and are connected to the aorta via an outflow cannula providing circulatory support to the patient. A driveline passes from the device through the skin, connecting to a system controller that in turn is connected to external power. While the first generation VADs were pulsatile, all current devices are continuous flow, which have improved survival and lowered rates of device failure.[4] This paper will focus on the second- and third-generation continuous-flow VADs currently approved by the FDA, as very few patients still have first-generation VADs.

The HeartMate II™ (HMII), the HeartMate III™ (HMIII), and the HeartWare® (also called HVAD) are the three FDA-approved assist devices. The characteristics of the various pumps are highlighted in the table. In the case of an obtunded or altered patient, this table provides a reference to distinguish devices and information to relay over the phone to the VAD team or implanting hospital.

Notable VAD components include the driveline, controller, and battery pack.[5] The driveline is tunneled from the device to the skin and exits through the abdominal wall. It forms the connection between the surgically implanted VAD, which is located in the thoracic cavity (HVAD, HMIII) or intra-abdominal cavity (HMII), and the external controller. The controller serves to convey pump function parameters and alarms as well as provide a medium to adjust the device settings. Finally, an external, replaceable, and rechargeable battery pack powers the device.

Initial Approach and Emergency Department Management

Evaluation, management, and troubleshooting for patients with a VAD represent a unique clinical challenge as the presence of a mechanical support device changes native cardiovascular physiology. The evaluation of the stable VAD patient is similar to other patients, and should appropriately address the chief complaint. Because seemingly minor ailments can mask more significant pathology, the VAD team/coordinator should always be contacted. This will mobilize appropriate resources and facilitate communication. In hospitals with a cardiothoracic intensive care unit or VAD unit, evaluation of VAD patients (particularly vital signs) can often be facilitated through the services of the on-call VAD nurse/tech/physician. Given the complexity and increase in utilization of durable mechanical support devices, it is appropriate for all EDs and urgent care facilities to have a written protocol in place to provide optimal care for patients with VADs.

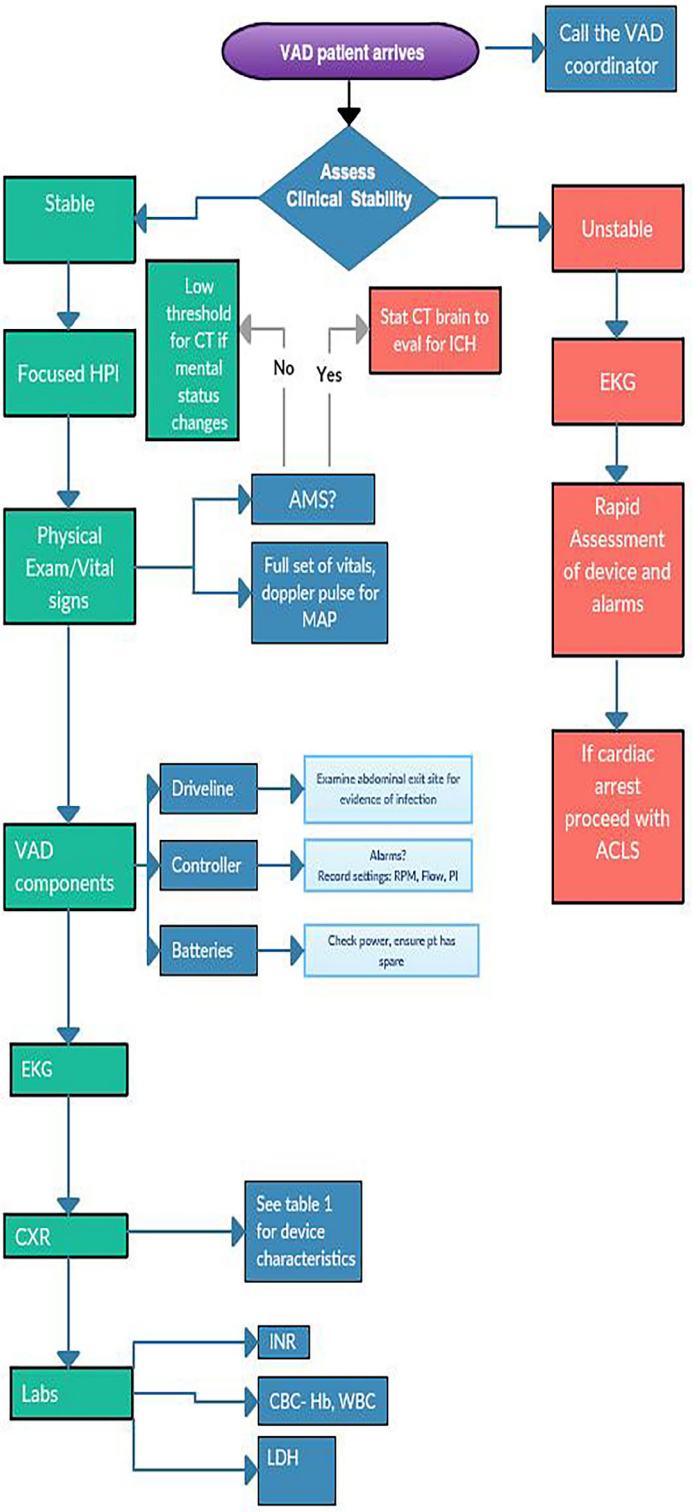


Figure 1. Emergency department approach to VAD patient. *VAD*, ventricular assist device; *HPI*, history of present illness; *CT*, computed tomography; *ICH*, intracranial hemorrhage; *EKG*, electrocardiography; *AMS*, altered mental status; *MAP*, mean arterial pressure; *RPM*, revolutions per minute; *PI*, pulsatility index; *PT*, patient; *ACLS*, advanced cardiovascular life support; *CXR*, chest x-ray; *CBC*, complete blood count; *Hb*, hemoglobin; *WBC*, white blood cell count; *LDH*, lactic acid dehydrogenase.

Primary ED evaluation begins with a full history, physical, and evaluation of the device (Figure 1). Heart rate is variable depending on the patient's intrinsic rate and rhythm. Many patients with VADs also have cardiac pacemakers or implantable cardioverter defibrillators (ICD) in place. The continuous-flow VAD device does not generate a pulse, but patients may have enough residual or recovered ventricular function to mount intrinsic pulsatile flow. Because the degree of pulsatility is variable among VAD patients, a standard approach to measuring a blood pressure is recommended (Figure 2). Given the continuous-flow pump characteristics, measuring the mean arterial pressure (MAP) is the most reliable measure of perfusion pressure and is standard of care for VAD patients. First, palpate the radial artery. If a pulse is present and consistent, obtain a blood pressure using a standard sphygmomanometer. If unable to obtain a blood pressure reading or if there is no pulse, use the Doppler method to obtain the MAP: Place a pencil Doppler probe over the brachial (or radial) artery and inflate a blood pressure cuff 30 millimeters of mercury (mmHg) past when the arterial pulse is no longer detected by Doppler. Slowly deflate the cuff until arterial flow is once again audible. The corresponding pressure is the MAP. If unable to reliably measure MAP using the Doppler method, consider an arterial line to evaluate perfusion. Due to continuous flow, the arterial line waveform will often remain flat or have minimal pulse pressure.

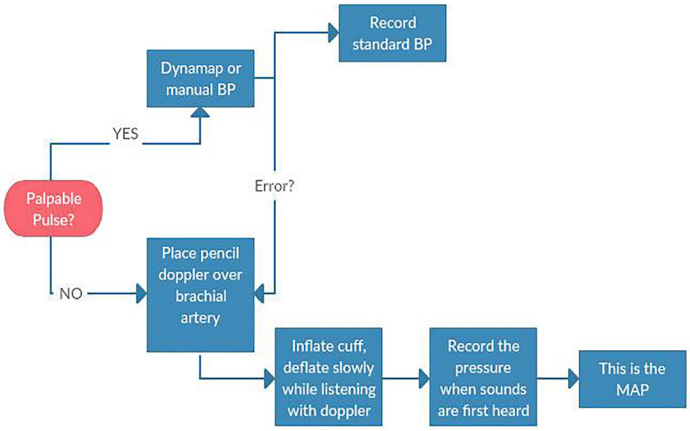


Figure 2. Obtaining a blood pressure (BP) for patient with Ventricular Assist Device.
MAP, mean arterial pressure.

Continuous-flow devices are very sensitive to afterload. Higher mean arterial blood pressures lead to increased afterload on the device and may lead to decreased pump flow. Clinically, this may manifest as worsening symptoms of HF. Increased afterload can also lead to subendocardial ischemia, which may potentiate ventricular arrhythmias. Adequate MAP control is essential in VAD patients; current guidelines recommend a target MAP <80 mmHg as long as symptomatic hypotension can be avoided.[4] The Interagency Registry for Mechanically Assisted Circulatory Support has defined a hypertension adverse event as MAP >110 mmHg for continuous-flow pumps.[6] Angiotensin-converting-enzyme inhibitors and beta blockers are the preferred agents for outpatient management of blood pressure.[2] Oral hydralazine is often a preferred antihypertensive agent for reducing blood pressure in the ED.

Physical Exam Including VAD Components

Evaluation of a stable VAD patient should include a focused physical exam and inspection of the major device components. Cardiac auscultation facilitates rapid evaluation of the device; in a properly functioning VAD, a "whirring" sound should be heard. By definition, patients with VADs should be relatively free of signs and symptoms of HF due to the presence of the mechanical support device. Thus, any signs of volume overload (e.g., elevated jugular venous pressure, presence of ascites or peripheral edema) may be indicative of subacute or chronic right ventricular failure, while shortness of breath, pulmonary edema, or hypotension are often present with acute device malfunction (e.g., pump thrombosis, cannula obstruction).

Distal perfusion should be assessed via capillary refill or simply by palpating the extremities. Because of an increased propensity for bleeding, the VAD patient should be evaluated for focal neurologic deficits, change in mental status, or presence of headache with a stat non-contrast computed tomography (CT) of the brain to rule out intracranial hemorrhage.[7]

The VAD driveline exit site will be covered with a sterile dressing and should be inspected carefully in a sterile fashion (mask, gloves) for any evidence of infection. The controller should be inspected and current settings and pump parameters recorded, including any alarms. Finally, ensure that the patient has brought along his or her back-up batteries and controller.

Relevant Studies and Workup

Initial workup in a VAD patient centers on the chief complaint similarly to non-VAD patients with significant cardiac disease. Electrocardiogram (ECG) findings in VAD patients may be nonspecific, but in addition to stigmata of end-stage heart failure they tend to include low limb lead voltage, ubiquitous electrical artifact, and QRS splintering.[8] Although the VAD performs the primary left ventricular pumping function, the native heart still contributes to cardiac output. The right ventricle must provide adequate preload to the left ventricle and subsequently fill the LVAD. Accordingly, although some VAD patients may have a higher tolerance for ventricular arrhythmias, if the patient becomes unstable or symptomatic, termination of the ventricular arrhythmia is paramount. In most cases, this will require electrical cardioversion, although intravenous (IV) doses of antiarrhythmic medications such as amiodarone can be given simultaneously

and may reduce recurrence.[9,10] One important etiology of ventricular arrhythmia in a VAD patient is a suction event, which occurs when the inflow cannula contacts and stimulates the ventricular septum.[11,12] This occurs as the result of decreased left ventricular (LV) filling (potentially from hypovolemia), myocardial recovery, or excessive pump speed. Treatment of suction events includes a fluid challenge and/or adjusting the device speed in conjunction with the VAD team.

The chest radiograph (CXR) is an important diagnostic tool for VAD patients. Direct visualization of VAD positioning as well as presence/absence of ICD aids the emergency physician in baseline evaluation. CXR can also help to identify the particular device if it is not otherwise apparent (Table).

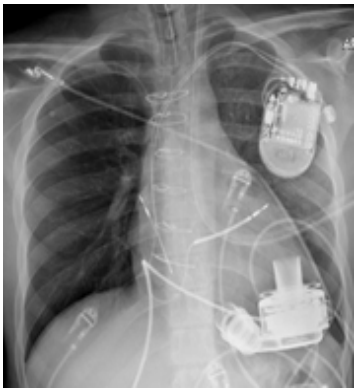
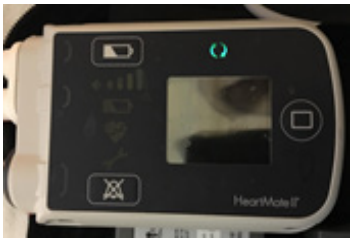
Laboratory workup is vital in the evaluation of VAD patients. All patients with VADs are anti-coagulated with vitamin K antagonists (e.g., warfarin) with an international normalized ratio (INR) goal of 2.0-3.0 unless contraindicated.[7] Troponin (troponin T, hsTnI), creatine kinase-MB, and myoglobin may be useful in evaluating VAD patients with chest pain or ECG changes. Elevated brain natriuretic peptide (BNP) (or NT-proBNP) may help identify right heart failure, or pump thrombosis/malfunction. As BNP is primarily an atrial responsive agent, it remains a useful marker for identifying volume overload in VAD patients and can guide therapy (e.g. diuresis). Finally, lactic acid dehydrogenase (LDH) is useful in screening for evidence of hemolysis. LDH levels 2.5 times upper limit of normal are suggestive of pump thrombosis in the appropriate clinical setting.[7]

Specific Complications in VAD Patients

Complications unique to VAD patients can be classified as "VAD-specific" and "VAD-associated." VAD-specific complications include 1) pump failure/malfunction, and 2) pump thrombus. These will be discussed in detail in the next section. VAD-associated complications include the following: 1) gastrointestinal (GI) bleeding, specifically related to the presence of arteriovenous malformations (AVM); 2) cerebrovascular accidents (CVA), either embolic or hemorrhagic in etiology; 3) VAD driveline infections, which may be localized to the percutaneous exit site or deeper within the pump or pump pocket;[13] and additionally, 4) right ventricular (RV) failure occurs in 15-20% of VAD patients and can lead to persistent HF symptoms and/or pump dysfunction (e.g. low flows).[14]

GI bleeding in VAD patients is multifactorial. Patients are maintained on lifelong therapeutic anticoagulation. Additionally,

Table. U.S. Food and Drug Administration-approved assist devices.

	HVAD (Heartware®)	HeartMate II™	HeartMate III™
CXR Image			
RPM	2500-3500	8800-10,000	4000-6000
Flow	4-6L/min	4-6L/min	4-6L/min
Controller			

CXR, chest radiograph; *RPM*, revolutions per minute; *HAVD*, heart assist ventricular device; *L*, liter..

continuous-flow VAD patients will usually develop acquired von Willebrand factor (vWF) disease.[14,15] The relatively higher shear stress brought on by non-physiologic circulation distorts the vWF multimers and leads to increased systemic cleavage and subsequent deficiency.[15] Furthermore, VAD patients are susceptible to GI vascular malformations secondary to the decreased pulse pressure from continuous flow. A retrospective analysis of patients implanted with a HMII device found that 43% had a major bleeding episode requiring blood transfusion, the majority of which were localized to the GI tract.[14] Management of GI bleeding often requires examination via endoscopy and colonoscopy for source control of AVM lesions. Blood transfusion should not be reflexive for the stable patient with GI bleeding, especially in BTT patients, as blood products are sensitizing and may reduce the chance of successful heart transplantation. In addition, robust transfusion of blood products will increase afterload and may lead to HF exacerbation. However, for larger GI bleeds or bleeding resulting in hemodynamic instability, blood transfusion is crucial. Because blood transfusion may lead to an increase in circulating antibodies and make it more difficult to find a donor match, transfuse with leukoreduced and irradiated blood products if available to decrease sensitization.[16] Multidisciplinary consultation with VAD and transplant teams is essential in the management of GI bleeding.

CVA, either embolic or hemorrhagic, is often a devastating VAD-associated complication. In addition to the pro-thrombotic milieu of a failing heart, the implantation of a mechanical assist device creates a nidus for the formation of clots. Development of atrial fibrillation after VAD implantation is common, and increases risk of embolic CVA.[17] Blood pressure control with a MAP <90, daily 81mg aspirin, and avoidance of supratherapeutic INR levels (>3.0) have shown to be effective at reducing stroke risk.[18] Data from the ADVANCE trial estimates prevalence of ischemic CVA at 6.8% and hemorrhagic CVA at 8.4%.[14,18] In the event of a CVA, early coordination with the VAD team and neurology/neurosurgery team is necessary to discuss reversal of anticoagulation and surgical options.

The driveline exit site provides a conduit for bacterial entry, making infection a relatively common VAD-associated complication affecting nearly 20% of patients within the first year of implantation.[19] Infections may be superficial and localized to the percutaneous exit site or deeper within the pump pocket or pump itself.[13] Blood cultures and driveline cultures should be obtained in any patient with suspected infection.[20] Staphylococci are the most commonly isolated organism, but pseudomonas and other gram-negative bacteria are common culprits as well.[21] Empiric antibiotics should be tailored to each individual patient. An abdominal CT is often helpful to evaluate for an associated fluid collection.[20] In the event of systemic spread, management of sepsis mirrors that of non-VAD patients: aggressive fluid resuscitation; early delivery of antimicrobials; and central/arterial line placement as indicated. Central catheterization can be achieved from any of the routine sites. Unless patients have residual RV failure, the risk of "volume overloading" a VAD patient is generally low. Vasopressors may be appropriate after adequate volume resuscitation.

While the VAD provides circulatory support to the failing LV, RV failure is a common problem, occurring in 15-20% of VAD patients.[22,23] Reduced preload to the LV leads to low VAD flows. "Low- flow alarms" on the VAD may be related to reduced preload from RV failure, but also may be secondary to hypovolemia or inflow cannula obstruction (less common, but a known complication). Laboratory markers of end organ dysfunction can aid in the diagnosis of RV failure. Elevated creatinine, liver transaminases, and the presence of lactic acidosis can indicate cardiogenic shock. If a shock state is suspected due to RV failure, inotropes (e.g. milrinone or dobutamine) should be used.

VAD Device: Alarms and Troubleshooting

The parameters reported on the HMII and HMIII controller are speed, power, flow, and pulsatility index (PI). The HVAD controller reports speed and power only; waveforms are reported on the system monitor reflective of pulsatility. Speed is the only parameter that is set, in revolutions per minute. Power is measured in watts and is indicative of the work being done by the device. Flow is calculated based on the power and speed, and is a result of both the device speed and the pressure gradient between the inflow and outflow cannula. PI is related to flow through the device and can be thought of as the contribution of the native LV. As the native LV contracts, there is a pressure wave sent through the pump. The magnitude of this pressure pulse is measured by the device, averaged over time, and reported as the PI.

The HVAD device uses waveforms on the system monitor to provide an estimate of intrinsic LV function. A larger delta between the peak flow and trough flow represents greater contribution from the native LV. Clinical situations with less LV filling (e.g. hypovolemia) result in low PI. The PI may also be low if pump support is increased; blood is preferentially pulled into the device circuit and intrinsic LV volume is reduced. When troubleshooting the device, it is important to consider all of the parameters. For example, suction events often present with low flow, low power, and low speed because the device senses the event and responds by slowing down to allow for increased LV filling. In the setting of high flow and high power, pump thrombosis must be considered, especially when accompanied by signs and symptoms of HF.

The VAD controller will display, or alarm, in the setting of device malfunction or organic pathology interfering with device functioning. Immediate consultation with the VAD team is necessary. Make sure to properly identify the VAD type. Patients should know this information, which is found on the controller. Devices can also be identified by radiograph appearance as discussed above. An overview of each device and the corresponding alarm types is presented below. This is

followed by a general outline of the approach to several common VAD alarms.

Heartmate II and III Alarms

The HM controller has two alarm icons: a battery and a heart. Most patients now have a pocket controller that has a user interface screen with further text information such as "Low Flow" or "Connect Driveline." The battery alarm icon will flash either yellow or red to indicate the remaining charge. The yellow alarm indicates 15 minutes of remaining battery power. The red alarm indicates only five minutes remaining. The flashing red heart alarm indicates low flow or pump stoppage. This necessitates emergent discussion with the VAD team. In the setting of a red heart alarm ensure adequate IV access and maintain hemodynamic stability with inotropes as needed. See the discussion of low-flow alarms below for further detail.

HVAD Alarms

The HVAD controller has three levels of alarms, categorized by level of priority: low (solid yellow), medium (flashing yellow), and high (red). There are two parts to the display, an alarm and an action. In general, the alarms are intuitive. For example, the "Low Battery" or "Critical Battery" alarm is accompanied by an action such as "Replace Battery 1." Even critical alarms such as "VAD Stopped" can have potentially easily reversible actions such as "Connect Driveline." Several of the more common alarms are addressed separately below.

Controller Fault

VAD patients and their caregivers are instructed to carry a back-up controller in case of controller malfunction. This alarm necessitates immediate consultation with the VAD team. Controller exchanges should only be performed by a trained professional.

Electrical Fault

The driveline contains six separate wires to maintain pump function. There is a level of redundancy but fracture of these wires will cause an electrical fault alarm, and complete severance can result in pump malfunction.[24] Consult with the VAD team immediately.

High Watts

Power spikes are often the result of pump thrombosis due to the increased energy requirement. The HMII and III devices - in the setting of obstructive thrombus - will display a flashing red alarm on the attached monitor; the HVAD monitor will read "Low flow – Call."

Low Flow

Evaluation of a VAD patient with a low-flow alarm starts with an assessment of overall clinical stability (Figure 3). In a hemodynamically unstable VAD patient, a low-flow alarm

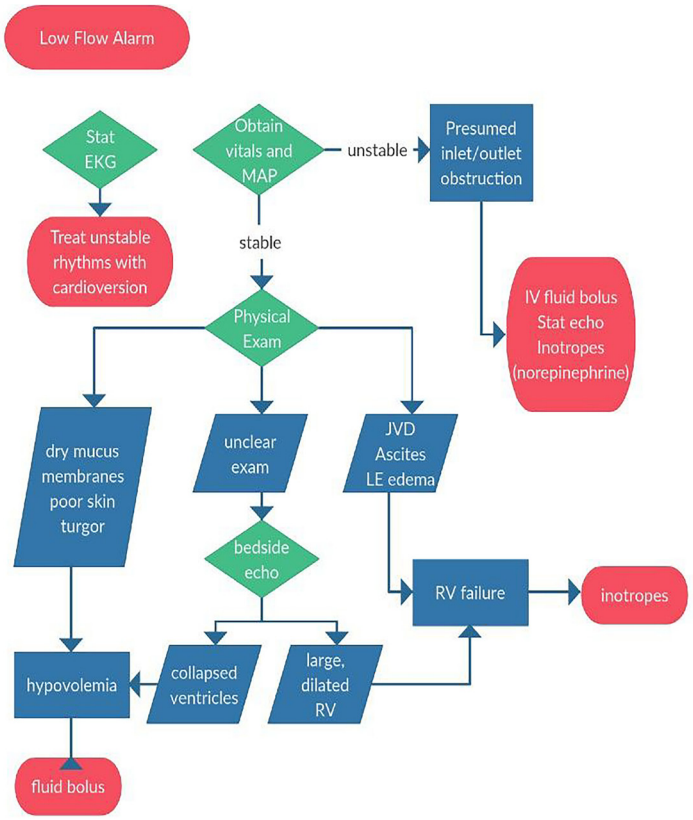


Figure 3. Approach to low flow alarms for patient with Ventricular Assist Device.
EKG, electrocardiography; *MAP*, mean arterial pressure; *IV*, intravenous; *JVD*, jugular vein distention; *LE*, leg; *RV*, right ventricle.

should be treated as pump malfunction until proven otherwise. With a severe inlet cannula obstruction from thrombus flow through the VAD will be negligible and cardiac output is dependent on intrinsic LV function, which is likely insufficient to maintain adequate end organ perfusion. In this scenario, emergency physicians should treat the patient as you would any patient in cardiogenic shock.

Place large-bore IVs, obtain a stat echocardiogram (begin with a bedside point-of-care ultrasound if a formal study is not immediately available), and start inotropic support. Be sure to check a stat ECG, as ventricular dysrhythmias can precipitate acute right heart failure and subsequent shock. If the patient is stable, the provider should focus on differentiating other causes of low-flow alarms: hypovolemia and RV failure. If the etiology remains unclear after physical examination, a point-of-care ultrasound can be useful.

An inferior vena cava (IVC) that collapses on inspiration suggests inadequate pre-load and should be addressed with volume resuscitation.[25] On the other hand, right heart failure or RV myocardial infarction may be detected by measuring the RV:LV ratio. On an apical four view, measure the widest diameter of each ventricle transversely from endocardium to endocardium. If the RV:LV ratio is greater than 0.6, this may

indicate RV failure or RV strain.[25] RV dysfunction can be suggested if the IVC decreases less than 50% with inspiration.[5]

Ultrasound can also be useful when troubleshooting other alarms. If both ventricles are large and dilated, this suggests pump failure, perhaps from thrombosis. Pump thrombosis is a true emergency and often requires surgical exchange of the device. Without pump exchange or transplant, pump thrombosis carries a 48% six-month mortality.[26] Alternatively, a small LV could represent a suction event and can be addressed with a volume challenge and a discussion with the LVAD team about turning down the device speed.

Management of the Unstable and Crashing Patient

When caring for an unresponsive or hemodynamically unstable VAD patient, one must emergently contact the VAD team while simultaneously stabilizing the patient. In a code, follow the conventional Advanced Cardiac Life Support algorithm including chest compressions, medications, and defibrillation as indicated. While there is a manufacturer warning regarding the risk of cannula dislodgment with manual chest compressions, the small body of available evidence suggests that this is rare.[27] Withholding cardiopulmonary resuscitation in this scenario is universally fatal. Chest compressions should be performed on a pulseless VAD patient in an attempt to perfuse vital organs, while troubleshooting the device and contacting the VAD team.

Pulse checks should include brachial artery Doppler for MAP and review of the VAD monitor for signs of mechanical failure as discussed above. Auscultate the heart to listen for the "whirring" sound of the device. If you cannot hear the device functioning, troubleshoot the controller, ensure adequate power supply, and check all device connections. If the patient is hypotensive and has low VAD flows, consider a quick bedside ultrasound to evaluate for hypovolemia vs. RV failure. If the patient is hypotensive with elevated VAD flows, consider pump thrombosis, and also sepsis (extreme afterload reduction from vasodilation leads to higher VAD flows). If you suspect device malfunction, advanced therapies such as extracorporeal membrane oxygenation should be considered, especially in younger patients who are heart transplant candidates without significant comorbidities.

Evaluation of VAD patients can be daunting, but focused clinical priorities – taken in the context of the implanted device – facilitate rapid and appropriate management of both stable and critically ill VAD patients. Regular review of available support sources and quick access to reference material can greatly improve the care of VAD patients in the ED. Given the evolving technology and increasing prevalence of VADs, the ED community would benefit from both VAD-specific training programs in residency training and continuing medical education curricula.

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A Risk Score to Predict Short-term Outcomes Following Emergency Department Discharge

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Introduction: The emergency department (ED) is an inherently high-risk setting. Risk scores can help practitioners understand the risk of ED patients for developing poor outcomes after discharge. Our objective was to develop two risk scores that predict either general inpatient admission or death/intensive care unit (ICU) admission within seven days of ED discharge.

Methods: We conducted a retrospective cohort study of patients age > 65 years using clinical data from a regional, integrated health system for years 2009-2010 to create risk scores to predict two outcomes, a general inpatient admission or death/ICU admission. We used logistic regression to predict the two outcomes based on age, body mass index, vital signs, Charlson comorbidity index (CCI), ED length of stay (LOS), and prior inpatient admission.

Results: Of 104,025 ED visit discharges, 4,638 (4.5%) experienced a general inpatient admission and 531 (0.5%) death or ICU admission within seven days of discharge. Risk factors with the greatest point value for either outcome were high CCI score and a prolonged ED LOS. The C-statistic was 0.68 and 0.76 for the two models.

Conclusion: Risk scores were successfully created for both outcomes from an integrated health system, inpatient admission or death/ICU admission. Patients who accrued the highest number of points and greatest risk present to the ED with a high number of comorbidities and require prolonged ED evaluations. [West J Emerg Med. 2018;19(5)842-848.]

INTRODUCTION

The emergency department (ED) is inherently a high-risk setting, and understanding outcomes following the ED visit is difficult. This is mainly due to the inability to track most patient visits after discharge. Knowledge of a risk score for negative outcomes following ED discharge and probabilities of those outcomes for adults discharged from the ED could help ED practitioners better manage patients as well as their discharge plan.

Risk scores have traditionally helped ED practitioners better understand the risks ED patients face when presenting with certain conditions and signs/symptoms.[1] The objective of this study was to conduct a retrospective cohort analysis and develop a risk score for adults

experiencing an inpatient admission or death/intensive care unit (ICU) placement within seven days of ED discharge.

Population Health Research Capsule

What do we already know about this issue?
We know that older white males are at greater risk for poor outcomes after emergency department (ED) discharge, a change in disposition from "admit" to "discharge", cognitive impairment, systolic blood pressure (SBP) < 120 mmHg, and pulse > 90 beats/min.

What was the research question?
This study developed a risk score for adults experiencing an admission or death/intensive care unit placement within 7 days of ED discharge.

What was the major finding of the study?
Patients at risk for either outcome were: age > 80, body mass index<18.5, SBP < 120 mmHg, pulse >100 bpm, high comorbidities, ED length of stay > 4 hrs, and prior admission.

How does this improve population health?
This information helps ED providers and hospital administrators better manage ED patients.

METHODS

Study Design

A multisite retrospective cohort study of ED visits was conducted following the Strengthening the Reporting of Observational studies in Epidemiology guidelines.[2] This study was approved by the institutional review boards of Kaiser Permanente Southern California and the University of California, Los Angeles.

Setting

We analyzed clinical data from Kaiser Permanente Southern California (KPSC), an integrated health system that provides comprehensive care to over 3.5 million members at 14 medical centers and 197 offices throughout Southern California. There were 13 health system EDs in operation during the study period. All members have very similar healthcare benefits, including coverage of emergency services both within and outside the health system. Members of the health plan are generally representative of the population of Southern California, which is a racially and socioeconomically diverse region.[3] Approximately 7% of members enroll through Medicaid and 10% through Medicare.

Selection of Participants

Patients were members of KPSC with at least one ED visit and discharge from January 1, 2009, to December 31, 2010. A patient had to be a member of the health plan at the time of the ED visit; however, no minimum enrollment history was required. Analyses were restricted to adults age ≥ 65 years, as these patients have a greater number of poor outcomes after discharge.[4,5] All patients in the study were discharged from the ED to home or a non-acute care facility such as a nursing home or rehabilitation facility. If patients had multiple ED visits, then only the first visit was included in the analysis.

We exluded patients who left the ED without being seen by a health provider. Patients transferred to observation status from the ED were also excluded, as encounters in this setting could resemble an inpatient admission. Patients receiving hospice care were also excluded, as the goal of this type of care is to provide palliative services rather than prolong life. In addition, patients who were transferred to and from other hospitals were excluded. The small number (<0.1%) of visit records that had potentially erroneous day and time entries resulting in either negative or excessively long ED lengths of stay (LOS) (>48 hours), were also excluded from the analysis.

Data Sources

The analyses used the Kaiser Permanente Epic-based electronic health record (EHR) (KP HealthConnect) for all variables. The EHR contains records of all member visits to health plan EDs. This system contains past history, mode of arrival, vital signs, staff notes, orders, diagnoses, and test results. Standardized data fields from ED visits provide time-stamps for patient registration, triage, assignment to provider, and disposition order (discharge to home, a care facility, or an inpatient bed). KP HealthConnect was also used to identify the *International Classification of Diseases* (ICD) diagnoses associated with the ED visit.

Risk Factors

The clinical variables were dichotomized a priori by members of the project team (GZG, MKG, SFG, CAS) based on clinical judgment and prior literature.[6-8] Rather than incorporating all vital signs, two vital signs were chosen for parsimony of the risk score.[9] For 96% of encounters, patients had at least a single vital sign recorded. For patients with visits with more than one measure for a given vital sign, the vital sign closest to discharge was chosen for the analysis. For extreme values of vital signs that were not compatible with life and most likely a coding error, the vital signs were coded as missing: systolic blood pressure (SBP) <50 or >300, heart rate (HR) < 25 or >225. In addition, as the team has shown ED LOS to be a possible risk factor for poor outcomes after discharge,[7] we included ED LOS in the model and defined it as the total time

a patient spent in the ED from the time they checked in to ED triage to the time they were discharged from the ED.

Outcome Measures

The primary outcome was an inpatient admission within seven days of discharge from the ED and the secondary outcome was ICU admission or death over the same time period. The seven-day period was chosen based on frequency results that indicated the highest percentage of admissions occurring within seven days of discharge and also because of its clinical relevance, implications for health policy decisions, and use in previous studies.[6,10,11] Information regarding admissions to non-KPSC hospitals was obtained through Kaiser billing data. Deaths were identified using vital statistics data from the California Vital Statistics files linked to Kaiser billing data.

Analysis

We treated each outcome in the same manner. All patient ED visits were identified over the two years and randomly divided into a derivation sample (75% data) and validation sample (25% data). First, each patient characteristic was assessed for associations with the outcomes in the derivation sample using a Pearson's chi square test. Then, we included statistically significant variables ($p < 0.1$) in the full logistic regression model for each outcome. To evaluate the accuracy of the final logistic regression models, the study team inspected receiver operating characteristic curves and calculated a C-statistic.[12]

To arrive at the risk score, the study team standardized all coefficient estimates of the model variables by dividing by the smallest variable coefficient. Then, a numeric score (point) was applied to each variable based on the result. All points were rounded to the nearest whole number. Predicted probabilities were calculated for each risk score.[13] To evaluate the calibration of the scoring system, the study team compared the predicted probability of a given score with the observed probability in both the derivation sample and the validation sample.

In the model for inpatient admission, the initial variables were age, gender, race/ethnicity, smoking, Emergency Severity Index, body mass index (BMI), vital signs of SBP and HR, CCI[14] (see Appendix for measures), ED LOS, ED visit in week prior, and inpatient admission in week prior the ED visit. Then, the study team omitted the variables not statistically significantly associated with the outcome (p-value >0.1) and arrived at a final model of age, BMI, vital signs of SBP and HR, CCI, ED LOS, and inpatient admission in week prior. For death or ICU admission, the same methodology was used, except that the final model included gender.

RESULTS

Characteristics of Study Subjects

As illustrated in the figure, during years 2009-2010, there were 1,552,594 visits among 922,005 patients to KPSC ED facilities. Excluded from the analyses were the following: visits from non-KPSC members; visits with missing gender or birthdate; ages lower than 65 years; patients in hospice care; transfers out of or into the ED; death in the ED; direct admission to an inpatient or observation bed from the ED;

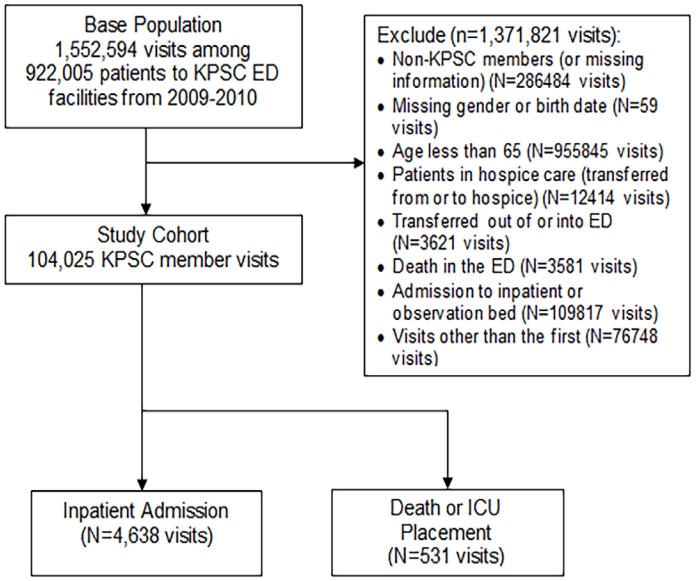

Figure. Outline of study cohort.

and visits other than the first visit. The study cohort contained 104,025 patient visits, of which 4.5% experienced an inpatient admission within seven days of ED discharge and 0.5 % either died or had an ICU admission.

Characteristics of the patients are presented in Table 1 by outcome. The mean age of patients who visited the ED and were discharged was 75.3 years (standard deviation [SD] 7.6), while the mean age for patients with an admission and death/ICU placement respectively was 76.8 years (SD 7.9) and 78.0 years (SD 8.3). The cohort contained slightly more visits by females (57%, n=59,517), as well as White (54%, n=56,052) and Hispanic (22%, n=22,963) patients.

Main Results

Table 2 presents the risk scores for the two outcomes based on the logistic regression models that were composed. The minimum score a patient could receive was 0 for ages 65-79 years, BMI $\geq$ 18.5, SBP > 120 mmHg, HR < 100 bpm, no Charlson comorbidities, ED LOS < 5 hours, and no inpatient admission the week prior. The maximum score was 30. In the model predicting death/ICU placement, the minimum score a patient could receive was 0 and the maximum 21. While risk factors were similar for the two outcomes, the scoring was slightly different.

Table 1. Characteristics of the study cohort.

Characteristics	Total N=104,025	Patients w/ admission N=4,638 (%)	P value*	Patients w/ death or ICU placement N=531 (%)	P value*
Age (mean, SD)	75.3 (7.6)	76.8 (7.9)	< 0.0001	78.0 (8.3)	< 0.0001
Age			< 0.0001		< 0.0001
65-79	73845	2975 (4.0%)		312 (0.4%)	
80+	30180	1663 (5.5%)		219 (0.7%)	
Gender			0.0008		< 0.0001
Male	44508	2095 (4.7%)		275 (0.6%)	
Female	59517	2543 (4.3%)		256 (0.4%)	
Race			< 0.0001		< 0.0001
White	56052	2791 (5.0%)		305 (0.5%)	
Black	14349	585 (4.1%)		73 (0.5%)	
Hispanic	22963	920 (4.0%)		101 (0.4%)	
Asian	8354	319 (3.8%)		47 (0.6%)	
Other	2307	23 (1.0%)		5 (0.2%)	
BMI			< 0.0001		< 0.0001
< 18.5	2077	163 (7.8%)		36 (1.7%)	
18.5+	101948	4475 (4.4%)		495 (0.5%)	
Charlson index			< 0.0001		< 0.0001
0	20335	449 (2.2%)		32 (0.2%)	
1	18176	515 (2.8%)		39 (0.2%)	
2	14901	554 (3.7%)		64 (0.4%)	
3	13369	590 (4.4%)		66 (0.5%)	
4	10276	533 (5.2%)		61 (0.6%)	
5	7621	448 (5.9%)		44 (0.6%)	
6	6441	441 (6.8%)		62 (1.0%)	
7+	12906	1108 (8.6%)		163 (1.3%)	
Vital signs					
SBP			< 0.0001		< 0.0001
≤ 120	19726	1224 (6.2%)		185 (0.9%)	
> 120	84299	3414 (4.0%)		346 (0.4%)	
HR			< 0.0001		< 0.0001
< 100	99760	4294 (4.3%)		458 (0.5%)	
≥ 100	4265	344 (8.1%)		73 (1.7%)	
Length of stay			< 0.0001		< 0.0001
0-4 hrs	78774	2734 (3.5%)		301 (0.4%)	
5-9 hrs	22967	1671 (7.3%)		193 (0.8%)	
10-24 hrs	2284	233 (10.2%)		37 (167%)	
Admission**			< 0.0001		< 0.0001
Y	2734	289 (10.6%)		44 (1.6%)	
N	101291	4349 (4.3%)		487 (0.5%)	

*P-value is generated using chi square analysis.
**Inpatient admission in past seven days.
ICU, intensive care unit; *SD*, standard deviation; *BMI*, body mass index; *SBP*, systolic blood pressure; *HR*, heart rate.

Table 2. Risk scores.

Score for inpatient admission		Score for death/ICU placement	
Risk factor	Score	Risk factor	Score
		Gender (Male)	1
Age 80+	1	Age 80+	1
BMI < 18.5	3	BMI < 18.5	3
SBP ≤ 120	2	SBP ≤ 120	2
Pulse ≥ 100	4	Pulse ≥ 100	3
Charlson score		Charlson score	
1	1	1	1
2	3	2	3
3	4	3	3
4	5	4	3
5	6	5	3
6	7	6	4
≥ 7	8	7+	5
Length of stay		Length of stay	
5-9 hrs	4	5-9 hrs	2
10-24 hrs	7	10-24 hrs	4
Inpatient 7 (Yes)	5	Inpatient 7 (Yes)	2

ICU, intensive care unit; *BMI*, body mass index; *SBP*, systolic blood pressure.

This table presents the risk scores for the two outcomes. For inpatient admission, the minimum score a patient could receive was 0 and the maximum 30. For the death/ICU placement, the minimum score was 0 and maximum score was 21.

To illustrate the application of the risk score, assume a very thin (with an estimated BMI of 16), 70-year-old male is seen in the ED with a SBP of 110 millimeters mercury (mmHg), HR of 110 beats per minute (bpm), has a history of diabetes and hypertension, stays in the ED for 12 hours, and has not been admitted in the prior seven days. The patient's risk factors would give him a score of 19 for inpatient admission and 16 for death/ICU placement.

To assess the validity of the risk scores, the predicted as well as the observed probabilities of seven-day admission and seven-day death/ICU placement were assessed (Appendix). Following the numerical predictions are plots and ROC curves for the two models. The C-statistic was 0.68 (for inpatient admission) and 0.76 (for death/ICU placement).

DISCUSSION

The study identified simple measures that can be used to calculate a risk score for developing a poor outcome after ED discharge. Patients with the greatest likelihood and highest score (score of 40) for developing an inpatient admission within seven days of discharge were age ≥ 80 years old (score of 1), BMI <18.5 (score of 3), SBP ≤120 mm Hg (score of 2), HR ≥ 100 bpm (score of 4), CCI score of 7 or greater (score of 8), ED LOS of 10-24 hours (score of 7), and an inpatient admission in the past seven days (score of 5). Patients at greatest risk for death or an ICU placement (score of 19) were male (score of 1), age ≥ 80 years old (score of 1), BMI <18.5 (score of 3), SBP ≤120 mmHg (Score of 2), HR ≥100 bpm (score of 3), CCI score of 7+ (Score of 5), and ED LOS of 10-24 hours (score of 4).

A low BMI (<18.5) led to greater risk for either outcome. Various studies have found that adults with higher BMIs, either overweight range (BMI ≥ 27.3) or obese (obese ≥ 30), often experience worse outcomes.[15-17] Yet, recent studies suggest that older adults with high BMIs have lower incidences of poor outcomes and that a low BMI could result in worse outcomes.[16,18] The current study results in older adults confirm these findings.

As can be clinically concerning, an SBP below or equal to 120 mmHg and a HR ≥ 100 bpm was associated with a poor outcome after discharge. While these vital signs are markers of hemodynamic instability, they should especially concern an emergency provider.

The study found a high CCI[14] (>4) to be the greatest predictor (with highest number of points) for both outcomes. Since its publication, the CCI has undergone numerous modifications to conform with recent changes in ICD codes.[19,20] This study indicates that although a specific complaint (i.e., chest pain) requires attention, so too does the past medical history.

While ED LOS, defined as the total time a patient remains in the ED from registration to discharge, can be a marker of ED crowding, it may capture something unrelated to ED crowding about the patient's complexity and risk for poor outcomes. There have been conflicting results regarding ED LOS and outcomes after discharge, which suggest that this is a complicated measure. A prior study that did not adjust for case-mix severity found a relationship between ED LOS and poor outcomes after discharge.[11] A study conducted by our project team that did adjust for case mix did not find an association with a poor outcome.[7] This study found that a prolonged ED LOS past four hours contributes to the risk score (5-9 hours, 2 points) and (10-24 hours, 4 points).

Admission in the past seven days was also found to contribute to developing a poor outcome after discharge (inpatient admission, 5 points; death/ICU placement, 2 points). Older adults have a higher rate of utilization of medical services[21] and prior studies have attempted to predict hospital utilization following an ED visit.[22-25] Yet there is insufficient evidence to understand whether patients with recent use of hospital services are at greater risk for a poor outcome after ED discharge. This study found that patients with an inpatient hospitalization within the seven days prior to the ED visit have a greater likelihood of a poor outcome after discharge.

Although this study identified patients who sustain poor outcomes after discharge, the study team did not determine whether the outcomes were preventable vs. inevitable. The study

team suggests that the risk score components identified compose either an electronic or mental flag for each provider seeing the patient. The provider could then ensure that the patient receives an evaluation prior to discharge or arrange for close follow-up following discharge. In addition, the rate of discharge of patients in this cohort was higher than national averages, which have been found to be in the 40% range.[26] This could be attributed to the lack of generalizability of the KPSC system as indicated below. It may also affect the rate of admission rates after discharge.

LIMITATIONS

The study has some limitations. First, as indicated above, the results may not generalize to other settings. KPSC members have access to follow-up care that patients in other settings may lack. KPSC hospitals may also have different disposition courses for patients seen in the ED as a cause of their follow-up options. Second, the admission outcome did not include observation stays. Given the increasing use of observation services, however, future studies should consider incorporating observation stays into admission outcomes. A third limitation inherent to the type of study performed was the lack of available clinical information regarding the chief complaint as well as the extent of management/treatment performed. Also, the reason why patients were admitted or died following discharge from the ED is unknown. Finally, the data used for this analysis are for years 2009-2010; while this is an extended time frame, patients have not changed since then.

CONCLUSION

This study determined two risk scores for developing a poor outcome following ED discharge in an integrated health system. Patients at greatest risk for either inpatient admission or death/ICU placement within seven days of ED discharge have the following characteristics: age $\geq$ 80, BMI <18.5, SBP $\leq$ 120 mmHg, HR $\geq$100 bpm, high number of comorbidities, ED LOS greater than four hours, and prior inpatient admission in seven days prior to the ED visit.

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Impact of a Pharmacist-Driven Prothrombin Complex Concentrate Protocol on Time to Administration in Patients with Warfarin-associated Intracranial Hemorrhage

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Introduction: Advancements in the treatment of warfarin-associated intracranial hemorrhage (ICH) include the use of four-factor prothrombin complex concentrate (4F-PCC), which has demonstrated more rapid reversal of the international normalized ratio (INR) when compared with fresh frozen plasma. A pharmacist-driven protocol for 4F-PCC was implemented within our institution, which allows for pharmacist approval of 4F-PCC in patients diagnosed with warfarin-associated ICH and an INR ≥2. The pharmacist is responsible for determining the appropriate dose of 4F-PCC, preparation, bedside delivery, and order entry into the electronic medical record. Prior to implementation of the new protocol, the blood bank was responsible for 4F-PCC approval, dosing, product preparation, and arranging delivery with emergency department (ED) staff. The purpose of this study was to evaluate the impact of a pharmacist-driven protocol on time to 4F-PCC administration in warfarin-associated ICH.

Methods: We performed a retrospective review of consecutive patients who received 4F-PCC in a single ED from September 2015 through February 2017. Patients ≥18 years old were eligible for inclusion based on three criteria: confirmed diagnosis of ICH; confirmed warfarin use; and INR ≥2. Secondary outcomes included dose of 4F-PCC in concordance with INR and weight-based dosing recommendations and hospital protocol, as well as concomitant intravenous vitamin K administration.

Results: A total of 48 patients met inclusion criteria for the study with 24 patients in each protocol group. The median time to administration of 4F-PCC in the pharmacist-driven protocol group was 35 minutes (interquartile range [IQR] [25-62]; range, 11-133) compared with 70 minutes (IQR [34-89]; range, 14-244) in the pre-protocol group (p=0.034). We saw no differences for appropriate 4F-PCC dosing based on INR and patient weight between the two groups.

Conclusion: Implementation of a pharmacist-driven protocol for 4F-PCC in the ED at our institution significantly reduced time to administration in patients presenting with warfarin-associated ICH. [West J Emerg Med.2018;19(5)849–854.]

INTRODUCTION

Warfarin is a commonly prescribed oral anticoagulant indicated for prevention and treatment of venous thromboembolism and prevention of ischemic stroke in atrial fibrillation.[1] One potential adverse effect of anticoagulation is bleeding, including intracranial hemorrhage (ICH).

Until recently, warfarin-associated ICH in the United States was typically treated with fresh frozen plasma (FFP) and intravenous (IV) vitamin K.[2] However, a four-factor prothrombin complex concentrate (4F-PCC) was approved by the U.S. Food and Drug Administration (FDA) in 2013 and has since become widely available for reversal of vitamin K antagonists, such as warfarin.[3-5] The reversal effects of 4F-PCC occur through exogenous replacement of inactivated coagulation factors II, VII, IX, and X. The use of 4F-PCC has demonstrated a more rapid reversal of anticoagulation and the international normalized ratio (INR) compared with FFP.[6,7]

Clinical practice guidelines recommend prompt correction of the INR as soon as possible in patients with warfarin-associated ICH.[3,4,8,9] Delays in administration of 4F-PCC for life-threatening bleeding have been recognized in several institutions, prompting review of hospital protocols. In a survey of United Kingdom (UK) stroke physicians, specific delays identified included time to hematology approval for 4F-PCC use, time to receive INR results, time to 4F-PCC delivery to the emergency department (ED), and time to infusion start.[10] Solutions implemented within one healthcare system, based on survey results, included expanding approval privileges to include stroke physicians, purchasing point-of-care INR devices for bedside results, and moving 4F-PCC to be stored in the ED.

A second UK hospital observed a large delay in 4F-PCC administration with a median time of approximately five hours from initial presentation and almost two hours after vitamin K administration.[11] Investigators also identified relocating 4F-PCC to the ED, incorporating point-of-care INR testing, and eliminating mandatory hematology consultations as future directions for reducing delays to administration. Bordeleau and colleagues evaluated administration delays of 4F-PCC prior to implementing a flowchart and new delivery process to improve communication between ED staff and the hospital blood bank.[12] Use of the flowchart decreased time to obtain the product from the blood bank, and reduced time to 4F-PCC administration by almost half.

At our institution, the 4F-PCC was initially stored in the blood bank. To obtain the agent, ED clinicians contacted the blood bank for approval, and then ordered it via handwritten, paper slips that were delivered to the blood bank by pneumatic tube. The product was then prepared and delivered to the clinical nurse for infusion. To optimize 4F-PCC management, a new system was implemented in 2016 that led to product storage in the ED automated-dispensing cabinet and a revised protocol involving pharmacists physically present in the ED. Clinicians requesting 4F-PCC for warfarin-associated ICH contacted the ED pharmacist for dosing, preparation, bedside delivery, and order entry into the electronic medical record (EMR). The use of 4F-PCC for indications other than warfarin-associated ICH required approval from the on-call hematologist.

Population Health Research Capsule

What do we already know about this issue?
Many institutions have guidelines and restrictions for using four-factor prothrombin complex concentrate (4F-PCC) and may also require designated services to grant approval for using the reversal agent.

What was the research question?
We looked to evaluate implementation of a pharmacist-driven protocol on time to administration of 4F-PCC in warfarin-associated ICH.

What was the major finding of the study?
The pharmacist-driven protocol significantly reduced time to administration compared with the previous work-flow process.

How does this improve population health?
Incorporating emergency department (ED) pharmacists as an approval service for 4F-PCC and storing the reversal agent in the ED may reduce time to administration during episodes of life-threatening bleeding.

The purpose of this study was to assess the impact of the pharmacist-driven protocol on time to 4F-PCC administration in the ED for patients presenting with warfarin-associated ICH.

METHODS

We conducted a single-center, retrospective review of consecutive patients issued 4F-PCC for warfarin-associated ICH. Patient characteristics collected included patient age, sex, type of ICH, and dose of 4F-PCC administered. Data points collected included ED registration time, initial INR, time INR was drawn and resulted, time ICH was confirmed on imaging, and documented time of 4F-PCC administration. We obtained institutional review board approval, and the need for informed consent was waived.

Our institution is a 1000-bed, Level I trauma and major regional referral center with more than 110,000 annual ED visits. During the study period, clinical pharmacists were physically present in the ED daily from 07:30 a.m. to midnight. During the overnight period, pharmacy services were provided from a separate, centralized location. The blood bank was staffed 24/7. Emergency medicine clinical pharmacy services were established

in our ED prior to development of this protocol; therefore, no changes in the pharmacy-staffing model were required to support implementation of the pharmacist-driven 4F-PCC protocol.

We identified patients issued 4F-PCC between September 2015 and February 2017 from the hospital's EMR and the blood bank data system. We chose parallel six-month pre- and post-implementation time periods for investigation. Patients treated between September 2015 and February 2016 were considered part of the pre-protocol group, and those treated between September 2016 and February 2017 were considered part of the pharmacist-driven protocol group. The new protocol was implemented in April 2016, but full education of clinicians was not yet complete and operational components were still being optimized. For this reason, we excluded this transitional period and included patients starting from September 2016 for the purposes of this analysis.

Patients were included in the analysis if they met the following criteria: ≥18 years of age; ICH confirmed on imaging; documented warfarin use; and initial INR ≥2 (Figure). Patients were excluded if they received more than one dose of 4F-PCC during the same hospitalization or if they received 4F-PCC under the pharmacist-driven protocol outside of ED clinical pharmacist coverage hours. To account for potential changes in staffing and blood bank workflow during the overnight time period, patients in the pre-protocol group were also excluded if they presented between midnight and 7:30 a.m. While hospital policy permitted 4F-PCC use for indications other than warfarin-associated ICH during both study periods, such use was rare and required extra levels of approval, introducing excess variability. As a result, we only analyzed those with warfarin-associated ICH for ease of analysis.

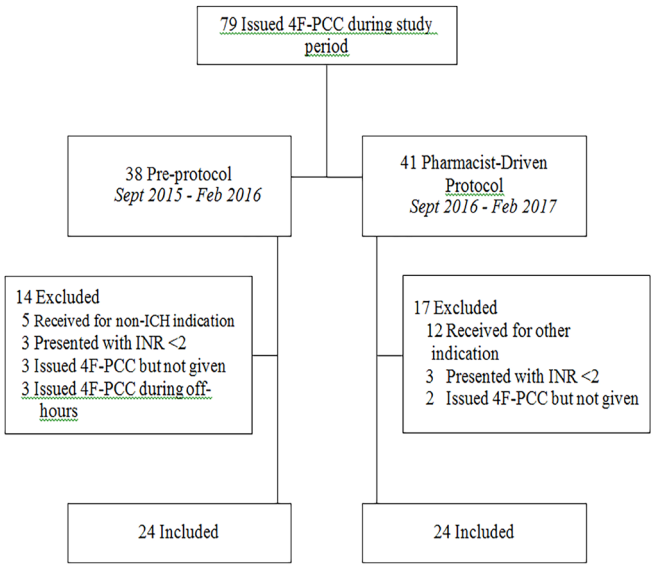

Figure. Inclusion and exclusion criteria.
4F-PCC, four-factor prothrombin complex concentrate; *ICH*, intracranial hemorrhage *INR*, international normalized ratio.

The primary outcome of the study was the amount of time from when the patient met criteria for 4F-PCC to the time of administration. The criteria required both an initial INR ≥2 and confirmation of ICH on imaging; the latter of the two recorded times was designated as the earliest time 4F-PCC was indicated for use. All time stamps were determined from the EMR, including the resulting time of the INR documented by the laboratory, and the final read time on neuroimaging results. For patients who were transferred to our facility, if both the patient's INR and neuroimaging were already available from outside hospital records and used for 4F-PCC criteria, then the arrival time to our ED was designated as the starting time point. This starting time point was chosen since our ED clinicians receive the INR and neuroimaging information telephonically prior to the patient's arrival. Once the patient arrived to the ED, they were already considered a 4F-PCC candidate. Our protocol's intention was for the 4F-PCC procurement process to begin immediately upon arrival. However, if the transferred patient did not have both INR and neuroimaging results readily available and communicated to the clinicians, then the starting time point was pushed back until the patient was officially deemed a 4F-PCC candidate, after the missing information was resulted in our ED.

Secondary outcomes included dose of 4F-PCC in concordance with INR and weight-based FDA-label dosing recommendations and hospital protocol, as well as concomitant IV vitamin K administration. We also evaluated in-hospital mortality between the two protocol groups.

For our study purposes, appropriate dosing of 4F-PCC was determined based on the patient's pre-treatment INR and recorded weight at the time of administration. Administered 4F-PCC doses exceeding five units per kilogram above or below the recorded weight were operationally defined as "inappropriate." This was to account for potential differences in estimation of patient weight, in cases when an accurate weight was not easily attainable.

We considered that if our protocol shortened time by 20 minutes it would be deemed clinically relevant. A power calculation showed that we would need 32 patients, 16 in each arm, to detect this difference at the $p < 0.05$ level. We analyzed the primary outcome using the Mann-Whitney *U* test. Baseline characteristics, secondary outcomes, and clinical outcomes were assessed using Student's t-test, chi-square test, or Fisher's exact test where appropriate. A *p*-value <0.05 was noted to be statistically significant.

RESULTS

A total of 79 patients were issued 4F-PCC during the two six-month observational periods under each protocol. Overall, we included 48 patients in the study, with 24 patients in the pre-protocol group and 24 in the pharmacist-driven protocol group

(Table 1). The median time to administration of 4F-PCC in the pre-protocol group was 70 minutes (interquartile range (IQR) = 34-89; range, 14-244) compared with 35 minutes (IQR = 25-62; range, 11-133) in the pharmacist-driven protocol group (p=0.034). There were no significant differences in dosing, based on pre-treatment INR and patient weight, between the pre-protocol group and the pharmacist-driven protocol group (p=0.174). All patients, with the exception of two in the pre-protocol group, received concomitant IV vitamin K, either at a referring hospital or in our ED upon diagnosis of warfarin-associated ICH (Table 2). In-hospital mortality occurred at comparable rates between the two study populations (p=1).

DISCUSSION

Overall, we found that our change in protocol was associated with a 35-minute decrease in time to administration of 4F-PCC for warfarin-associated ICH in the ED. Numerous changes were made simultaneously, including the need for approval, the use of a pharmacist at the bedside, and the change in storage location leading to more rapid accessibility. The pharmacist also played an active role in dosing the reversal agent accordingly, based on the patient's INR and weight, and served as a resource at the bedside for answering staff questions regarding administration and monitoring.

Prior to implementation of the pharmacist-driven protocol,

Table 1. Patient demographics in study assessing impact of pharmacist-driven protocol for warfarin-associated intracranial hemorrhage.

Characteristic	Pre-protocol (n=24)	Pharmacist-driven protocol (n=24)	p-value
Age	76 (72-88)	83 (66-86)	0.59
Weight, kilograms	77.8 (60.5-87.5)	78.4 (65.2-83.4)	0.98
Gender, male	12 (50%)	11 (45.8%)	1.00
Transferred from outside hospital	15 (62.5%)	9 (37.5%)	0.15
Initial INR	2.3 (2.1-2.8)	2.7 (2.1-3.3)	0.35
2-3.9	22 (91.6%)	21 (87.5%)	1.00
4-6	1 (4.2%)	2 (8.3%)	1.00
>6	1 (4.2%)	1 (4.2%)	1.00
Location of ICH			
Subarachnoid	5 (20.8%)	2 (8.3%)	0.42
Intraventricular	2 (8.3%)	1 (4.2%)	1.00
Intraparenchymal	3 (12.5%)	8 (33.3%)	0.17
Subdural	9 (37.5%)	13 (54.2%)	0.39
Two or more sites	5 (20.8%)	0 (0%)	0.05

*All numbers are expressed as median (IQR) or n (%).
INR, international normalized ratio; *ICH*, intracranial hemorrhage.

Table 2. Study outcomes

	Pre-protocol (n=24)	Pharmacist-driven protocol (n=24)	p-value
Time to 4F-PCC administration, min	70 (34-89)	35 (25-62)	0.034
Appropriate 4F-PCC dosing‡			
Appropriate	20 (83.3%)	23 (95.8%)	0.174
Dose less than recommended	3 (12.5%)	1 (4.2%)	
Dose greater than recommended	1 (4.2%)	0 (0%)	
Concomitant vitamin K administration	22 (91.7%)	24 (100%)	0.244
In-hospital mortality	7 (29.2%)	7 (29.2%)	1

*All numbers are expressed as median (IQR) or n (%)
‡Appropriate dosing based on international normalized ratio (INR) and weight-based FDA label dosing recommendations and hospital protocol.
4F-PCC, four-factor prothrombin complex concentrate.

4F-PCC was purchased by and stored within the blood bank. Ownership of the product was transferred from the blood bank to the Department of Pharmacy in April 2016 and is now purchased under the department's budget. The protocol was developed in conjunction with the transfer of ownership.

Other institutions have performed similar analyses of systems changes. Through changing the approval process to include stroke physicians, implementing point-of-care INR testing, and moving a stock of 4F-PCC to the ED, one UK institution was able to decrease time to administration from a median of 127 minutes (IQR, 111-208) to 58 minutes (IQR, 50-91).[10] A Canadian institution developed a new protocol to replace written orders sent to the blood bank for 4F-PCC with a verbal order from the ED attending, and designated a specific orderly to retrieve the prepared product from the blood bank, leading to a 40-minute improvement in time to administration.[12] With our new protocol in place, the time to 4F-PCC administration improved by a median of 35 minutes, which is comparable to previous reports demonstrating an improved administration time of 30-58 minutes after protocol implementation.[10-12]

A number of factors can lead to delays in 4F-PCC administration in a real-world setting. Pre-intervention, numerous steps were required to obtain 4F-PCC, and it is not clear which steps required more or less time. Post-intervention, fewer steps were required, a dedicated pharmacist was readily available, and the primary storage location was a medication-dispensing cabinet within the ED. While both protocols required an approval service, the blood-bank fellow in the pre-protocol group and the pharmacist in the new protocol group, the pharmacist may already be actively involved in other facets of the patient's care and can assess the patient earlier in their ED visit. However, it is unclear whether the presence of the pharmacist, the fact that fewer steps were necessary, or an unmeasured confounder led to the changes in administration times. One strength of our study is that the data represent a real-world setting of 4F-PCC administration, rather than the controlled environment and selected patients in a clinical trial.

There are no guidelines regarding optimal time to administration of anticoagulation reversal agents in relation to clinical outcomes and mortality. Though this study demonstrated a reduced time to administration, it was not powered to detect differences in clinical outcomes. Recent literature comparing 4F-PCC to FFP in the setting of warfarin-induced ICH has suggested faster reversal may be associated with a lower risk of hematoma expansion.[13-14] While it is known 4F-PCC more rapidly reverses the INR in comparison with FFP, it remains unclear how soon 4F-PCC should be administered after the onset of warfarin-associated ICH and if there are any clinically significant benefits with faster reversal. Further study is needed to assess clinical measures and outcomes in earlier reversal of anticoagulation for warfarin-associated ICH and the optimal timeframe for 4F-PCC administration.

LIMITATIONS

There are several limitations to address within the design of this study. First, this was a single-center, retrospective chart review. Second, patients were only included if 4F-PCC was requested during clinical ED pharmacist coverage hours (7:30 a.m. to midnight daily). As workflow processes differ overnight, we were unable to assess the impact on time to administration during this time period. Third, as this was a retrospective study, there may have been differences between the time of administration documented in the chart and the true time of administration. While neuroimaging results may have been discussed verbally prior to documenting the final read in the EMR, time stamps from the EMR were used to eliminate variation between cases. Fourth, as this was an observational study, it is possible the change in 4F-PCC administration time was due to an unmeasured confounder rather than the change in workflow. However, we are unaware of any other clinical process surrounding 4F-PCC administration that changed during this time frame. Fifth, given the small sample size, we were underpowered to evaluate any effect on clinical outcomes.

CONCLUSION

Our study found the use of an ED pharmacist, in combination with 4F-PCC storage directly in the ED, was associated with a significant reduction in time to 4F-PCC administration after warfarin-associated ICH.

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NHAMCS Validation of Emergency Severity Index as an Indicator of Emergency Department Resource Utilization

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Introduction: Triage systems play a vital role in emergency department (ED) operations and can determine how well a given ED serves its local population. We sought to describe ED utilization patterns for different triage levels using the National Hospital Ambulatory Medical Care Survey (NHAMCS) database.

Methods: We conducted a multi-year secondary analysis of the NHAMCS database from 2009-2011. National visit estimates were made using standard methods in Analytics Software and Solutions (SAS, Cary, NC). We compared patients in the mid-urgency range in regard to ED lengths of stay, hospital admission rates, and numbers of tests and procedures in comparison to lower or higher acuity levels.

Results: We analyzed 100,962 emergency visits (representing 402,211,907 emergency visits nationwide). In 2011, patients classified as triage levels 1-3 had a higher number of diagnoses (5.5, 5.6 and 4.2, respectively) when compared to those classified as levels 4 and 5 (1.61 and 1.25). This group also underwent a higher number of procedures (1.0, 0.8 and 0.7, versus 0.4 and 0.4), had a higher ED length of stay (220, 280 and 237, vs. 157 and 135), and admission rates (32.2%, 32.3% and 15.5%, vs. 3.1% and 3.6%).

Conclusion: Patients classified as mid-level (3) triage urgency require more resources and have higher indicators of acuity as those in triage levels 4 and 5. These patients' indicators are more similar to those classified as triage levels 1 and 2. [West J Emerg Med. 2018;19(5)855-862.]

INTRODUCTION

The emergency department (ED) plays a pivotal role in providing healthcare for the nation, with the number of patients seeking care in EDs being estimated at 136 million per year.[1] In addition, EDs often see more patients in a given time period than they have resources to provide care.[2–5] In response to this issue, triage systems have been implemented to prioritize and allocate patients for these scarce resources.[6–10] Given this vital role, initial triage designation can have a significant impact on any given patient's experience in times of emergency illness. Although some triage systems have been proposed, it is currently unclear how well such systems perform to differentiate resource needs on a national scale.

Ranking ED patients based on perceived acuity of the illness or injury is necessary so that priorities can be established.[11–13] Triage systems such as the Emergency Severity

Index (ESI) are an important tool to accomplish this in EDs around the world. The current version of the ESI ranks acuity using five levels: (1) = Immediate or resuscitation, (2) = Very urgent, (3) = Urgent, (4) = Less urgent and (5) = Non-urgent.[14] This five-level ESI has been validated across many metrics. Most EDs allocate dedicated spaces for patients at both ends of the spectrum of acuity: resuscitation and high-acuity care spaces often are used for patients triaged as levels 1 and 2, and "fast-track" spaces often are used for low-acuity patients triaged as levels 4 and 5. Despite these previous validation studies, it is currently unclear whether the ability of ESI triage levels to discriminate across resource utilization has been sustained over time, especially in the face of changes in patient sociodemographic, economic, clinical characteristics and crowded ED conditions. Furthermore, their performance has not been studied at a national level under real-life conditions.

Our anecdotal experience suggested that patients assigned level 3 triage acuity are often too complicated to be seen in a fast-track area and are not viewed as sick enough to compete with higher acuity patients for available beds. Especially in times of crowding, any non-acute designated beds are full with higher acuity patients, or admitted patients waiting for an inpatient bed. In addition, resource needs for level 3 triage patients seemed to be more similar to more-emergent, triage acuity levels despite having long wait times to see a physician and long overall ED lengths of stay (LOS).

Our objective was to compare patient sociodemographic, clinical characteristics, and utilization patterns for patients assigned different triage levels in the National Hospital Ambulatory Medical Care Survey (NHAMCS) database. We hypothesized that triage level 3 patients would require significantly more resources than levels 4 and 5 patients despite having similar wait times.

Population Health Research Capsule

What do we already know about this issue?
Triage is a vital activity in the modern emergency department (ED). There are many systems for conducting triage in the ED that have been well validated.

What was the research question?
We sought to determine whether a patient's triage classification accurately predicts subsequent resource utilization.

What was the major finding of the study?
Patients classified as mid-level (3) triage urgency require more resources and have higher indicators of acuity lower levels.

How does this improve population health?
More accurate understanding and prediction from triage can allow EDs to better assist the populations they serve.

METHODS

Study Design and Setting

We conducted a secondary analysis of NHAMCS to compare patient sociodemographic, as well as clinical and utilization patterns, at different triage levels with a particular focus on triage level 3 (urgent) patients compared to other groups. Since the database shifted to a five-level triage system in the acuity-level classification in this database, we used the data from 2009-2011. We examined the effect of the potential changes in triage distributions during this period. This study is described per the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines.[15]

Ethics

This study was exempted from full review by our institutional review board.

Database

We obtained the data from NHAMCS, a nationally representative survey conducted annually in the United States by the National Center for Health Statistics at the Centers for Disease Control and Prevention. We included datasets for the years 2009 through 2011 for an evaluation of triage-level categories. Data were collected on visits to outpatient and EDs of non-institutional, short-stay, and general hospitals located in 50 states and the District of Columbia, excluding federal, military, and Veterans Affairs hospitals.

NHAMCS uses a four-stage probability sampling design including selection of primary sampling units (PSU), hospitals within PSUs, clinics within hospitals, and patient visits within clinics. The exact methods of the NHAMCS survey have been described elsewhere.[16] Briefly, hospitals are selected based on 112 geographic PSUs from the 1985-1994 National Health Interview Surveys. Approximately 480 hospitals within PSUs were surveyed. For the years included, an average of 411 hospitals were eligible, and an average of 369 participated for an unweighted average hospital sampling response rate of 89.8% annually. These hospitals are randomly assigned to 16 data collection groups that rotate across 13 four-week reporting periods throughout the year.

NHAMCS contractors (SRA International, Inc., Durham, NC) collect data from ED-visit medical records during a randomly assigned four-week period while being monitored by NHAMCS field representatives. NHAMCS staff members independently check 10% of the data for accuracy. Error rates are 0.3%-0.9% for various items on the survey. The NHAMCS survey records demographic data, payment source, provider

types, procedures, prescriptions, laboratory and radiographic tests ordered for each visit, up to three reasons for visit (chief complaints), the ED diagnosis (*International Classification of Diseases Ninth Revision, Clinical Modification* (ICD-9-CM) codes), and the final hospital discharge diagnosis for those patients admitted to the hospital.[17].

Selection of Participants

The study sample includes all patients having a visit record to EDs in the NHAMCS.

Variables

Our main variables of interest were triage level (immediacy with which patient should be seen, categorized as 1-Immediate; 2-Emergent; 3-Urgent; 4-Semi-urgent; 5-Non-urgent, and emergency service area does not conduct nursing triage); chief complaints for visit; primary diagnosis related to visit; total number of procedures provided; total number of tests/services provided; number of medications given in the ED; and visit disposition.

Analysis

Our exploratory analysis started by evaluating distributions, frequencies, and percentages for each of the numeric and categorical variables. Categorical variables were evaluated for near-zero variation.[18] We used graphical displays for both univariate analysis and bivariate associations. Missing data were explored using a combination of graphical displays involving univariate, bivariate, and multivariate methods. Imputation was performed using a k-nearest neighbors algorithm (n = 5).[19] We generated population estimates through masked sample design variables, clustered PSUs, marker, and clustered PSUs, stratum marker, along with patient weights. We made use of line plots with confidence bands calculated to represent inferences to the U.S. population. All calculations were performed using the R language[20] along with the survey package.[21] Comparisons between the aggregate of triage level groups 1-3 vs. aggregate of 4-5 were made using Student's t-test.

RESULTS

We analyzed 100,962 emergency visits between 2009 and 2011, corresponding to 402,211,907 emergency visits when inferences were made to the entire U.S. population. Level 3 (Urgent) visits were the most frequent. The frequency of triage levels was stable over this period (Figure).

A total of 136,296,400 visits were inferred for 2011 in our analysis. Table 1 compares the five different acuity levels. Most patients in our sample were female (54.7%), except in the triage level 1 group. Level 3 was the most frequent triage acuity level, representing 42.3% of all cases. Patients triaged as levels 1-3 had a mean age above 40 years, while most patients in levels 4 and under were in their early thirties. There were significant differences in vital sign measures, pain level, reason for visit, and diagnoses across different triage

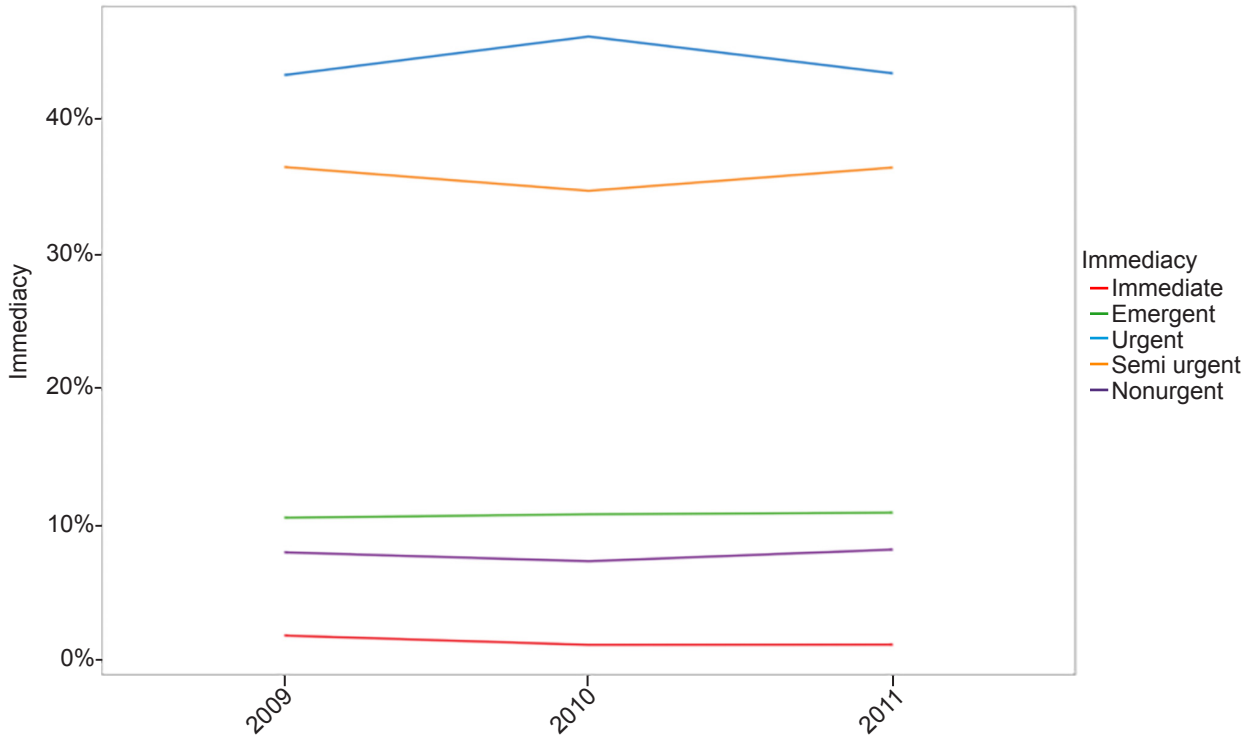

Figure. Frequency of emergency visits according to triage level between 2009 and 2011.

Table 1. Inferences for the United States regarding characteristics of study participants, chief complaints and primary diagnosis in 2011.

Variable	Total (136,296,400)	1-Immediate (1,638,167-1.2%)	2-Emergent (14,590,086-10.7%)	3-Urgent (57,689,765-42.3%)	4-Semi-urgent (48,452,556-35.5%)	5-Nonurgent (10,966,056-8.04%)	No triage (2,959,770)	P value
Patient age in years	37.14 (±0.46)	43.24 (±2.19)	46.02 (±0.96)	40.79 (±0.57)	31.73 (±0.57)	28.81 (±1.39)	38.10 (±1.6)	< .001
Female	74,620,514 (54.7% ±4.4%)	651,322 (39.8% ±8.2%)	7,547,970 (51.7% ±4.6%)	33,005,491 (57.2% ±3.7%)	26,106,889 (53.9% ±3.6%)	5,656,675 (51.6% ±6.2%)	1,652,167 (55.8% ±22%)	< .001
Hispanic ethnicity	15,932,426 (11.7% ±1.6%)	125,325 (7.7% ±2.2%)	1,570,681 (10.8% ±1.8%)	6,389,676 (11.1% ±1.2%)	5,983,797 (12.3% ±1.5%)	1,612,349 (14.7% ±2.5%)	250,598 (8.5% ±6.4%)	.318
Race								.268
Asian	2,248,640 (1.9% ±0.4%)	24,213 (1.7% ±0.9%)	262,507 (2% ±0.4%)	1,067,602 (2.2% ±0.4%)	722,486 (1.8% ±0.3%)	140,101 (1.5% ±0.3%)	31,731 (1.2% ±0.7%)	
Black	29,463,330 (25.4% ±3.5%)	270,646 (19.3% ±5%)	2,748,765 (21.5% ±3.1%)	12,217,466 (25% ±2.9%)	11,235,429 (27.6% ±3.5%)	2,563,547 (27% ±4.2%)	427,477 (15.6% ± 3.5%)	
Other	2,075,107 (1.8% ±0.6%)	27,202 (1.9% ±1.4%)	171,785 (1.3% ±0.4%)	779,101 (1.6% ±0.5%)	814,297 (2% ±0.5%)	115,022 (1.2% ±0.5%)	167,700 (6.1% ±5.2%)	
White	82,290,829 (70.9% ±6.4%)	1,078,307 (77% ±19.7%)	9,627,332 (75.2% ±6.8%)	34,778,809 (71.2% ± 4.7%)	28,004,392 (68.7% ±5.4%)	6,685,121 (70.3% ±10.1%)	2,116,868 (77.2% ±30.7%)	
Presenting level of pain	4.93 (±0.06)	3.93 (±0.22)	4.36 (±0.17)	5.00 (±0.07)	5.16 (±0.08)	4.39 (±0.17)	4.85 (±0.2)	< .001
Waiting time to see provider	48.89 (±2.37)	25.44 (±4.44)	40.21 (±3.7)	51.81 (±3.01)	51.32(± 2.65)	41.85 (±2.29)	33.92 (±11.47)	.005
Visit reason								
Abdominal pain	11,069,123 (8.1% ±0.9%)	30,554 (1.9% ±0.9%)	964,851 (6.6% ±1.2%)	7,336,403 (12.7% ±0.9%)	2,046,818 (4.2% ±0.5%)	406,777 (3.7% ±1%)	283,720 (9.6% ±5.1%)	< .001
Trauma	7,208,961 (5.3% ±0.6%)	147,099 (9% ±2.3%)	458,883 (3.1% ±0.4%)	2,150,809 (3.7% ±0.4%)	3,743,009 (7.7% ±0.7%)	554,235 (5.1% ±1%)	154,926 (5.2% ±2.3%)	< .001
Chest pain	7,051,953 (5.2% ±0.6%)	191,780 (11.7% ±4.3%)	2,152,744 (14.8% ±1.7%)	3,417,028 (5.9% ±0.5%)	966,750 (2% ±0.2%)	200,630 (1.8% ±0.5%)	123,021 (4.2% ±2.3%)	< .001
Diagnosis								
Trauma	24,806,511 (18.2% ±1.6%)	242,168 (14.8% ±3.3%)	1,322,862 (9.1% ±1.1%)	7,227,376 (12.5% ±0.9%)	13,150,153 (27.1% ±1.9%)	2,241,924 (20.4% ±3.2%)	622,028 (21% ±7.8%)	< .001
Altered mental status	6,999,248 (5.1% ±0.6%)	106,805 (6.5% ±2.2%)	1,122,289 (7.7% ±0.9%)	3,864,029 (6.7% ±0.6%)	1,412,586 (2.9% ±0.3%)	325,682 (3% ±0.6%)	167,857 (5.7% ±2.4%)	< .001
Non-specified chest pain	4,939,289 (3.6% ±0.5%)	117,538 (7.2% ±3%)	1,753,781 (12% ±1.6%)	2,455,365 (4.3% ±0.4%)	463,078 (1% ±0.1%)	87,980 (0.8% ±0.3%)	61,547 (2.1% ±0.9%)	< .001

acuity levels. The most common reasons for an ED visit were abdominal pain (8.1%), trauma (5.3%) and chest pain (5.2%). The most frequent diagnoses were trauma (18.1%), altered mental status (5.1%) and non-specified chest pain (3.6%).

In 2011, patients classified as levels 1-3 received a higher number of diagnoses (5.5, 5.6 and 4.2, respectively) when compared to those classified as semi-urgent and non-urgent (1.61 and 1.25) (Table 2). This group also underwent a higher number of procedures (1.0, 0.8 and 0.7, vs. 0.4 and 0.4), had a higher ED LOS (220, 280 and 237 minutes, vs. 157 and 135 minutes), and had higher admission rates (32.2%, 32.3% and 15.5%, vs. 3.1% and 3.6%). Finally, the level 1-3 group was also more frequently transferred (5.2%, 2.3% and 1.9%) when compared to the less-urgent group (below 0.5%). As expected, triage level 1 patients presented a markedly higher mortality rate (3.9%) when compared to other acuity levels. (See Appendix Tables 1-4.)

In assessing the impact of missing data, our imputation algorithms followed by sensitivity analyses did not demonstrate any directional changes in final conclusions.

DISCUSSION

To the best of our knowledge, this is the first study evaluating ED triage acuity systems in the U.S., and their relationship to resource utilization. Triage systems have been extensively studied for validity. For example, it has been demonstrated that five levels are more reliable than a simpler system involving only three levels.[22] In addition, ESI levels have been demonstrated to predict outcomes including hospital admission, length of hospital stay, and mortality rates.[23,24] From 2009 to 2011, the NHAMCS classification was changed to a five-level system mirroring ESI, and the most common acuity level during this period was triage level 3 (level 3).

When evaluating 2011, patients classified as triage level 1, triage level 2, and triage level 3 formed a cluster that was consistent across sociodemographic, clinical and resource utilization categories, clearly differentiating themselves from semi-urgent and non-urgent patients. We identified a trend toward increased similarity among triage level 1-3 patients concerning resource utilization. In fact, within that group one may actually conclude that patients with ESI 2 are more similar to ESI 3 patients than ESI 1. While the admission rates for ESI 2 are more similar to those with ESI 1 (Table 3), the actual resource utilization and total LOS are more similar between ESI 2 and ESI 3.

Moreover, clinically it is easier to discern between an ESI of 1 vs. 2 purely based on obvious acuity at time of presentation then it is to distinguish between an ESI 2 vs. 3. That is to say, it is easier to determine that a patient is in need of "immediate resuscitation" upon their presentation than to distinguish whether a patient needs "urgent" vs. "very urgent" evaluation and management. Additionally, despite different admission rates, ESI 2 and 3 patients had similar need for procedures and testing, highlighting the clinical ambiguity and higher cognitive burden for providers treating these patients.

These similarities are striking considering the different resources allocated to these distinct populations. For example, most EDs have dedicated resuscitation or acute rooms for highest acuity patients (usually ESI 1 and some ESI 2 patients). Similarly, most departments also assign space (fast track, minor care) to the lowest triage acuity patients (ESI 4-5). The ESI 3 patients are often viewed as too sick for the less-acute areas and not sick enough to compete for the more-acute areas. Only recently have departments proposed a mechanism such as "middle track" or "flexible fast track" areas and physician triage processes to address the needs of triage level 3 patients.[6,8]

Our analysis suggests that such interventions are warranted and worthy of further research. Moreover, based on LOS, resource utilization and potential provider-cognitive burden, it may actually be necessary to develop areas where ESI 2 and 3 patients would be cohorted and treated together. In addition, some EDs have developed "non-acute" rooms to accommodate the middle triage groups. However, in times of crowding and increased acuity being seen across the country, these beds are now filled with higher acuity patients, or admitted patients waiting for an inpatient bed.

In agreement with previous reports, our analysis contradicts the myth that emergency services are being proportionally dedicated to non-urgent patients.[25–27] In fact, at least based on triage, non-urgent patients represented less than 10% of all patients seeking emergency care. These findings have important consequences since potential policies referring non-urgent patients to facilities other than the ED might not reduce ED crowding and boarding as much as expected.[28,29] Instead, measures aimed at optimizing ED workflow might be more effective.[30–36]

Our results likely reflect a growing shift in population mix for individuals seeking care at the ED, with fewer patients now falling into a non-urgent triage category. At the same time, level 3 cases have become more complicated, often requiring extensive evaluations. With an aging population, admissions and resources used per patient will likely require an increase in ED capacity of approximately 10%, with an increase in admissions predicted at 23%.[37]

The intensive use of health resources by mid-level urgency patients has important implications for patient safety and resource allocation in EDs, as urgent patients compete for resources with triage level 1 and 2 patients.[38,39] This shift in case mix is important when devising ED workflow, ensuring that patients are not exposed to additional risk due to ED overload.

LIMITATIONS

Despite filling an important gap in the literature, our study does have limitations. First, we did not evaluate whether triage assignment was reliable or uniform over time. It is possible that, along with a shift in case mix, the classification criteria used by triage professionals might also have changed. The ESI system has good inter-rater reliability, but its performance over time has

Table 2. Resource utilization of emergency departments according to triage acuity level in 2011.

Variable	Total (136,296,400)	1-Immediate (1,638,167)	2-Emergent (14,590,086)	3-Urgent (57,689,765)	4-Semi-urgent (48,452,556)	5-Nonurgent (10,966,056)	No triage (2,959,770)	P value
Length of visit	203.59 (±4.81)	219.72 (±14.34)	280.11 (±10.5)	237.01 (±5.84)	157.36 (±4.21)	134.65 (±6.63)	167.65 (±26.86)	< .001
Number of procedures	0.57 (±0.02)	0.97 (±0.1)	0.77 (±0.03)	0.67 (±0.02)	0.44 (±0.02)	0.36 (±0.02)	0.51 (±0.06)	< .001
Number of diagnostics	3.18 (±0.1)	5.45 (±0.71)	5.56 (±0.21)	4.20 (±0.14)	1.61 (±0.08)	1.25 (±0.09)	3.01 (±0.45)	< .001
Number of medications given in ED	1.41 (±0.03)	2.31 (±0.2)	1.97 (±0.09)	1.64 (±0.04)	1.04 (±0.03)	0.95 (±0.08)	1.38 (±0.17)	< .001
Hospital admission	16,228,737 (11.9% ±1.3%)	527,876 (32.2% ±8.8%)	4,712,570 (32.3% ±3.3%)	8,942,106 (15.5% ±1.3%)	1,483,549 (3.1% ±0.5%)	394,351 (3.6% ±1%)	168,285 (5.7% ±3.3%)	< .001
Admission to observation unit, then hospitalized	964,907 (0.7% ±0.2%)	4,253 (0.3% ±0.2%)	286,256 (2% ±0.5%)	601,216 (1% ±0.2%)	65,924 (0.1% ±0%)	7,258 (0.1% ±0.1%)	0 (0% ±0%)	.024
Died in ED	143,498 (0.1% ±0%)	64,137 (3.9% ±1%)	26,907 (0.2% ±0.1%)	37,412 (0.1% ±0%)	3,252 (0% ±0%)	2,897 (0% ±0%)	8,893 (0.3% ±0.2%)	< .001
Transfer to other hospital	1,950,270 (1.4% ±0.3%)	84,900 (5.2% ±1.9%)	341,898 (2.3% ±0.4%)	1,088,620 (1.9% ±0.3%)	203,857 (0.4% ±0.1%)	55,836 (0.5% ±0.2%)	175,159 (5.9% ±2.4%)	< .001

ED, emergency department.

Table 3. Resource utilization according to acuity level in 2011 for Emergency Severity Index 2 vs. 3.

Variable	2-Emergent (14,590,086)	3-Urgent (57,689,765)
Length of visit	280.11 (±10.5)	237.01 (±5.84)
Number of procedures	0.77 (±0.03)	0.67 (±0.02)
Number of diagnostics	5.56 (±0.21)	4.20 (±0.14)
Number of medications given in ED	1.97 (±0.09)	1.64 (±0.04)
Return for appointment as needed	3,390,755 (23.2% ±3.2%)	18,584,580 (32.2% ±2.4%)
Return/refer to physician/ clinic for follow-up	7,333,338 (50.3% ±5.2%)	37,836,752 (65.6% ±4.9%)
Hospital admission	4,712,570 (32.3% ±3.3%)	8,942,106 (15.5% ±1.3%)
Died in ED	26,907 (0.2% ±0.1%)	37,412 (0.1% ±0%)
Transfer to other hospital	341,898 (2.3% ±0.4%)	1,088,620 (1.9% ±0.3%)

ED, emergency department.

never been assessed.[40,41] Second, studies based on administrative data are susceptible to biases during the data collection process, ultimately affecting our results. Nevertheless, the NHAMCS has been widely used to study nationwide ED processes, and the key variables (triage level, admission rates, ED LOS, tests and studies ordered) we studied were straightforward, standard information collected on most ED visits. Third, missing data were present, which might have biased our results. To minimize this limitation, we used imputation algorithms followed by sensitivity analyses to ensure that our final conclusions were valid under different assumptions.

CONCLUSION

We found that patients classified as triage level 3 (Urgent) are now one of the major components in the case mix for EDs, and their resource utilization profile is similar to triage levels 1 and 2 patients. These findings have implications for triage algorithms, emergency resource allocation, and care coordination. Future studies should prospectively evaluate the impact of different triage algorithms among patients presenting to the ED, considering both clinical as well as public health perspectives.

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The Misunderstood Coagulopathy of Liver Disease: A Review for the Acute Setting

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The international normalized ratio (INR) represents a clinical tool to assess the effectiveness of vitamin-K antagonist therapy. However, it is often used in the acute setting to assess the degree of coagulopathy in patients with hepatic cirrhosis or acute liver failure. This often influences therapeutic decisions about invasive procedures or the need for potentially harmful and unnecessary transfusions of blood product. This may not represent a best-practice or evidence-based approach to patient care. The author performed a review of the literature related to the utility of INR in cirrhotic patients using several scientific search engines. Despite the commonly accepted dogma that an elevated INR in a cirrhotic patient corresponds with an increased hemorrhagic risk during the performance of invasive procedures, the literature does not support this belief. Furthermore, the need for blood-product transfusion prior to an invasive intervention is not supported by the literature, as this practice increases the risk of complications associated with a patient's hospital course. Many publications ranging from case studies to meta-analyses refute this evidence and provide examples of thrombotic events despite elevated INR values. Alternative methods, such as thromboelastogram, represent alternate means of assessing in vivo risk of hemorrhage in patients with acute or chronic liver disease in real-time in the acute setting. [West J Emerg Med. 2018;19(5)863–871.]

INTRODUCTION

Liver disease presents a major burden on healthcare systems in both North America[1,2] and Europe[3] and can result in more than 70,000 annual visits to the emergency department (ED).[4] Liver disease in the setting of acute liver failure (ALF)[5] or trauma in a patient with cirrhosis[6-8] are predictors of increased mortality and poor patient outcome. One of the challenges these patients pose to healthcare providers in acute settings, such as sepsis and trauma, relates to the coagulopathy of liver disease – specifically, is an individual patient at an increased risk of a spontaneous hemorrhagic event or hemorrhagic procedural complication? The commonly accepted paradigm - increased risk of hemorrhagic events in the setting of elevated international normalized ratio (INR) - is being challenged though it still widely influences day-to-day practice.[9,10]

The most commonly used tests for identifying and monitoring coagulopathy include partial thromboplastin time (PTT), prothrombin time (PT), and INR. INR, a ratio of the patient's PT as compared to a laboratory normative PT value, was designed as a method of monitoring individual patient responses to anticoagulation therapy with a vitamin-K antagonist such as warfarin.[11] Despite this, tests including INR are often incorrectly applied clinically as a general indication of a patient's overall bleeding risk due to the ease with which the results are obtained and interpreted. This is particularly true in patients with chronic liver disease and cirrhosis.[12] However, the utility of INR with respect to predicting risk of hemorrhagic event in chronic liver patients has been refuted[13-15] and warrants further review. An early study concluded that isolated evaluation of bleeding or clotting time is of little prognostic value in patients with liver disease during pre-operative screening.[16] Given that this study is nearly a half-century old, why are many clinicians still making important clinical decisions based on the interpretation of an INR value in patients who are not being anticoagulated with a

vitamin-K antagonist? More specifically, how did the medical community arrive at the commonly accepted "INR less than 1.5" as a safe threshold for invasive procedures?

The liver is responsible for the synthesis of many of the procoagulant and anticoagulant proteins responsible for maintaining hemostasis.[17] Liver dysfunction is often assumed to be associated with increased bleeding risk, but evidence suggests that other factors such as sepsis, hepatorenal syndrome, hypotension, and endothelial dysfunction contribute to this bleeding tendency rather than isolated cirrhosis and liver disease.[10,18] In most cases, a "rebalancing" occurs and the vast majority of chronic liver disease patients achieve a hemostatic equilibrium.[10,15,19-21] In cases of traumatic injury or prior to surgical procedures, the measured coagulopathy as assessed by INR is often reversed with pharmaceutical agents (e.g., vitamin K, prothrombin complex concentrate) or transfused blood products (e.g., plasma or platelets). However, this practice of prophylactic transfusion to minimize the risk of hemorrhagic complications is not evidence based despite its wide acceptance.[15,19,21]

Prophylactic transfusions may expose the patient to increased risk of adverse events (e.g., transfusion reactions including transfusion-related acute lung injury [TRALI] and exacerbation of portal hypertension) as a result of the transfusion, while providing no protective effects.[19,22,23] PT and INR analyses assess isolated clotting pathways in vitro despite our knowledge that in vivo clotting pathways do not function in isolation.[24] As a result, significantly different INR results can be obtained from the analysis of a sample of blood from a cirrhotic patient based on the commercially available thromboplastin used in performing the analysis.[25] This review intends to address these issues as they pertain to practice in the acute setting such as an ED, a trauma surgeon's operating room, or an intensive care unit (ICU).

METHODS

The author conducted a comprehensive search of the relevant literature as it related to chronic liver disease, cirrhosis, ALF, and hemostasis. Searches were performed using PubMed, OVID, Web of Science, Google Scholar, and the Cochrane Library databases. The following criteria were used to search these databases:

1. Access to full-text articles, reports, books, and book chapters in English.
2. Inclusion of a combination of at least two of the terms "coagulopathy," "INR," "cirrhosis," "chronic liver disease," "acute liver failure." A secondary search was performed using at least two of the terms listed previously in combination with at least one of the following: "hemorrhage," "bleeding," "emergency department," "trauma," "central venous catheter," "lumbar puncture," "thoracentesis," "paracentesis," "procedure," and "surgery."

The bibliography of each publication was reviewed to identify any relevant sources that were not identified using the primary search strategies indicated. The author identified over 5,000 articles with these search criteria; many of these were duplicates between search engines and many more related specifically to the perioperative period and management of liver transplantation. A total of 89 articles were reviewed in the final manuscript preparation; these included 76 full-text articles and textbook chapters specific to the search terms above and 13 articles related to the clotting cascade, rates of morbidity and mortality in patients without liver disease and its associated coagulopathy, and statistics specific to the prevalence of and morbidity and mortality of liver disease. In total, the author included in the final manuscript preparation 71 references that were most applicable to the aim of the paper (i.e., the acute setting specific to patients in the ED or the ICU with coagulopathy due to liver disease) and published in full-text English.

RESULTS

Pathophysiology of Coagulopathy in Liver Disease

The liver is responsible for the synthesis of nearly all clotting factors and their inhibitors[9,12,17] (Table). As a result, patients with chronic liver disease and cirrhosis experience a rebalancing of their hemostatic variables.[15] Patients in ALF likely experience minimal effects on their in vivo coagulation profiles as assessed with thromboelastography (TEG) despite mean INR values >3.[26] Furthermore, these patients have significant rates of hypercoagulable (35%) and hypocoagulable (20%) states.[12] To further complicate matters, the presence of a hypercoagulable state does not exclude the presence of a tendency toward increased bleeding risk, and conversely, increased bleeding risk does not rule out the development of a new thrombus.[27,28] Publications have discussed exactly this paradoxical phenomenon.[28,29]

Overall, compensated and decompensated cirrhotic, non-septic patients live in either a balanced homeostatic state or, due to the systemic inflammation associated with liver dysfunction, a prothrombotic state.[10,12,17,20,24,30] This concept has been demonstrated and validated using TEG.[26,30] Clinically this phenomenon is often demonstrated by the prevalence of portal vein thromboses[31] and increased frequency of catheter clotting events during renal replacement therapy.[12] More specifically, serum levels of antithrombin, protein C, and protein S range from 30-65% of normal; this is comparable to levels observed in patients with inherited deficiencies.[17] In addition to decreased production of pro- and anticoagulant factors, cirrhotic patients often live in a chronic consumptive state that further decreases these already-low levels of factors on both sides of the clotting spectrum.[27]In summary the risk of thrombotic events thus may exceed the risk of hemorrhage, and prophylactic anticoagulant therapy – currently regarded as contraindicated in liver disease – may actually provide therapeutic benefit.[10]

Table. Summary of factors associated with hemostasis (compiled[9,10,24,31]).

Procoagulants		Anticoagulants		Fibrinolytics	
Hepatic synthesis	Non-hepatic synthesis	Hepatic synthesis	Non-hepatic synthesis	Hepatic synthesis	Non-hepatic synthesis
Factors: I II(prothrombin) III IV V VI VII VIII* IX X XI XII Fibrinogen	Factors: VIII* von Willebrand (vWf) Platelets** Anti-phospholipid antibodies***	Proteins: C S Z Anti-thrombin III	Tissue factor pathway inhibitor	Plasminogen (zymogen) and plasmin	

*Factor VIII is synthesized primarily by hepatic sinusoidal endothelial cells, but a sizeable proportion of the synthetic process also occurs in non-hepatic sinusoidal cells. As a result, liver disease does not decrease plasma concentrations of von Willebrand factor (vWf); the chronic inflammation associated with chronic liver disease may actually increase plasma concentrations of vWf.[10,31]
**Decreased in circulating number and function in liver disease.
***Increased in liver disease.

Risk of Hemorrhagic Events with Procedures, Trauma, and Critical Illness

The primary concern related to the elevated INR often observed in cirrhotic patients relates to either unintended or uncontrollable bleeding despite literature suggesting this to be a rare event.[32] While the INR is often the variable that surgical and interventional services will cite while expressing their concerns about procedural safety,[33,34] platelet concentration and platelet function is a more concerning factor in influencing bleeding risk in this population.[13,17] Regardless, in practice elevated INR is often considered a contraindication for procedural intervention including liver biopsy, intracranial pressure monitor placement, central venous catheter (CVC) placement, paracentesis, thoracentesis, and lumbar puncture.[11,17]

The guidelines in both the anesthesiology and the interventional radiology literature, based on a Delphi consensus panel, recommend transfusions in patients with liver disease to correct coagulopathy as determined by INR measurement. The initial guidelines recommended transfusion to correct to an INR≤1.5,[33,35] but more recent guidelines were updated to recommend transfusions to achieve a goal of INR≤1.5 for moderate to significant bleeding risk procedures and INR≤2.0 for low risk procedures.[34] However, these practices are not supported as evidence based.[15,19] Nonetheless, these recommendations persist despite knowledge that INR results may differ by as much as 0.7 depending on the assay, based on a study of 150 patients, seven commercially available reagents, and four different calibrator sets.[34,36] Intrasubject results for INR values demonstrated statistically significant differences ($p<0.001$) for 17 of the 21 possible permutations (reagent x calibrator).[36]

In a large prospective study (N=658) of critically ill cirrhotic patients with elevated INR (peak = 17) and thrombocytopenia (nadir = 9 x 10^9/L), who required CVC placement for the purposes of intravenous access, fluid resuscitation, or initiation of temporary dialysis,[13] the single major complication in the placement of CVC placement without the assistance of ultrasound guidance in either the subclavian or the internal jugular vein was secondary to the unintended puncture of the subclavian artery. Patient safety in the setting of cirrhotic coagulopathy during invasive procedures can be further augmented with the use of guidance from ultrasound or other imaging modalities.[22,23,37] Overall, there is little strong evidence to support the predictive value of abnormal coagulation test results with respect to bleeding with invasive procedures.[14]

Reviews of studies of procedures such as bronchoscopy, femoral angiography, liver biopsy, renal biopsy, thoracentesis, lumbar puncture, and dental extraction also do not support the concept that elevated INR due to liver disease is associated with increased risk of hemorrhagic events.[14,38,39] Overall, the risk of hemorrhage in minor procedures that can be performed at bedside is <3% with <1% risk of major bleeding events; in those rare cases of major hemorrhagic complication, mortality may be as low as 0.016%.[17,32,39,40] To further discredit the

utility of INR in predicting these events, it has been reported that the majority of these events, especially in percutaneous liver biopsy procedures, occur in patients with what would be accepted as a normal INR value (INR<1.3).[14,24,38]

The overall mortality risk in this population, however, is substantial, and one study goes so far as to recommend the consideration of ICU admission for all cirrhotic patients being admitted to the hospital.[6] Cirrhotic patients with blunt abdominal trauma are significantly more likely to experience injuries that require operative management and experience post-operative complications associated with significant morbidity and mortality.[8,41] Up to a six-fold increase in mortality that approaches 43%, even from minor trauma, has been reported in cirrhotic patients as compared to non-cirrhotic controls.[7,8,41,42]

Predictable tools for risk stratification in liver disease such as Child-Pugh classification and Model for End-stage Liver Disease (MELD) scores correlate well with the increased risk of mortality as a result of trauma[6,8] while trauma-related Injury Severity Scores have been described as grossly inadequate for accurately risk stratifying the cirrhotic trauma patient.[41] These findings were not necessarily associated with hemorrhagic events, and the occurrence of disseminated intravascular coagulation trended towards significantly increased in cirrhotic patients as compared to controls.[42] In fact, the serious complications noted often include acute respiratory distress syndrome, pneumonia, renal failure, or sepsis rather than massive hemorrhage.[41,42]

Risk of Thrombotic Events in Critically Ill Patients with Hepatic Dysfunction

A paradox is commonly observed during the care of patients with liver cirrhosis: Despite elevated INR values, clinicians often evaluate for (and subsequently diagnose) portal vein thromboses while clotting of extra corporeal circuits (e.g., hemodialysis or extracorporeal mechanical oxygenation [ECMO]) is a common occurrence in cirrhotic patients.[24,27] Despite the notion of "auto-anticoagulation," patients with hepatic dysfunction are not protected against the occurrence of venous thromboembolism or other thrombotic events merely by the presence of an elevated PT and INR.[17,43] The increased thrombotic risk in cirrhotic patients is likely attributable to the maintained or even increased capacity for thrombin generation[44,45] or elevations in fibrinogen, FVIII, and von Willebrand factor.[17] The result is an incidence of 6.3% in one study despite the inclusion of cirrhotic patients with INR>3[43] and a >50% risk of thrombotic events being identified on autopsy.[17] In fact, the greatest risk of thromboembolic events was observed in the patients with Child-Pugh Stage C (8.0%).[43]

The risk factors for thrombosis are consistent with elements of Virchow's triad including procoagulant state, endothelial damage, and turbulent flow; a chronic inflammatory state such as cirrhosis further increases the risk of thrombotic events.[24,27] The procoagulant state is often due to a localized phenomenon of persistently present procoagulant factors due to disrupted hemodynamics[20] or a decreased hepatic ability to clear activated procoagulant factors.[31] Given the intricate interplay between factors, platelets, and other physiological conditions, in vitro models to accurately predict in vivo thrombotic events are often inadequate.[20]

Alternatives for Laboratory Evaluation of Coagulopathy

The elevated PT and INR observed in cirrhotic patients often occurs with a normal or near-normal activated PTT; this is representative of an isolated factor VII or concurrent factor VII / VIII elevations.[17] The isolated evaluation of PT and INR does not take other defects such as thrombocytopenia and platelet function defects into account,[17] despite the prevalence and importance of these factors in evaluating for the presence of in vivo coagulopathy in a cirrhotic patient.[9] Another century-old test of coagulopathy is bleeding time, although the evidence is equivocal regarding is reliability and reproducibility[34,46,47] and it is seldom used in modern medicine due to its unreliable utility on the individual patient basis.[47] However, the proposed benefit of assessing bleeding time is the inclusion of the entire in vivo clotting cascade rather than the incomplete, in vitro coagulation cascade commonly assessed with PT, PTT, and INR evaluation. In ALF patients, PT results and INR calculation do not correlate well with more advanced and specific assessments of coagulation state from tools such as TEG.[12]

TEG represents an alternative to bleeding time, PT measurement, and INR calculation in patients with hepatic dysfunction for whom a provider wishes to evaluate a true coagulation profile that correlates well with the in vivo clinical presentation.[12,26,31,48] While not yet a "gold standard" technique, it does demonstrate benefit in guiding transfusion-based decisions in elective cardiac procedures[49] and liver transplantation.[50] It also provides promising results in the management of acute coagulopathy in critical acute settings such as trauma in the ED,[49,51,52] military theater of operations,[53] and ECMO,[54] although more research is needed in these settings.

In currently available studies in acute clinical settings,[48,54,55] TEG provides a rapid bedside tool to assess and monitor hemostatic characteristics using whole blood samples (Figure). A small amount of whole blood, <5mL, at body temperature (37^{O}C) is placed in an oscillating cup after sampling from venipuncture. A pin suspended from a torsion wire couples with the blood as fibrin strands form, and the result is increased wire tension as detected by an electromagnetic transducer. The resulting electrical signal is converted to the TEG trace, which can be displayed in real time on a computer monitor.[30,56] Complete results are available in less than 30 minutes, though preliminary results are available much sooner (<15 minutes).[30,56] This provides the clinician the ability to consider the multiple

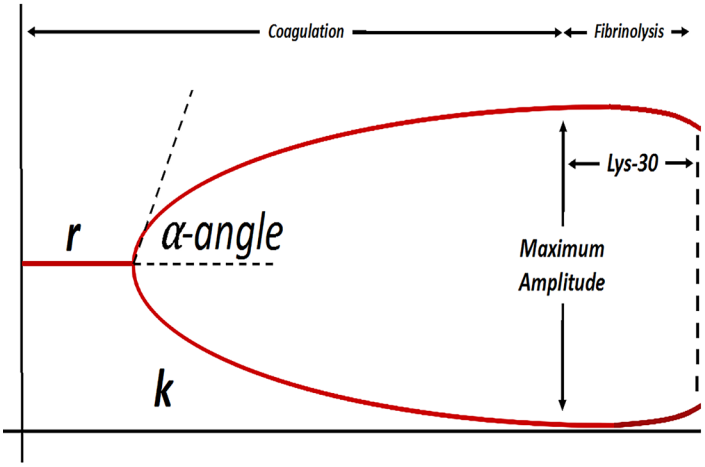

Figure 1. Example of thromboelastogram analysis curve (adapted from Stravitz et al, 2012[26]).
r – measured in minutes, the reaction time (r) represents the latency period between the initiation of the reaction and the initiation of fibrin formation, represented by *k; k* – measured in minutes, the kinetic time (k) represents the time required to reach a clot strength of 2mm; *α*-angle – measured in degrees, corresponds to kinetics of clot formation; a steeper angle corresponds to a more rapid rate of clot formation. Maximum amplitude – measured in mm, represents the maximum clot strength and is a function of both platelet count / function and fibrinogen concentration; Lys-30 – represents the rate of clot degradation in the 30-minute period following the achievement of maximum clot strength as represented by maximum amplitude.

factors associated with a true coagulopathy including activation of the coagulation cascade, the inhibition of the clotting cascade, fibrinolytic activity, and platelet function.[26,48] This information from a point-of-care tool can guide the transfusion of specific blood products (e.g., platelets, fresh frozen plasma [FFP], cryoprecipitate) or medications (e.g., tranexamic acid)[55] while minimizing unnecessary medications or blood product transfusion[49,54,56,57] or predicting mortality[51] and thrombotic risk[58] following admission through the ED as a trauma activation.

Stravitz[26] provides an excellent summary with examples of TEG curves during a variety of clinical scenarios (thrombocytopenia, acute hepatic failure, decompensated cirrhosis, etc.) while da Luz et al.[55] provide similar information in the context of a trauma patient. The correlation of TEG results with dynamic risk of bleeding has been demonstrated during the course of a patient's hospitalization.[31] A pitfall of TEG must be recognized: given the dynamic state in which a cirrhotic patient and their coagulation profile exist, a baseline TEG result obviously does not accurately predict bleeding or thrombotic risk over a follow-up period measured in months or years.[30] It would not be unreasonable to assume that a critically ill, hospitalized patient with cirrhosis would require repeated TEG assessments during the course of their resuscitation and treatment. The utilization of TEG is associated with an increased cost as compared to ordering a laboratory test such as PTT,[54] though this cost may be in the order of $22 United States dollars per test.[39] Overall, TEG does provide trends toward improved hemostasis, decreased anticoagulant or blood product requirements, and improved patient outcomes[39,54] through which these additional costs may be quickly recouped. As a result, TEG has been described as cost-effective overall.[56]

Specific to liver disease, TEG-guided transfusion protocols during liver transplantation decrease the amount of bleeding but have no effect on overall mortality.[50] Similarly, TEG can predict post-operative thrombus risk in these patients.[50] With respect to acute procedural setting such as central line placement, a small nonrandomized prospective study (N=90) demonstrated TEG's ability to predict bleeding (n=11) in patients with cirrhosis and abnormal INR results during blind central line placement.[59] Additionally, the INR cut off for bleeding risk in this same study was 2.6. Overall, the majority of the TEG studies and specifically those specific to liver disease are small and not without limitations. Obviously prospective, randomized studies would strengthen the case for TEG's utility, given the plethora of literature that indicates the lack of utility of traditional laboratory studies of coagulation. The potential benefit of TEG with respect to point-of-care assessment of whole blood coagulation characteristics makes it a tool worthy of further study with larger populations in randomized controlled studies.

Management Options for Coagulopathy

A small study in a broad population of ED, surgical, general medical ward, and ICU patients demonstrated that the use of FFP to correct mild elevations in PT and INR only corrected the values to baseline in 0.8% of patients, while only 15.9% of this population achieved a 50% correction in PT and INR values.[60] These results are consistent with findings presented in multiple review papers on the topic[17,32] with one authoritative source bluntly stating that the transfusion of these products only provides partial and transient correction but never a complete correction of the laboratory derangements regardless of the number of FFP units transfused.[19] The transient mean change in INR as a result of transfusion ranges from 0.03 to 1.3 per unit of FFP,[24] and the effect is described as "trivial" because the transfusion of FFP "fails to correct the PT in 99% of patients."[60] Low-dose recombinant factor VIIa therapy has been associated with improved outcomes and decreased transfusion requirements in trauma patients with coagulopathy.[61]

It would appear the best management of suspected coagulopathy, as assessed by INR and whether the patient is actually hyper- or hypocoagulable, is the treatment of the underlying cause for the hepatic and synthetic dysfunction.[5] Given the limited utility of INR as a tool of assessing synthetic function in a cirrhotic patient, this might include administering vitamin K in an effort to augment synthetic

function of clotting fators.[17,32] However, the clinical benefit of this approach may not be predictable as the absorption of vitamin K (and A, D, and E) is dependent on bile production,[24] a process that is complex in itself but generally accepted to be decreased in the setting of cirrhosis.[31,62,63] On a more positive note, multiple studies have demonstrated that a surprisingly small proportion, generally <15%, of cirrhotic patients are truly vitamin-K deficient.[24] This provides further evidence that INR, a tool designed to monitor vitamin-K antagonism, is inappropriate for assessing the coagulopathy of cirrhotic patients.

The safety threshold of achieving and maintaining an INR<1.5 in patients prior to non-emergent invasive procedures was derived from a report by the American Society of Anesthesiologists Task Force on Blood Component Therapy.[35] A review by Ng[24] describes this "incorrectly" derived and accepted target value while chronicling subsequent publications demonstrating insufficient evidence to support prophylactic blood product transfusions to optimize INR. A major risk of blood product transfusions to correct an elevated INR in the setting of hepatic dysfunction is due to the lack of efficacy and inability to accurately assess the transfusion-related risk borne by the patient. While the risk associated with transfusion-associated reactions such as TRALI or hemolysis is significantly lower than the 1-3% risk of hemorrhage in minor procedures that can be performed at bedside, it should be noted that many transfusion-associated events are under-reported and the benefit, as summarized in the prior section to be often transient or minimal, does not outweigh the risk.[17,32,60,64-66]

In patients with liver disease in particular, the prophylactic transfusion of cryoprecipitate has been associated with an increased risk of thrombotic events in end-stage liver disease (ESLD) patients[17] and thus should be avoided if not absolutely necessary. Administering factor VIIa may be considered if FFP and vitamin K has not corrected the coagulopathy, but care should be taken to avoid treating simply to correct an abnormal laboratory result.[17,32] Other recombinant techniques such as plasma exchange have only demonstrated utility in pre-operative settings in preparation for liver transplantation.[17] The evidence published since the American Society of Anesthesiologists Task Force on Blood Component Therapy[35] recommendation of maintaining an INR <1.5 now suggests, as reviewed and summarized in Ng,[24] that procedural safety is achievable with INR values ranging from 2.5 to 4.0.

The final aspect of the management of coagulopathy in cirrhotic patients with elevated INR values is prophylactic anticoagulation for venous thromboembolism (VTE). Hospitalized patients with liver disease develop a deep vein thrombosis or pulmonary embolism (PE) at rates of 4-12% despite standard-of-care prophylaxis;[27] hospitalized cirrhotic and noncirrhotic liver disease patients may experience new VTE at a rate of up to 6% regardless of INR.[43,67] The risk of VTE is greater than the risk of PE, although the etiology of this discrepancy is not well understood.[10,67,68] The relative risk for VTE in cirrhotic patients is reported to be >2[68] and associated with greater mortality in higher Child-Pugh stages.[43] The best predictor of VTE in a cirrhotic patient assumed to be "auto-anticoagulated" based on an elevated INR value is serum albumin; it is hypothesized that lower serum albumin concentration is a surrogate for decreased protein synthesis by the liver and thus decreased production of endogenous anti-coagulant factors such as Protein C and S.[67] This is concerning as some studies report rates of prophylactic anticoagulation in this population to be as low as only 21%.[27,43]

Unfortunately, the available literature focuses on the under-recognized need for anticoagulation and the current misconception related to "auto-anticoagulation." The guidelines, however, do not provide the needed specifics related to the prophylactic approach in complex clinical scenarios such as caring for critically ill patients with cirrhosis.[50,69,70] Perhaps recognizing the misconception will be the first step toward the research and attention required to create guidelines related to these specific patients and scenarios.

DISCUSSION

Hemostasis in cirrhotic patients is a dynamic balance.[15,24] In the majority of clinical scenarios, patients with cirrhosis and impaired protein synthesis achieve hemostasis despite elevated INR values[20] and may be more prone to thrombotic or thromboembolic events.[27,43,67] The best application of INR to a patient with liver disease is to monitor the degree of impairment of synthetic function[12] or to predict mortality.[43] Predictive scores such as MELD make use of INR for this specific purpose in ESLD,[71] though this may have specific challenges based on the variation in results dependent upon the commercially available thromboplastin used in the analysis;[25] the universality of the results may not be as robust as widely assumed.

The commonly accepted dogma in the ED that an elevated INR is associated with increased risk of hemorrhagic events while protected from thrombotic complications is not supported by the literature[10,15] or by the underlying theory of INR testing. Furthermore, guidelines such as "INR≤1.5" are merely expert opinion that are not supported by more recent, evidence-based publications and may expose patients to more risk if prophylactic blood product transfusions occur in the futile pursuit of a transient decrease in INR.[24] Unlike other coagulopathies observed in ED and ICU settings such as hemophilia where life-threatening bleeding is a real and serious concern, cirrhotic patients often have rebalanced hemostasis and do not hemorrhage at the rates many clinicians wrongly assume to be the case.[10,15,24,57] The recognition of this commonly accepted pitfall will be the first step to addressing a number of questions: what is the best method by which to accurately assess the coagulopathy associated with liver disease?; and what is the threshold at which the risk/benefit ratio is exceeded for a specific procedure such as central line or lumbar puncture?

LIMITATIONS

Medicine's understanding of the physiology associated with normal coagulation stems from studies of rare congenital clotting disorders such as hemophilia A or factor VIII deficiency.[21] Studies with patients in these populations have not been able to identify thresholds of safe limits for individual clotting factor deficiencies, though the commonly accepted limit is to maintain clotting factor deficiencies at a level of >1%.[24] Given the deficiency in multiple coagulation factors in a cirrhotic presentation, vitamin K-dependent clotting factor deficiency (VKCFD) is thought to be a superior, naturally occurring analogue to hemophilia in assessing the bleeding risk associated with surgical procedures or trauma in the setting of an elevated PT or INR.[24] However, this analogue is not perfect and the natural history of VKCFD "suggests factors other than simple clotting-factor deficiencies alone predispose to bleeding."[24] When the multiple factors involved in thrombotic and thrombolytic events are considered as in the Table , the complexity of predicting "who will bleed" and "who will clot" becomes evident; it becomes even more evident that, as reported by Donaldson et al.,[16] a simple test of only one pathway is inadequate to accurately make this prediction.

CONCLUSION

In patients with abnormal coagulation testing results in the setting of liver disease, INR and PT may be best used to provide the practitioner with information about the synthetic function of the liver but not to assess hemorrhagic risk. The evidence supports a "watchful waiting" approach to the transfusion of platelets and fresh-frozen plasma with a bedside assessment of the patient's actual hemorrhagic risk. The safest assumption that a practitioner in an acute and critical setting can make about any cirrhotic patient is that, even on their healthiest day, they are at an elevated risk of adverse outcomes that may be associated with an adverse thrombotic rather than the commonly feared catastrophic hemorrhagic event.

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Transcutaneous Electrical Nerve Stimulation (TENS) in the Emergency Department for Pain Relief: A Preliminary Study of Feasibility and Efficacy

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Introduction: Given the high rates of opioid addiction and overdose in the United States, non-opioid means of treating pain are increasingly needed. Transcutaneous electrical nerve stimulation (TENS) therapy is an effective non-opioid modality for treating pain, but has not yet been routinely used in emergency department (ED) settings. In this study we asked the following questions: Are TENS units a feasible treatment for pain in the ED? How effective are TENS units for the management of pain in a general ED population?

Methods: At our institution, we performed a pilot study using TENS units for pain. Patients in the ED were given, at the discretion of the ED provider, TENS units for the treatment of pain. Patients could be included for acute or chronic pain on whatever part of the body that was safe to use with TENS.

Results: A chart review of patients receiving TENS units in the ED (n=110) revealed that TENS was useful in relieving pain, along with other treatments, in 99% of cases. When surveyed, 83% of patients reported a functional improvement while using the TENS, and 100% of patients would recommend a TENS unit to a family or friend. When surveyed, 100% of ED staff observed that TENS units were effective in treating pain for patients, and 97% would want to use them if they themselves were patients.

Conclusion: Overall, in this small pilot study, TENS units appeared to be effective in our ED for reducing pain, when added to standard treatment. Additional studies are needed to determine which conditions are most responsive to TENS therapy, and the magnitude of pain reduction when used alone. [West J Emerg Med. 2018;19(5)872-876.]

INTRODUCTION

With the high incidence of addiction, overdose, and death from heavy prescribing of opioids in the United States,[1-3] medical providers often try to avoid opioids but struggle with how to manage pain without using them. Transcutaneous electrical nerve stimulation (TENS) therapy is an effective non-opioid modality for treating pain,[4-16] but it is not yet commonly used in emergency department (ED) settings. TENS works by a phenomenon called "gate control theory."

There are multiple receptors in the periphery – pain, vibration, temperature, etc. – all of which transmit information to the brain via the spinal cord. The spinal cord fibers that transmit peripheral information cannot transmit information from multiple receptors simultaneously, and so the stimulation of multiple receptors at the same time results in decreased signal from each to the brain. TENS units, by providing a low-dose electrical current, stimulate vibration receptors, which when applied to an area having pain, reduces the transmission

of painful stimuli to the brain.[4] Additionally, when TENS units are repeatedly applied to an area, they increase the secretion of endogenous endorphins, reducing pain.[5] As such, they are useful for the management of both acute and chronic pain.

The goal of this study was to evaluate the efficacy of TENS units for the treatment of pain in the ED. The study questions were as follows: 1) Are TENS units a feasible treatment for pain in the ED?; and 2) How effective are TENS units for the management of pain in a general ED population? The project was a pilot program in our ED, and our study reflects the program evaluation. To the best of our knowledge, this is the first program to use TENS units on a routine basis for pain management in the ED, and represents the first study of using TENS therapy in the ED.

Population Health Research Capsule

What do we already know about this issue?
In the setting of the U.S. opiate epidemic, non-opiate pain treatment is desirable. Transcutaneous electrical nerve stimulation (TENS) therapy is an effective non-opioid treatment for pain.

What was the research question?
Are TENS units a feasible treatment for pain in the emergency department (ED), and if so, how effective are they in treating pain in a general ED population?

What was the major finding of the study?
In this small pilot study, nearly all patients (99%) had relief of pain in the ED with TENS therapy.

How does this improve population health?
Using TENS units for pain relief in the ED could reduce the need for opioids, while still treating pain.

MATERIALS AND METHODS

This study was conducted at a suburban community hospital, with an annual ED census of approximately 56,000 yearly visits. The hospital developed a pilot study of using TENS units for pain management in the ED, and we report here the program evaluation of this project. The study was deemed a program evaluation by the hospital's institutional review board committee, and therefore exempt from its approval.

When the project was designed, we chose to offer TENS therapy to our providers as a pain management option in our ED. We did not specify whether or not TENS units could be used as mono-therapy or in combination with standard treatment for painful conditions in our ED. While the overarching goal was to provide effective pain relief without the need for opioids, this project was a feasibility pilot study to see if TENS units could be used routinely in our ED for pain management, along with other treatments. ED staff were informed that we were conducting a pilot study of using TENS units in our ED for pain management, but were not informed how we would be collecting data.

We decided, when beginning the project, that we would collect data in three ways to evaluate the efficacy of our program: chart review of patients receiving TENS therapy; surveys of patient experience; and surveys of ED staff experience. Our study hypothesis was that as TENS units are effective in treating pain in multiple studies, TENS therapy for pain control in a general ED population would be, overall, effective in reducing pain. Our focus, given the preliminary nature of the study, was not to quantify the effect of pain relief, but rather to demonstrate that TENS could be used for pain control in an ED setting to support continuation of TENS therapy in our ED and provide preliminary positive study results to support additional, and more methodologically rigorous studies on the use of TENS units in the ED.

Patients were included in the study if they met the following inclusion criteria: age over 15 presenting with acute or chronic pain in any area of the body, and open to trying a TENS unit for pain control. Patients were chosen to receive a TENS unit at the discretion of the treating provider in the ED. Exclusion criteria, contraindications, and precautions for the use of a TENS unit are listed in Table 1.

For those patients given a TENS unit, the patient's name, age, medical record number, and email address (if available) were recorded for follow-up. The TENS units were applied by the treating provider to the area of greatest pain, guided by the following recommendations: First, when using the TENS unit, electrode pads should not be touching, and should be at least one inch apart. Second, the electrode pads should not be placed too far apart, as it reduces the efficacy of the therapy. Third, electrode pads should be placed surrounding the area of greatest pain, to allow for the electrical current to pass between the electrodes through the painful area.

Patients received instructions from the manufacturer and instructions written by ED staff after reviewing how to use the unit. Patients were treated with the TENS unit for 20-30 minutes. Patients could receive any other medication or treatment to manage pain as directed by the treating provider. Patients could adjust the settings of the unit by themselves, or with assistance from ED staff. At discharge, the patient took the TENS unit home with them for further use.

Table 1. Exclusion criteria/contraindications for the use of a transcutaneous electrical nerve stimulation (TENS) unit.

TENS unit cannot be placed over the eyes.
TENS unit electrodes cannot be placed on opposite sides of the head that would result in a transcerebral current.
TENS unit electrodes cannot be placed on the chest and back that would result in a transthoracic current.
TENS units cannot be placed on the anterior neck due to the possibility of a vasovagal event or laryngospasm.
TENS units cannot be placed internally.
TENS unit electrodes cannot be placed directly over the spinal column.
TENS unit electrodes should not be placed near any sort of implantable device (spinal stimulator, pacemaker, etc.) where current from the TENS would interfere with the device.
For pacemakers or pacemaker/defibrillators, a TENS unit must be placed at least six inches away from the pacemaker AND during initial TENS unit placement, the patient should be on a cardiac monitor to watch for any interference.
TENS units should not be used over the uterus in pregnant women.

Our primary assessment of the efficacy of TENS units for pain management in our ED was chart review. An ED staff member performed a retrospective chart review of the cases in which a TENS unit was used, reviewing whether or not providers documented a response to the TENS unit, and whether or not the TENS unit was documented anywhere in the medical record as being helpful in relieving pain. We also recorded whether pain was acute or chronic, traumatic or atraumatic, and on which part of the body the TENS unit was applied. Acute pain was defined as less than three weeks in duration, while chronic pain was defined as three or more weeks in duration. Traumatic was defined as resulting from an acute traumatic injury, while atraumatic was defined as occurring in the absence of an injury.

Data collection was done using a pre-prepared collection spreadsheet in Microsoft Excel (Microsoft Corp., Redmond, Washington) in a standardized fashion. Secondarily, we also surveyed patients who received TENS units and surveyed ED staff on their experience with TENS units. We sent out an anonymous email-based survey (SurveyMonkey, San Mateo, CA) eliciting patient feedback within one week of the ED visit to all patients who listed an email address. After four months of using the units, all ED staff received an anonymous, email-based survey (SurveyMonkey) eliciting their feedback on how well the units worked. Copies of both surveys are available as supplemental files. Data analysis was done using Microsoft Excel (Microsoft Corp., Redmond, Washington).

The TENS unit used was made by AccuRelief (Compass Health Brands, Middleburg Heights, OH), and the model was "Dual Channel TENS Electrotherapy Pain Relief System."

RESULTS

Between September 2017 and February 2018, 110 patients in our ED were treated with TENS units for pain management. Of those, 70 (64%) were female, and the average age of treated patients was 49 years. Patients who received a TENS unit varied in age from 15 to 92 years.

In our chart review, in 97 out of 110 cases (88%) in which a TENS unit was used, the ED documentation reported how the patient responded to the TENS unit. In the remainder of cases, there was no documentation at all of the patient's response to the TENS unit, merely that the patient had been treated with a unit.

In 96 out of 97 (99%) cases in which the response to the TENS unit was documented, the TENS unit improved the patient's pain. Information about the type of pain being treated is reported in Table 2.

Table 2. Information regarding type/location of pain in patients given a transcutaneous pain-relief unit (n=97).

	Total	Percent of total
Acute pain	54	55.7%
Chronic pain	43	44.3%
Traumatic pain	42	43.3%
Atraumatic pain	55	56.7%
Location of pain		
Back (thoracic/lumbar)	59	61.1%
Shoulder/clavicle	15	15.5%
Neck	8	8.2%
Flank/rib	6	6.2%
Hip	5	5.2%
Upper extremity	2	2.1%
Lower extremity	2	2.1%

For patient surveys, we had email addresses for 60 patients out of the 110 total patients who received a TENS unit, and 14 out of 60 patients (23%) responded to our email-based survey. Of the responders, 80% reported that they used their TENS unit multiple times after their ED visit. Zero patients required an opioid for pain relief when using the TENS unit; 92% of patients reported that they would use a TENS unit in the future. Of the patients surveyed, 100% said they would recommend a TENS unit to a friend or family, and 83% reported a functional improvement while using a TENS unit. Average pain scores from the survey are reported in Table 3, along with 95% confidence intervals.

Table 3. Pain scores from patient survey.

	Score is 0-10, 10 being most severe (with 95% CI)
Before using TENS unit	8.50 (7.52 - 9.48)
While using TENS unit	4.67 (3.51 - 5.89)
After ED visit, and after using TENS unit, on day of survey	2.58 (1.41 - 3.79)

CI, confidence interval; *TENS*, transcutaneous electrical nerve stimulation; *ED*, emergency department.

For staff surveys, 35 out of 132 ED staff (27%) responded to our survey: 20% of respondents were ED techs, 45% were nurses, 29% were physicians, and the remainder were a combination of scribes and physician assistants. The surveys indicated that 100% of all ED staff reported they had observed TENS units improving pain in the ED; 100% of all ED staff reported that patients liked TENS units, and 97% of ED staff reported that if they were a patient in the ED with a sprained back, they would want to receive treatment with a TENS unit. Furthermore, 100% of ED staff would recommend a TENS unit to a friend or family member.

DISCUSSION

In our pilot study, TENS units appeared to improve pain in ED patients, when combined with standard ED therapy. Between chart review, patient responses, and ED staff observations, TENS units were observed to improve pain and be useful in the treatment of pain in the ED.

A TENS unit is an inexpensive and reusable device with few side effects for the management of pain; therefore, the device should be considered as a high-yield intervention for the treatment of pain in the ED, particularly in the setting of this nation's opioid crisis and high rates of addiction. Our experience with this pilot study was that most ED providers are unfamiliar with the use of TENS units, creating a barrier to their use and implementation. In our ED, two providers (both are authors of this study) overcame this reluctance by championing the use of these devices, providing bedside teaching to all ED staff on how to use them, and developing protocols on their use. For departments considering using TENS units in their ED, one or more providers should consider taking the lead on implementing the project.

The authors are aware of the limitations of the study, as will be formally discussed below, but would like to highlight that this pilot study presents data that support our hypothesis that TENS therapy for pain control in a general ED population would be effective in reducing pain. As such, our hope is that the results of this study will encourage other institutions to consider similar pilot projects in their own institutions, and stimulate further, and more definitive, study on the topic. As mentioned earlier, in our ED TENS units were used in addition to standard treatment. Some patients received only a TENS unit, while others received multiple medications, including opioids in some cases.

Additionally, providers treated a wide array of complaints with TENS units, from humeral fractures and lumbar myofascial strains to chronic hip arthritis. As mentioned in the methodology section, our focus on the study was to prove that TENS units could be feasibly used in the ED setting for pain management, and that TENS units would be effective in reducing pain. Additional study to determine which types of pain and injuries respond best to TENS units would be useful to guide future implementation of programs for TENS therapy in the ED.

LIMITATIONS

This manuscript represents a pilot study at a single hospital on the use of TENS units for pain control, and has several limitations. First, providers did not document the response to a TENS unit in all cases, and not all patients or ED providers responded to our survey. As such, it is possible that there is a bias toward a positive effect, given that not all providers and survey recipients responded. As our online patient survey was anonymous, we could not track which patients who provided email addresses responded or did not respond, so we were not able to obtain any information on response bias by type of pain or other characteristic.

Additionally, our study was not able to quantify the magnitude of pain relief with TENS as we did not quantify the amount of pain relief in our chart review. In the patient survey, the downward trending pain scores seen in the patients using TENS units who responded to our survey may represent the natural course of an acute myofascial injury such as a strain to improve over time rather than the effect of the TENS unit. We also chose to evaluate all complaints of pain, acute or chronic, in any part of the body. As such, we did not focus on which types of pain or locations of pain were most responsive to TENS treatment.

Additionally, as this study lacks blinding or randomization, there may have been bias due to staff over-documenting positive results to TENS therapy, in the hope of creating a positive study. While this is possible, it is unlikely. Even though ED staff were aware that we were conducting a study of the use of TENS units, they were not informed of our collection methods beyond a survey of staff experience. Lastly, as ED providers had a large amount of freedom in choosing who received a TENS unit, it is possible that there was a bias, when deciding which patients should receive a TENS unit, toward patients who had a favorable perspective regarding these devices. A randomized, controlled, and blinded study design would yield more accurate data.

CONCLUSION

In this small pilot study of using TENS units in a community hospital ED, we found that these units were effective, when used with standard ED treatments, in reducing pain. Additional studies with more robust methodology are needed to confirm the utility of this treatment modality to support widespread adoption, and focus on what types and locations of pain are most responsive to treatment.

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Emergency Providers' Pain Management in Patients Transferred to Intensive Care Unit for Urgent Surgical Interventions

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Introduction: Pain is the most common complaint for an emergency department (ED) visit, but ED pain management is poor. Reasons for poor pain management include providers' concerns for drug-seeking behaviors and perceptions of patients' complaints. Patients who had objective findings of long bone fractures were more likely to receive pain medication than those who did not, despite pain complaints. We hypothesized that patients who were interhospital-transferred from an ED to an intensive care unit (ICU) for urgent surgical interventions would display objective pathology for pain and thus receive adequate pain management at ED departure.

Methods: This was a retrospective study at a single, quaternary referral, academic medical center. We included non-trauma adult ED patients who were interhospital-transferred and underwent operative interventions within 12 hours of ICU arrival between July 2013 and June 2014. Patients who had incomplete ED records, required invasive mechanical ventilation, or had no pain throughout their ED stay were excluded. Primary outcome was the percentage of patients at ED departure achieving adequate pain control of ≤ 50% of triage level. We performed multivariable logistic regression to assess association between demographic and clinical variables with inadequate pain control.

Results: We included 112 patients from 39 different EDs who met inclusion criteria. Mean pain score at triage and ED departure was 8 (standard deviation 8 and 5 [3]), respectively. Median of total morphine equivalent unit (MEU) was 7.5 [5-13] and MEU/kg total body weight (TBW) was 0.09 [0.05-0.16] MEU/kg, with median number of pain medication administration of 2 [1-3] doses. Time interval from triage to first narcotic dose was 61 (35-177) minutes. Overall, only 38% of patients achieved adequate pain control. Among different variables, only total MEU/kg was associated with significant lower risk of inadequate pain control at ED departure (adjusted odds ratio = 0.22; 95% confidence interval = 0.05-0.92, p = 0.037).

Conclusion: Pain control among a group of interhospital-transferred patients requiring urgent operative interventions, was inadequate. Neither demographic nor clinical factors, except MEU/kg TBW, were shown to associate with poor pain management at ED departure. Emergency providers should consider more effective strategies, such as multimodal analgesia, to improve pain management in this group of patients. [West J Emerg Med. 2018;19(5)877–883.]

INTRODUCTION

Although pain is the most common complaint for emergency department (ED) visits,[1,2] and the fifth vital sign,[3] inadequate treatment of pain occurs frequently in the ED: up to 74% of patients are discharged with moderate to severe pain[4] and 57% of patients fail to achieve a 50% pain score reduction.[5] Pain is a major cause of patient dissatisfaction in United States healthcare.[6] In 2012, the Centers for Medicare and Medicaid instituted the new value-based purchasing program, which tied financial incentives with higher patient satisfaction scores[7] and measures to improve patient care, including pain management.[7] Therefore, effective pain management has become an important aspect of patient care.

Pain undertreatment is multifactorial; it has been linked to providers' concern for drug-seeking behaviors[8] and physicians' perception that pain was exaggerated.[9] However, patients with objective findings of pain, such as long bone fractures, were twice as likely to receive opioid pain medication[10] than those who did not have fractures. Therefore, our goal was to study pain management among a group of patients who were inter-hospital transferred to intensive care units (ICU) for urgent surgical interventions and to identify any demographic or clinical factors associated with pain undertreatment. We hypothesized that these patients who showed objective findings for their pain complaints would receive adequate pain control at ED departure.

Population Health Research Capsule

What do we already know about this issue?
Pain management in the emergency department has been inadequate, but patients with objective findings for pain were more likely to receive pain medicine.

What was the research question?
Whether patients, who were transferred to a quaternary academic center for urgent surgical intervention, would receive adequate pain management.

What was the major finding of the study?
Pain management among patients with surgical pathology was inadequate. Emergency providers (EPs) did not employ effective strategies for pain management in these patients.

How does this improve population health?
EPs should employ effective strategies, including multimodal analgesia, to improve pain management among patients who needed surgical interventions.

METHODS

Patient Selection

We performed a retrospective study using a convenience sample of non-traumatic, interhospital adult patients who were transferred from a referring ED to any ICU at a quaternary, academic center for urgent surgical interventions, defined as having surgery within 12 hours of arrival. We included interhospital-transferred patients from referring EDs between July 2013 to June 2014 who were taken to the operating room urgently within 12 hours of arrival. We excluded patients who required mechanical ventilation in the ED and ED records missing pain assessment at ED triage or departure. We also excluded patients who reported no pain throughout their ED stay. The study was approved by our institutional review board.

Outcome

Primary outcome was percentage of patients receiving adequate pain control at ED departure. Adequate pain control was defined *a priori* as pain level, reported on 11-point verbal scale (0-11), at ED departure that was equal or less than 50% from triage levels. Pain reduction at equal or less than 50% was considered clinically meaningful to ED patients in previous studies.[5,11] We calculated percentage of pain reduction at ED departure as (pain level of departure / pain level at triage) x 100. If pain score at ED departure was equal or greater than triage pain score, percentage of pain reduction would be assigned 100%. Secondary outcomes included percentage of adequate pain control by admitting medical services, and predictors that may have been associated with inadequate pain control at ED departure.

Data Collection and Analysis

Investigators (TN, GT, LT, AA, RD, KJ, JR, DH), who were not blinded to the study hypothesis, were first trained by the principal investigator (PI) (QKT) for data extractions. Data were extracted to a standardized Microsoft Access form (Microsoft Corp, Redmond, Washington) and 40% was randomly reviewed by the PI to maintain interrater agreement of at least 90% for systolic blood pressure, heart rate, and pain at ED triage, ED departure and medication administration. The team met every month to discuss data extraction issues and to adjudicate disagreements between junior investigators and the PI until data collection was completed.

ED records from patients who were taken to the operating room within 12 hours of ICU arrival were identified and examined for data extraction. Independent variables extracted

from patients' ED records included demographic factors (age, gender, triage day of week, triage time of day, admitting services); clinical data (Emergency Severity Index [ESI]; vital signs/pain score at ED triage and departure; ED length of stay [LOS]; components for the sequential organ failure assessment score [SOFA]; presence of continuous infusion; and dosage of pain medication). The continuous infusion did not include vasopressors, which were part of the SOFA score. To evaluate the opioid dose that patients received, we converted the doses of the different parenteral or intravenous (IV) opioids to morphine equivalent unit (MEU), as previously described.[12,13] We considered 0.15 milligrams (mg) of IV hydromorphone and 0.01 mg of IV fentanyl as 1 MEU. Similarly, 5mg of oral oxycodone, hydrocodone were equivalent to 2 MEU.[12,13]

Data were expressed as mean and standard deviation (SD) or median with interquartile range (IQR), where appropriate. The effect of variables on inadequate pain control was assessed using multivariable logistic regression. We *a priori* selected therapeutic interventions, such as total MEU, MEU per kilogram (kg), and time interval to first narcotics, that may have clinically affected outcomes, to be included in the multivariable logistic regression. Independent variables were first evaluated in univariable analyses; we excluded those with weak association with outcome variable (p-value≥0.101) from the multivariable logistic regressions. All p-value ≤0.05 were considered statistically significant. We performed all statistical analyses using Sigma Plot version 14 (Systat Software, San Jose, California).

RESULTS

Patient Characteristics

We electronically identified 195 patients who were transferred to any adult ICU at our institution between July 2013 and June 2014; 112 patients who were transferred from 39 unique EDs met inclusion criteria and were included in the final analysis (Figure 1). The majority of patients were male (63%), and mean age was 57 (SD = 18) years. Median ED LOS was 3.9 [2.5-6.4] hours. Median [IQR] of ESI and SOFA scores for the patients were 3 [2-3] and 1 [0-3], respectively. The mean pain score at triage was 8 (3) with a majority of patients (66%) reporting a severe pain score from 8-10. The admitting service with the most patients in our study was vascular surgery (24%), while acute care emergency surgery (ACES) and cardiac surgery were second (18%) and third (17%), respectively.

Interventions by Emergency Providers (EP)

Most patients (66%) received only narcotics, and the median number of administered doses was 2 [1-2]. The median number of pain assessment was 3 [2-5]. The majority of administered pain medications were narcotics (66%), while the time interval from triage to first dose of narcotics was 61 (35-177) minutes. Median of total MEU administered was 7.5 [5-13] and median of total MEU per body weight was 0.09 [0.05-0.16] MEU/kg body weight (Table 1).

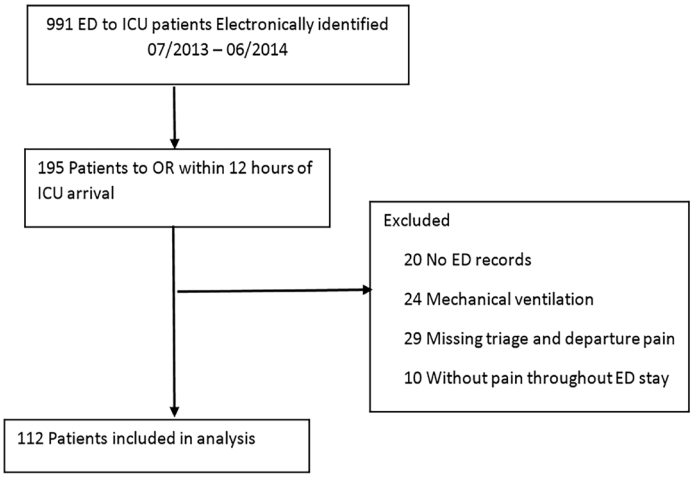

Figure 1. Patient selection diagram.
ED, emergency department; *ICU*, intensive care unit; *OR*, operating room.

Outcomes

Overall, emergency providers (EP) poorly managed pain in this high-risk group of patients. Pain control was adequate in only 38% of patients and inadequate in 62% (Table 2A), with the mean pain level at ED departure 5 (3). Vascular surgery had the highest percentage (59%) of patients receiving adequate pain control, among the five major admitting services. Among the independent variables, only ESI was significantly associated with inadequate pain control (OR = 8.29, 95% confidence interval [CI] = 1.01-68.1, p=0.049) (Table 2B). However, in the multivariable logistic model (Table 2B), only total MEU/kg body weight was associated with adequate pain control (OR = 0.22, 95% CI = 0.05-0.92, p = 0.037).

We also performed a subgroup analysis of patients presenting with severe pain (triage pain 8-10) only, to avoid the confounding factor of whether the patient refused pain treatment. There were 74 (66%) patients presenting with severe pain. Thirty patients (41%) had adequate pain control at ED departure. Comparing to all patients, median of total MEU (8 [5-14], p=0.3) or MEU/kg of body weight (0.11 [0.06-0.17], p = 0.14) was not significantly different. Multiple logistic regression adjusting for the same clinically-significant factors showed that no interventions by EPs were associated with adequate pain control (Table 2B).

DISCUSSION

Our study showed that among patients who were transferred from EDs to ICUs for urgent surgical interventions, only 38% achieved meaningful reduction of pain level at ED departure, defined as 50% or less of triage levels. We identified one factor, total MEU/kg total body weight, associated with adequate pain control. However, we identified three potential barriers for adequate pain management in the EDs. Our findings suggested that pain control for this group of

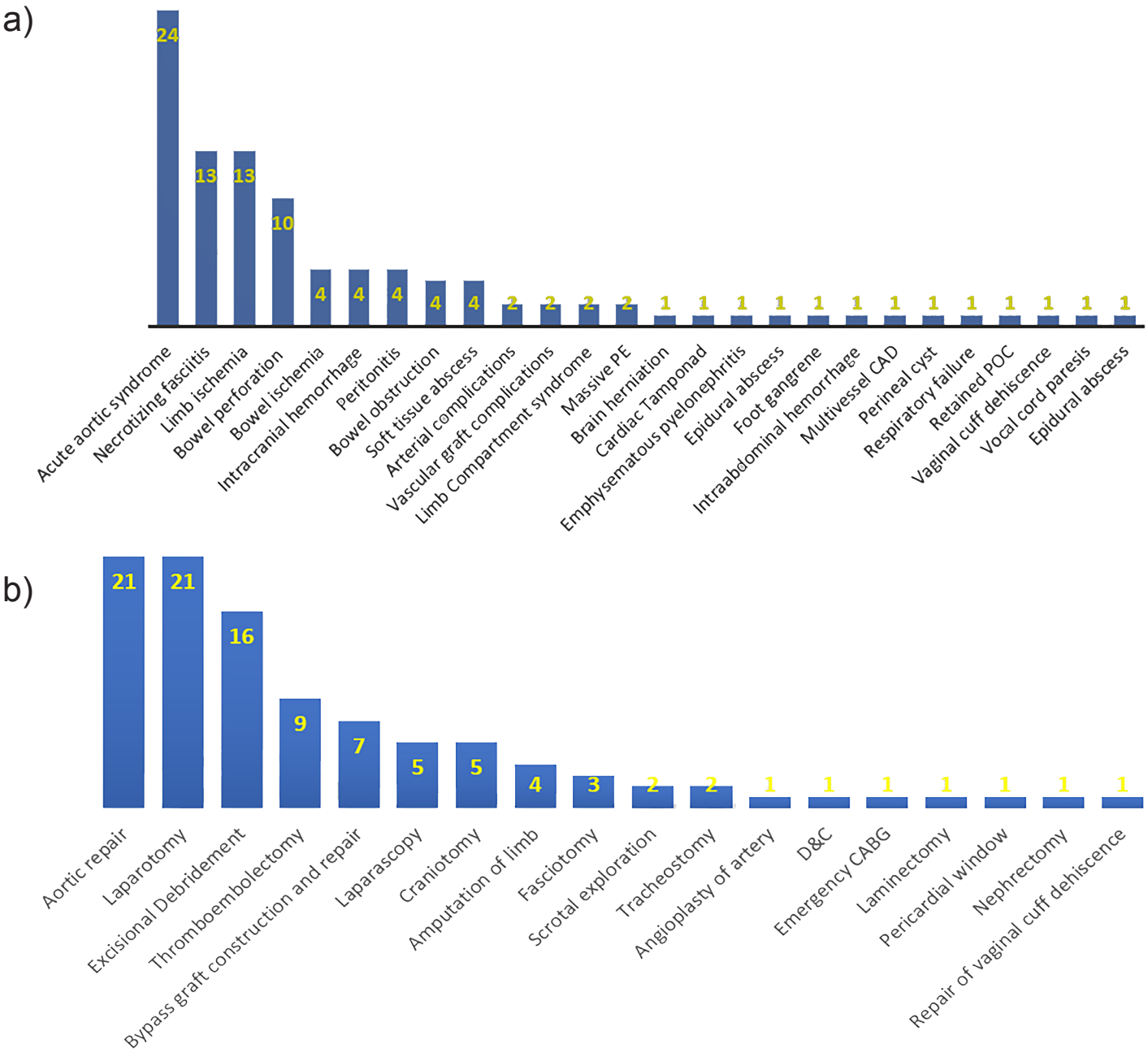

Figure 2ab. a) Categories of diagnoses among patients transferred for immediate surgical interventions; b) Categories of surgical procedures for transferred patients requiring urgent surgical interventions. Y-axis represented percentage of total population; X-axis represented names of categories. Acute aortic syndrome included type A and type B aortic dissection, aortic aneurysm, intramural hematoma, etc.
PE, pulmonary embolism; CAD, coronary artery disease; POC, product of conception; Dand C, dilation and curettage; CABG, coronary artery bypass graft.

ED patients with time-sensitive diseases was inadequate.

In our study, the median time interval from triage to IV morphine was 61 minutes (range 35-177). A previous prospective, multicenter study showed that the median time from ED triage to any analgesic administration for ED patients presenting with moderate to severe pain[4] was 90 minutes (range 0-962 minutes). Only 29% of patients who were given analgesics received them within one hour of arrival. Although the results from these two studies may not be comparable, our study suggested a shorter time from triage to administration of pain medication and that 50% of the patient population received pain medication within one hour of arrival (data not shown). These

Table 1. Demographic information from 112 patients who were transferred to an Intensive care unit at a tertiary referral academic center and underwent surgical interventions within 12 hours of arrival.

Total patients, N (%)	112 (100)
Gender	
Male (N, %)	70 (63)
Female (N, %)	42 (37)
Age (years), mean (SD)	57 (18)
18-40 (N, %)	22 (20)
41-60 (N, %)	42 (38)
>61 (N,%)	48 (42)
Teaching hospital status,	
Non-teaching (N, %)	82 (73)
Teaching (N, %)	30 (27)
Ground travel distance (km)	51 [22-11]
≤20, (N, %)	24 (21)
20.1-50, (N, %)	25 (22)
50.1-100, (N , %)	30 (28)
≥100.1, (N, %)	33 (29)
ESI, median [IQR]	3 [2-3]
1-2 (N, %)	5 (4)
3 (N, %)	103 (92)
4-5 (N, %)	4 (4)
SOFA score, median [IQR]	1 [0-3]
0-1 (N, %)	63 (56)
2-5 (N, %)	43 (38)
>6 (N, %)	6 (6)
Triage systolic blood pressure, mean (SD)	134 (37)
≤89 mm Hg (N, %)	13 (12)
90-179 mm Hg (N, %)	84 (75)
≥180 mm Hg (N, %)	15 (13)
Triage heart rate, mean (SD)	92 (24)
≤59 bpm, N (%)	7 (6)
60-99 bpm, N (%)	64 (57)
≥100 bpm, (%)	41 (37)
Triage pain score, mean (SD)	8 (3)
0-3 (N, %)	8 (7)
4-7 (N, %)	30 (27)
8-10 (N, %)	74 (66)
Presence of continuous infusion, N (%)	
Yes	32 (29)
No	80 (71)
ED length of stay (hours), median [IQR]	3.9 [2.5-6.4]
Transport type, N (%)	
Air	38 (34)
Ground	74 (66)
Medical admitting services, N (%)	
ACES	20 (18)
Cardiac surgery	19 (17)
Neurosurgery	10 (9)
Soft tissue surgery	16 (14)
Vascular surgery	27 (24)
Other	20 (18)
Number of pain assessment, median [IQR]	3 [2-5]
≤3 (N, %)	64 (57)
≥4 (N, %)	48 (43)
Number of pain medication administration, median [IQR]	2 [1-3]
Pain medication type, N (%)	
No medication	27 (24)
NSAIDS only	2 (2)
Narcotics only	74 (66)
Narcotics and NSAIDs	9 (8)
Total MEU, median [IQR]	7.5 [5-13]
MEU per Kg median, [IQR]	0.09 [0.05-0.16]
Time to first NSAIDs (min), median [IQR]	55 [22-113]
Time to first narcotic (min), median [IQR]	61 [35-177]
ICU arrival – operations (min), median [IQR]	195 [121-422]
Hospital LOS (day), median [IQR]	9 [6-16]
Mortality, N (%)	10 (9)

N, number of patients; *SD*, standard deviation; *ESI*, Emergency Severity Index; *km*, kilometers; *IQR*, interquartile range; *mmHg*, millimeters of mercury; *ED*, emergency department; *ACES*, acute care emergency surgery; *MEU*, morphine equivalent unit; *ICU*, intensive care unit; *LOS*, length of stay; *SOFA*, sequential organ failure assessment; *NSAID*; nonsteroidal anti-inflammatory drug.

results suggested that EPs in our study did recognize the distress of their patients and tried to relieve their discomfort, but their efforts appeared inadequate.

Pain management has been shown to be poor in the ED.[5,11] Reasons for inadequate pain control in EDs may result from EPs' misconception of compromising a patient's mental status[8] or clouding physical examination in surgical patients[14] such as patients in our population. In addition to these possible barriers, our study identified three additional potential barriers for adequate pain control. First, the amount of total MEU that our patients received was less than the recommended 0.1mg/kg body weight,[15] although even this dosage of 0.1mg/kg morphine was inadequate in relieving severe pain.[15] A second potential barrier was from the EPs' practice of giving patients in our

Table 2A. Outcome, defined as pain level at ED departure was greater or equal to 50% of pain level at ED triage.

Categories of Outcome	Result
Pain level at ED departure, mean (SD)	5 (3)
Pain control at departure	
Adequate, N (%)	43 (38)
Inadequate, N (%)	69 (62)
Adequate pain control by admitting medical services (N, % of patient in service) *	
ACES	5 (25)
CS	4 (21)
NS	4 (40)
Soft tissue surgery	6 (38)
Vascular surgery	16 (59)
Other	12 (60)

ED, emergency department; *SD*, standard deviation; *N*, number of patients; *ACES*, acute care emergency surgery; *CS*, Cardiac Surgery; *NS*, Neurosurgery.
*Percentage was expressed as number of patients achieving adequate pain control at ED departure as percentage of total patients within one particular service, not the total patient population.

study multiple smaller doses of pain medication. Administering multiple doses of pain medication was not associated with adequate pain control in a randomized study by Chang et al.,[16] comparing to a single dose of 2mg hydromorphone, which is equivalent to 14 MEU. According to this study, one single dose of 2mg of hydromorphone was significantly associated with higher percentage of adequate pain control, comparing to multiple smaller dosage of pain medication, while achieving similar safety profiles. Therefore, EPs should consider giving patients with clear pathology for pain higher initial doses of pain medication to achieve levels higher than 0.1 mg/kg body weight.

Our study also identified the lack of multimodal analgesia among our patient population, who only received either narcotic or nonsteroidal anti-inflammatory drug (NSAID) pain medication. A recent study showed that a combination of ibuprofen and acetaminophen was equally effective as a single dose of opioids among patients with severe extremity pain.[17] Furthermore, other analgesic modalities such as regional analgesia, gabapentinoids, and/or the N-methyl-D-aspartate class of glutamate receptor antagonists (tramadol, nitrous oxide) have been shown to be effective adjuncts to narcotic analgesia.[18] Therefore, more education to increase awareness and comfort about using other analgesic modalities for pain management will improve patients' pain relief.[19]

LIMITATIONS

Our study had several limitations. First, we did not have a control group to compare the efficacy of pain management in non life-threatening situations to these patients who would need transfer for urgent surgical intervention. Secondly, we did not assess the effect of ethnicity on inadequate pain control among our group of critically ill patients. A previous study suggested that African-American patients who were not taking opioids at home were less likely to achieve a 50% pain score reduction than other patients, even with similar analgesic dosage.[5]

Our study consisted of a heterogenous group of patients with a limited sample size; therefore, it did not allow us to investigate which disease states would be at higher risk for inadequate pain control. Although patients included in our study required urgent surgical intervention, the sample size of mortality was low (9%), which did not allow us to examine the association of poor analgesia with outcome, as refractory pain

Table 2B. Results from multivariable logistic regressions assessing association between clinically-important factors and all patients or only patients who presented with severe triage pain (pain level 8-10). Independent variables were first assessed for association with inadequate pain control at ED departure (Appendix). Independent variables were first assessed for association with inadequate pain control at ED departure (Appendix). Variables with p-value<0.10 were included in the multivariable logistic regression in addition to other clinically significant factors (total MEU, MEU per Kg total body weight, time interval from triage to first administration of narcotics [time to first narcotics]).

	Univariable analysis			Multivariable analysis					
	All patients			All patients			Severe pain (8-10)		
Variables	OR	95% CI	p-value	OR	95% CI	p-value	OR	95% CI	p-value
ESI	8.29	1.01-68.1	0.049	44	0.00-infinity	0.99	39	0-infinity	0.99
Type of medication	1.39	0.93-2.09	0.10	1.26	0.43-3.70	0.68	1.76	0.4-8.1	0.47
Total MEU	1.03	0.97-1.10	0.34	1.12	0.99-1.26	0.059	1.2	0.99-1.4	0.055
MEU per Kg	0.64	0.27-1.56	0.33	0.22	0.05-0.92	0.037	0.21	0.03-1.2	0.077
Time to first narcotics	1.00	0.99-1.01	0.39	1.00	0.99-1.005	0.55	1.0	0.99-1.004	0.90

CI, confidence interval; *OR*, odds ratio; *ESI*, Emergency Severity Index; *MEU*, morphine equivalent unit; *kg*, kilogram.

was shown to be associated with poor outcomes in some disease states such as aortic dissection.[20] Furthermore, we excluded a group of patients requiring invasive mechanical ventilation, who had been shown to be at higher risk of not receiving analgesia in the ED.[21] Finally, we were not able to assess whether patients took medication prior to presenting to the ED or whether patients refused pain medication in the ED, which would affect the amount of pain medication administration and overall effectiveness of pain management.

CONCLUSION

Pain control among a group of interhospital-transferred patients requiring urgent operative interventions, was inadequate. No demographic or clinical factors, except total morphine equivalent unit per kg body weight, was associated with adequate pain management at ED departure. Emergency providers should consider a more effective strategy, such as multimodal analgesias, to improve pain management in this group of patients.

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The Effect of Point-of-Care Testing at Triage: An Observational Study in a Teaching Hospital in Saudi Arabia

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Introduction: Prolonged waiting times during episodes of emergency department (ED) crowding are associated with poor outcomes. Point-of-care testing (POCT) at ED triage prior to physician evaluation may help identify critically ill patients. We studied the impact of ED POCT in a single ED with a high degree of crowding for patients with high-risk complaints who were triaged as non-critically ill.

Methods: We conducted the study from April–July 2017 at King Abdulaziz University (KAU) Hospital in Jeddah, Saudi Arabia. Patients with one of seven complaints received triage POCT. The primary outcome was whether POCT results at triage resulted in immediate transfer of the patient from the waiting room into the ED. Secondary outcomes were whether the triage nurse felt that the POCT results were useful, and whether triage POCT changed triage acuity. We used simple descriptive statistics to summarize the data.

Results: A total of 94 patients were enrolled and received i-STAT® POCT. The most common symptoms and triage protocols were for chest pain (42%), abdominal pain (31%), and shortness of breath (22%). In 11 cases (12%), care was changed as a result of triage POCT. In 12 cases (13%), triage level was changed. The triage nurse found POCT helpful in 93% of cases.

Conclusion: In this ED, triage POCT was a helpful adjunct at ED triage and resulted in immediate care (transfer to an ED room) in one in eight cases. Therefore, POCT at triage may be a useful adjunct to improve patient safety, particularly in crowded EDs. [West J Emerg Med. 2018;19(5)884–888.]

INTRODUCTION

Emergency departments (ED) worldwide are facing increasing crowding and prolonged waiting times, which are associated with poor outcomes.[1,-5] During episodes of ED crowding, patients experience critical care delays, increased errors, and commonly a poorer experience.[6] Crowding can worsen outcomes for acute myocardial infarction, sepsis, and trauma.[7,8] One area of particular concern is the ED waiting room, where patients with undifferentiated conditions wait before physician evaluation. Patients who are obviously critically ill rarely spend any time waiting. Yet some patients triaged as safe to wait actually have occult, severe conditions requiring immediate treatment, which this may go unrecognized in a crowded ED.

One intervention to help detect patients who require immediate care is point-of-care testing (POCT) at ED triage. Triage POCT occurs prior to physician evaluation and can aid in identifying clinically important and abnormal test results, reduce the time to detect critical illness, and identify patients safe to wait.[9] In previous studies, we developed POCT triage protocols and found they changed management decisions in a simulation with triage nurses.[10,11] We conducted a prospective study at a single, academic ED in Jeddah, Saudi Arabia, with critical crowding and long ED wait times for patients with high-risk complaints triaged as safe to wait. Our goal was to determine the effect of POCT on decisions to transfer patients from the waiting room to the main ED, changes to triage prioritization, and perceived utility of POCT by triage nurses.

Population Health Research Capsule

What do we already know about this issue?
Point-of-care testing (POCT) at emergency department (ED) triage can aid in identifying clinically important and abnormal test results, reduce time to detect critical illness, and identify patients safe to wait.

What was the research question?
Does POCT affect decision to transfer patients from waiting room to main ED and change triage prioritization?

What was the major finding of the study?
Triage POCT directly resulted in immediate transfer of patients to ED room in one in eight cases. Triage level was changed in 13% of cases.

How does this improve population health?
POCT at triage is a helpful adjunct at ED triage and resulted in immediate care changes. It may be a useful adjunct to improve patient safety for waiting patients, particularly in crowded EDs.

METHODS

Study Design

We conducted a prospective, observational study of an ED POCT triage program. This was approved by the institutional review boards at George Washington University and King Abdulaziz University (KAU) Hospital in Jeddah, Saudi Arabia.

Setting

This was an observational pilot study with a total enrollment of 94 patients. KAU is a tertiary care, academic medical center with 71 ED beds, 845 hospital beds, and an annual ED census of 66,000 visits. In April 2017 POCT became available, and enrollment took place from April to July 2017. Prior to POCT implementation, blood-based ED POCT was unavailable and no POCT was conducted at triage except for finger-stick glucose.

In Saudi Arabia the government has a very clear and strict law, which states that any patient presenting to any ED with a life- or limb-threatening condition is to be attended to immediately, regardless of any other factors used to determine eligibility. However, other less-urgent or non-emergent conditions vary dramatically in terms of acceptance in EDs based on each facility's regulations. Even governmental institutions vary dramatically in their eligibility criteria, which makes ED populations vary significantly based on an institution's rules.

All patients who arrive to the ED are triaged using the Canadian Triage and Acuity Scale (CTAS), a five-level triage system corresponding to 1 (Resuscitation), 2 (Emergent), 3 (Urgent), 4 (Less Urgent), and 5 (Non-Urgent). During registration, patients are assigned in the health information system into their respective ED section (i.e., fast track or main ED) by their CTAS level (1-5). All CTAS 1-2 patients are registered with no restrictions and regardless of nationality. However, CTAS 3-5 patients are registered based on certain eligibility criteria. Eligible patients are citizens of Saudi Arabia/Gulf region and university/hospital staff including their dependents, regardless of nationality. Additionally, also eligible for registration are non-Saudis who are sponsored by individuals (not companies), some infectious diseases (assigned by the Ministry of Health), active cancer patients on chemotherapy, and some nationalities facing crisis in their homeland (decided by the government).

Ineligible patients (CTAS 3-5 patients) are non-Saudis who hold health insurance through their sponsors (companies, agencies, etc.). Ineligible patients do not get registered and are advised to seek medical care in the private sector or governmental hospitals that offer services for the privately insured. In triage, all patients regardless of eligibility may receive electrocardiograms (ECGs); however, other testing is not done. Patients are seen by a physician after arrival in an ED room, where they have laboratory tests drawn and sent to a central laboratory adjacent to the ED.

Subjects

The study sample consisted of registered patients triaged CTAS 2-5 with one of seven predefined conditions who received POCT at triage. Patients were enrolled in the study when the study team of nurses and medical interns was available. Potential study subjects meeting inclusion criteria were approached by an enroller. After consent, a nurse drew a venous blood sample and conducted POCT using i-STAT® (Abbott Point of Care, Inc., Princeton, NJ) based on a clinical protocol (Table 1).

Table 1. Triage point-of-care protocol.

Condition	Inclusion	Exclusion	i-STAT POCT ordered
Symptoms of	≥ 40 yo OR cardiovascular risk factor OR congestive heart failure	-Chest trauma -Suspected respiratory infection -History of asthma OR COPD with bilateral wheezingNone	Troponin
chest or epigastric pain / shortness of breathSymptoms of generalized weakness	≥ 55 yo OR multiple comorbidity	None	Troponin CHEM8+ Lactate Hgb/Hct
Symptoms of abdominal pain (young female)	< 55 yo	Post-menopausal (medical and surgical menopause included)	Pregnancy test
Symptoms of abdominal pain (older pain)	≥ 55 yo OR multiple co-morbidity	None	Lactate
History of syncope (older patient)	≥ 40 yo OR multiple co-morbidity	None	Troponin Glucose
History of missed dialysis	None	None	CHEM8+
History of GI bleeding symptoms	None	Suspected benign etiology	Hgb/Hct
Suspected sepsis	≥ 2 SIRS criteria or debilitated/ill-appearing	≥ 18 years old	Lactate WBC

POCT, Point-of-care testing; *GI*, gastrointestinal; *Hgb/Hct*, hemoglobin/hematocrit; *SIRS*, systemic inflammatory response syndrome (temp >38°C (100.4°F) or < 36°C (96.8°F), heart rate > 90, respiratory rate > 20 or $PaCO_2$ < 32 mm Hg, white blood count (WBC) > 12,000/mm³, < 4,000/mm³, or > 10% bands).

i-STAT® POCT results are typically available in under 10 minutes. Test results were presented to the ED attending physician who determined whether the patient required immediate care. We used a structured data form to collect demographic and clinical information on each patient. The triage nurse was then asked to complete a brief survey on whether POCT was useful in determining urgency, and how it changed triage for the patient. This was done for every patient (See Appendix).

Study Outcomes

The primary study outcome was whether the POCT results resulted in immediate transfer from the waiting room to the main ED. Secondary outcomes were whether the triage nurse felt that the POCT results were useful, and whether triage POCT changed the patient's triage acuity.

Data Analysis

We used simple descriptive statistics and completed analyses using Stata version 14.2 (StataCorp, College Station, TX).

RESULTS

A total of 94 patients were enrolled. Average age was 59, and 48% were female. The triage protocols used the most were chest pain (42%), abdominal pain (31%), and shortness of breath (22%). CTAS 3 was the most common triage level (72%). The most common POCT was troponin (56%), followed by lactate (18%) (Table 2).

In 11 cases (12%), patients were moved directly from the waiting room to an ED room. In 12 cases (13%), the triage level was changed. While the triage nurse found POCT helpful in 93% of cases, triage POCT increased the level of concern in 12 cases (13%) and decreased it in six cases (6%). With respect to disposition, 30 patients (32%) left the ED before being seen by a physician (Table 3).

DISCUSSION

We found that triage POCT was a helpful adjunct to triage in a crowded ED where patients experience long waits and commonly leave the ED before physician evaluation, even with potentially emergent conditions. Triage POCT directly resulted in immediate transfer of the patient to an ED room in one in eight cases. In addition, triage level was changed in several cases.

POCT was particularly helpful in diagnosing atypical presentations of acute myocardial infraction. For example, a mid-30s male patient with several cardiovascular comorbidities and atypical chest pain of longstanding duration yet well appearing and in no acute distress had a positive troponin of 0.89 and was immediately brought to an ED room and diagnosed with non-ST

Table 2. Study subjects who received point-of-care testing at emergency department triage (n=94).

	No.	%
Female	45	47.9
Mean age (SD), years	58.8	(14.0)
Chief complaint		
Abdominal pain	29	30.9
Chest pain	39	41.5
Shortness of breath	21	22.3
Fatigue/weakness	6	6.4
Nausea/vomiting	4	4.3
Syncope	3	3.2
Triage level		
2	19	20.2
3	67	71.3
4	8	8.5
Disposition		
Admitted	18	28.1
Discharged	46	71.9
Left without being seen	30	31.9
POC test type		
Troponin only	53	56.4
Lactate only	17	18.1
BHCG only	11	11.7
Troponin, CHEM8+, Lactate, and HGB/HCT	6	6.4
CHEM8+ and PT/INR	4	4.3
Troponin and glucose	3	3.2

SD, standard deviation; *BHCG*, beta human chorionic gonadotropin; *POC*, point-of-care; *HGB*, hemoglobin; *HCT*, hematocrit; *PT*, prothrombin time; *INR*, international normalized ratio.

Table 3. Care management / triage survey results (n=94).

	No.	%
Total cases	94	100
Changed triage		
No change	82	87.2
CTAS 2-->3	5	5.3
CTAS 3-->2	7	7.4
Changed care		
Brought immediately to the main ED	11	11.7
POCT helpful	87	92.6

CTAS, Canadian Triage Acuity Scale; *ED*, emergency department; *POCT*, point-of-care testing.

segment elevation myocardial infarction. In another case, a mid-40s male presented with vague generalized weakness and was prioritized as CTAS 3. POCT showed a positive troponin (0.55) and a low pH (6.8). An immediate ECG showed an ST-segment acute myocardial infarction and the patient was transferred to the cardiac catheterization laboratory. In a third case, a mid-50s male presented with fatigue and generalized weakness and had been in the waiting room most of the day. After enrollment, he was found to have a low pH (7.1), a low bicarbonate (13), and hyperkalemia (6.7 meq/L). He was also brought back for immediate care. POCT troponin was the test that most changed triage decisions. It helped to change six (30%) of the 18 cases. These six patients had normal ECGs and negative POCT troponin.

Several prior studies have also explored how POCT changes triage decisions.[8,9] One study implemented triage POCT for similar conditions (i.e., chest pain, infection, and older adults) and found that triage POCT resulted in immediate transfer in 6% of cases, lower than in our study.[8] Differences in rates are likely due to differences in the ED environment, and the policies surrounding triage prioritization. Specifically at KAU, considerably higher risk patients must commonly wait and may not receive treatment. This approach is more common outside of the United States, particularly in countries such as Saudi Arabia, the Gulf region, India, and others.[1] Therefore, the value of POCT at triage may be magnified in those settings.

LIMITATIONS

There are several study limitations. This was a single-center study and may not generalize to other settings. It was a convenience sample of patients who presented during times when study staff were available. Enrolling patients who presented at other times may have yielded different results. POCT can incur significant costs to implement and maintain. There was no follow-up done for patients who left without being seen. The research protocol stated that lactate should be tested in suspected sepsis cases, but during the study period no sepsis cases were enrolled. Triage decisions are by their nature subjective, and results may differ with different triage nurses or other local protocols. However, triage nurses at our hospital have a minimum of five years of ED experience, and all of them went through CTAS triage training conducted by emergency physicians (EP). Moreover, triage nurses have direct communication with all EPs on duty using mobile phones provided by the hospital, and they call frequently for any inquiries or concerns.

CONCLUSION

POCT was a useful adjunct at triage and resulted in changes in triage level and immediate transfer to an ED room in one in eight cases, suggesting that point-of-care testing may improve patient safety in similar settings.

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Universal Health Coverage in Rural Ecuador: A Cross-sectional Study of Perceived Emergencies

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Introduction: In many low- and middle-income countries emergency care is provided anywhere in the health system; however, no studies to date have looked at which providers are chosen by patients with perceived emergencies. Ecuador has universal health coverage that includes emergency care. However, earlier research indicates that patients with emergencies tend to seek private care. Our primary research questions were these: What is the scope of perceived emergencies?; What is their nature?; and What is the related healthcare-seeking behavior? Secondary objectives were to study determinants of healthcare-seeking behavior, compare health expenditure with expenditure from the past ordinary illness, and measure the prevalence of catastrophic health expenditure related to perceived emergencies.

Methods: We conducted a cross-sectional survey of 210 households in a rural region of northwestern Ecuador. The households were sampled with two-stage cluster sampling and represent an estimated 20% of the households in the region. We used two structured, pretested questionnaires. The first questionnaire collected demographic and economic household data, expenditure data on the past ordinary illness, and presented our definition of perceived emergency. The second recorded the number of emergency events, symptoms, further case description, healthcare-seeking behavior, and health expenditure, which was defined as being catastrophic when it exceeded 40% of a household´s ability to pay.

Results: The response rate was 85% with a total of 74 reported emergency events during the past year (90/1,000 inhabitants). We further analyzed the most recent event in each household (n=54). Private, for-profit providers, including traditional healers, were chosen by 57.4% (95% confidence interval [CI] [44-71%]). Public providers treated one third of the cases. The mean health expenditure per event was $305.30 United States dollars (USD), compared to $135.80 USD for the past ordinary illnesses. Catastrophic health expenditure was found in 24.4% of households.

Conclusion: Our findings suggest that the provision of free health services may not be sufficient to reach universal health coverage for patients with perceived emergencies. Changes in the organization of public emergency departments and improved financial protection for emergency patients may improve the situation. [West J Emerg Med. 2018;19(5)889-900.]

INTRODUCTION

Globally most deaths from injuries, infections, childhood diseases, and maternal conditions occur in low- and middle-income countries (LMIC). Many of these conditions can be effectively treated through immediate, inexpensive interventions; however, most LMIC still lack effective emergency medical systems to provide such interventions.[1-7] In 2007 the World Health Assembly passed a resolution strengthening emergency care systems in LMIC, which led to increased interest and scientific literature related to the field.[4,5,7-9]

In many LMIC, emergency care is provided anywhere in the health system, including the primary care setting.[1,3,6,8,10,11] For example, in Cuba emergency care is explicitly included in the primary care package,[12] while many countries give it low priority.[1] Most studies of medical emergencies are hospital based, while population-based investigations are scarce.[13-15]

A central element when studying emergency care is defining the term "medical emergency." Health professionals usually define "emergency" as acute impaired physiology, and a threat to life, organs or limbs.[16] According to Morgans and Burgess, a patient determines if he or she is experiencing an emergency or not based on layperson advice, psychosocial factors, and the pattern of the onset of symptoms.[17]

Poorer households in LMIC face barriers to emergency care due to weak or absent systems of financial protection.[1] When faced with the choice to seek treatment or not these households choose between risking life or health and possible financial ruin.[1,3] The latter is known as catastrophic health expenditure. It is widely defined as occurring when a household's healthcare expenditure exceeds 40% of its ability to pay (ATP), i.e., their remaining income after basic needs are met.[18,19]

Latin American countries are moving closer towards universal health coverage (UHC), as endorsed by the United Nations and World Health Organization.[21] UHC is part of the Sustainable Development Goals and is defined as everyone having access to needed health services without the risk of severe financial consequences.[22] UHC was introduced in Ecuador in 2008 and includes emergency care.[20,23] However, the country's financing and delivery functions within the health system are still fragmented.[20,24] The Ministry of Public Health (MPH) and the Ecuadorean Social Security Institute (Instituto Ecuatoriano de Seguridad Social, IESS) are the main public providers and run parallel systems of health centers and hospitals. The latter provides healthcare to entitled subscribing members.[25] In addition, multiple private for-profit, non-profit, and traditional providers exist.[25,26]

López-Cevallos and Chi studied healthcare utilization in Ecuador using national data, showing that uninsured and rural dwellers have significantly lower odds of using hospital services.[25] However, data on emergency care does not get presented separately. Guerra-Villavicencio's analysis of national data from 2006-2014 reported an increased percentage of emergencies in the MPH health centers.[24] Data concerning private providers do not exist. In an earlier, qualitative study conducted in rural Ecuador by our research group, we found indications that patients who perceive experiencing an emergency seek care from private providers.[27]

The primary research questions for this population-based study, with the aim of exploring features of emergency healthcare-seeking in rural Ecuador, were the following: What is the scope of perceived emergencies?; What is the nature of perceived emergencies?; and What is the related healthcare-seeking behavior (HCSB)? Secondary objectives were to study the determinants of HCSB, compare the related health expenditure with expenditure from the past ordinary illness, and measure the prevalence of catastrophic health expenditure.

Population Health Research Capsule

What do we already know about this issue?
Ecuador has a universal health coverage (UHC) system providing all citizens the right to free healthcare in public facilities, including emergency care.

What was the research question?
What is the scope of perceived emergencies and the related healthcare-seeking behaviors in rural Ecuador?

What was the major finding of the study?
In the past year, 90/1,000 inhabitants experienced an emergency event. For-profit providers treated half of all cases.

How does this improve population health?
Free emergency care may not be sufficient to reach UHC for patients with perceived emergencies. Changes in public emergency departments may improve the situation.

METHODS

Study Region

The study region is located in a rural rainforest area in Ecuador´s northwestern province Esmeraldas. Thirty communities are connected by muddy trails, usually traveled

by foot or mule. The population size is approximately 5,000. Poverty is widespread and most households are dependent on subsistence farming or livestock breeding.[28] A MPH health center operates in the central community, and traditional healers offer private services. There is a MPH hospital with a basic emergency department (ED), several private clinics, laboratories, pharmacies, and traditional healers located in the cantonal capital Quinindé. Private hospitals, specialized MPH hospitals and an IESS hospital are found in cities further away.

Study Design

We conducted a cross-sectional explorative household survey during November-December 2012. The study unit was a household. We calculated the sample size using the formula:

$$n = N * X / (X + N - 1)$$

where:

n = sample size
N = population size
$X = [Z^2_{1-\alpha/2} p(1-p)] / MOE^2$
$Z^2_{1-\alpha/2}$ = critical value of the Normal distribution a $_{1-\alpha/2}$ (for a 95% confidence level, α is 0.05 and $Z^2_{1-\alpha/2}$ is 1.96)
p = the sample proportion
MOE = margin of error

Official census data was absent. Informal census data from 16 communities was revised with local key informants who had knowledge about recent migration. They also provided population estimates for the remaining communities. This resulted in the estimated number of households N=1,074. In 2011 the average household size was 4.76 people (Foundation Human Nature 2012, Informe del procesamiento y análisis estadístico de la información del censo: sector Y de la Laguna *[Information about data handling and statistical analysis of the census information: sector Y de la Laguna]*, Working Document, Foundation Human Nature Ecuador, Quito). Thus, the total population size was estimated to be 5,112.

For the primary outcome – the scope of perceived emergencies – we estimated the annual risk on the individual level at 10% (p = 0.1).[25,28] The sample size was calculated with a 5% margin of error, 95% confidence interval (CI), and led to the conclusion that 135 people, representing 28 households, would have to be interviewed. The final step was to adjust for a response rate of 73% based on a previous study in the region, which resulted in 38 households.[28]

The calculations for one of the secondary outcomes, the prevalence of catastrophic household expenditure, were as follows. An individual's risk of 10% to experience an emergency implies a 90% (0.9) risk of *not* experiencing an emergency. An average household's annual risk to experience an emergency is therefore $1–(0.9^5) = 0.409$ (41%), yielding 440 households in the region. We assumed a 25% prevalence of catastrophic health expenditure, resulting in 110 households (10.2% of all households). With a 5% margin of error and 95% CI, this gave 123 households; adjustments for a 73% response rate resulted in a sample size of 168 households.

Due to the absence of exact population data, we applied two-stage cluster sampling with 30 clusters of seven households per cluster. Therefore, the probability of inclusion of a community was proportional to its size.[29,30]

Questionnaires

We developed two, structured questionnaires using the World Health Survey 2002 as a reference.[31] These were translated into Spanish by a bilingual speaker, pre-tested in the study region, and adjusted accordingly. Questionnaire 1 covered demographic and economic household data, expenditure data on the past ordinary illness, and the definition of perceived emergency. In the questionnaire, perceived emergency was defined as "a medical emergency exists, when a person has a health problem that you consider so urgent that you have to stop your current activity to seek help for this person (or yourself)." This definition was developed by two physicians and discussed and adjusted according to feedback from community health workers (CHWs) in the region. Questionnaire 2 covered the number of emergencies, symptoms, further case description, HCSB, and health expenditure. This questionnaire was administered directly after the first one when a household reported an emergency event.

Variables Related to Primary Outcomes

We measured the scope of perceived emergencies by presenting the above definition and recording the number of events in the past year. The nature of the emergencies was assessed by recording symptoms and sorting these into chief complaints adapted to the rural Ecuadorean context.[33,34] This was done independently by three physicians; discrepancies were discussed until consensus was reached. Further case description included perceived severity, hospitalization, surgery, days spent in bed, and decreased health status. Concerning HCSB, we collected the first provider contacted, reasons for this choice, and if a different choice would be made in case the emergency were to occur again. If several providers were contacted all were included.

For the analysis we constructed three dichotomous models, labeling cases either "public" or "private." Model 1 represents the first contacted provider; the same applies to model 2 but here less serious cases were filtered out by excluding contact with traditional healers. (Based on local experience we assumed allopathic care is sought in more severe events.) In model 3, all contacted providers were aggregated. A case was labeled "public" if it was treated entirely within the public system (MPH, IESS) or "private" if at least one private provider was involved.

Variables Related to Secondary Outcomes

The theoretical foundation to study determinants of HCSB is based on Andersen's healthcare utilization model.[35] The purpose is to discover which conditions facilitate or impede service utilization. In this model, the environment (healthcare system, external environment) and population characteristics (predisposing characteristics, enabling resources, need) influence HCSB (personal practices, service utilization), and outcomes (health status, satisfaction). Perceptions of severity are important determinants of HCSB.[36] The entire system is dynamic with both individuals and systems learning from experience.[35,37] Variables are displayed in Table 3. Our wealth index included eight typical household items (TV, DVD player, cellphone, refrigerator, motorbike, car, radio, and sound system) and was calculated using reciprocal proportions.[38,39] Health expenditure data for past ordinary illness and emergency were collected. We excluded lost income due to the inability to work. As a proxy for household ATP we used reported household expenditure during the past month minus expenditure for food (including food produced by the household).[19,38,40] This household expenditure was extrapolated over one year, and we calculated different thresholds of household ATP to determine if health expenditure was catastrophic.

Interviewers, Interviewees, and Data Quality

Fifteen to 30 days prior to field research community leaders were informed via letter about aims and practical issues. Five CHWs were employed as interviewers, most of whom had not completed secondary school. To increase reliability, we chose to recruit four foreign medical students with good Spanish skills as observers.[32] To maximize validity of the collected data, interviewers and observers were thoroughly trained by the first author during a five-day course. Most interviews took place in the interviewees' homes, and some were held in a quiet spot following a community meeting.

The interview subjects were selected based on their seniority within the household and based on the occurrence of a perceived emergency during the past year. Heads of households (principal decision makers in the household) were interviewed with questionnaire 1. If absent, the next, most-senior person was interviewed. If at least one household member had experienced a perceived emergency in the past year, questionnaire 2 was used to interview the patient. If the patient was unavailable, under 15 years of age or had impaired memory about the event, the person who took care of the patient (caretaker) was interviewed. If both the patient and the caretaker were unavailable, then the head of the household was interviewed as a proxy respondent.[32] The person who decided if and where to seek healthcare in the emergency situation was defined as "decision maker." We included cases with ongoing treatment at the time of the study. If an eligible interviewee was not at home on two consecutive days the household was excluded and not replaced.

Observers were present at 70 interviews mainly at the beginning of the study and provided feedback to the interviewers.[32] Questionnaires were checked by the first author at the end of each day. In case of missing or clearly erroneous data, interviewers revisited the households. Recall bias is related to less severe conditions that occurred a longer time ago.[41] With our definition of perceived emergency we deemed a 12-month time period as manageable to keep recall bias to a minimum.[32,41] Another source of error is familiarity of the interviewer with the respondent, thus tempting interviewers to help with the answers. To minimize this risk, we did not assign interviewers to their own community.

Statistical Methods

All data were entered into a digital spreadsheet, double checked by two researchers, and transferred into SPSS (IBM Corp. SPSS Statistics for Macintosh, Version 23. Armonk, NY). We used descriptive statistics as outlined in the "Results" section. The CI was set at 95%. For 2x2 and 2x3 tables we used Fisher's exact test.[40] We did an independent samples T-test to compare means of health expenditures for private and public health contacts in model 3. Results were considered significant at $p<0.05$.

Ethical Issues

Ethical approval was granted by the Bioethics Committee of the Pontificia Universidad Católica del Ecuador (Oficio-CBE-001-2013). The region's "Farmers' Health Committee" also approved the study. Participation was voluntary, with assured anonymity. We obtained written informed consent before the interviews, which could be interrupted at any time without negative consequences for the respondent.

RESULTS

General Results

The response rate was 85%. Figure 1 shows reasons for non-participation, and households interviewed with questionnaire 1 and 2. Characteristics of the interviewed households are shown in Table 1.

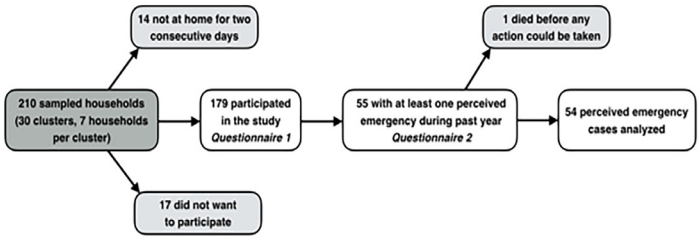

Figure 1. Sampled households, reasons for non-participation, and households interviewed with questionnaire 1 and 2.

Table 1. Characteristics of the interviewed households (n=179).

Household characteristic	Value	Comments
Mean number of household members (95% CI)	4.6 (4.3-4.9)	minimum-maximum: 1-12
Households with children <5 years	43.5%	
Households with members <18 years	77.7%	
Households with members >64 years	10.1%	
Households with members <18 and >64 years	82.1%	
Mean age of household head in years (95% CI)	44.0 (42.0-46.0)	3 missing
Number of household heads (%)		
Female	11 (6.1%)	
Male	168 (93.9%)	
Mestizo	175 (98.3%)	1 missing
Afro-Ecuadorean	3 (1.7%)	
No formal schooling & not completed primary school	76 (42.7%)	
Primary school completed & higher education	102 (57.3%)	1 missing
Marital status of the household head		
Living with partner	67.0%	
Married	24.6%	
Separated/divorced	4.5%	
Single	2.2%	
Widowed	1.7%	

CI, confidence interval.

Scope of Perceived Emergencies

Out of 179 households 55 had had at least one perceived emergency event during the past 12 months (30.7%; 95% CI [24.0-38.0%]). Several households reported more than one event; the total number of events was 74 (41.3%; 95% CI [34.0-49.0 %]). The mean number of events per affected household was 1.65 (95% CI [1.36-1.95]). The 179 participating households consisted of 825 persons, which yielded an incidence of 90 emergency events per 1,000 persons.

Case Descriptions

One adult person died at home with the chief complaint of chest pain before any action could be taken, and therefore this case was excluded, except for case descriptions in Table 2. We further analyzed the perceived emergencies in the remaining 54 households. The majority of patients were 18-64 years old (58.2%), followed by the 5-17 age group (20.0%), under five years (18.2%), and the elderly (3.6%). Almost half of the cases (43.6%) were female. See Table 2 for case details. Public health insurance existed in 23.0% (95% CI [11-34%]) of households. Three households reported having private insurance. We found no statistically significant association between perceived severity and hospital admission. About 30% were admitted, one quarter of whom underwent surgery.

Healthcare-seeking Behavior

Figure 2 shows where cases were initially managed. Private providers were contacted in over half of the cases (57.4%; 95% CI [44-71%]). These providers were mainly clinics in the cantonal capital and cities farther away, followed by traditional healers outside the study region. Cases seen by traditional healers included a variety of conditions, from bites and other traumas to fever and seizures. Those who contacted a public provider mainly went to the MPH hospital in the cantonal capital or the MPH health center in the study region. Of the cases initially managed at home, one household lacked resources to travel with the patient at that point in time and two of the patients could not leave their homes due to weather conditions.

The upper part of Table 3 displays our models. Model 3 shows an aggregate of all contacted providers to treat a case. The number ranged from one to four (mean 1.5; 95% CI [1.3-1.7]). One-third of all households (n=18) cured their case entirely with public providers. All others had at least one private contact. Those who favored private allopathic and traditional care over the public (MPH, IESS) systems were interviewed about their reasons (n=31). The most frequent reasons given were as follows: difficulty to get seen by a public provider – including long wait times (32.3%); belief or

Table 2. Description of the perceived emergency cases.

		Perceived severity‡							
Chief complaint	Number	Not very serious	Very serious	Life threatening	Number of patients hospitalized	Number of hospitalized patients who had surgery	Average number of nights spent in hospital	Average number of days spent in bed outside hospital (all cases)	Number of patients with decreased state of health after the event
Fever	21	6	11	4†	4	1	10.2	4.3	
Traumatic injury	10	2	6	2	3	1	2.3	21.3	4
Abdominal pain	5		4	1	1	1	3	11.2	1
Obstetrical complaint	3	1	2		3	1	3	13	
Chest pain	3	1	1	1*	1		1	6	1
Vomiting and/or diarrhea	2	1	1					2	
Convulsions/ seizure	2		2		1		12	1	
Eye or ENT problem	1	1							
Weakness	1		1					5	
Vaginal bleeding, discharge, or breast complaint	1			1	1	1	3	8	
Upper or lower extremity complaint	1		no data					8	
Psychiatric/ social problem	1		1					3	
Neurologic complaint	1			1				no data	1
Ingestion (accidental or intentional)	1			1	1		1	8	
Genitourinary problem	1		1		1		2	60	
Bites (human or animal)	1		1					2	
Total # (%)	55	12 (22.2%)	31 (57.4%)	11 (20.4%)	16 (29.6%**)	4 (25%)	4.94	7.2**	-

Empty cells = 0; ‡ = data on one case missing; † = one patient had ambulatory surgery; * = person died before any action could be taken, excluded in the further presentation; ** = the person who died is excluded from this calculation.

trust in traditional medicine (29.0%); quick attention (22.6%); and trust in the chosen private allopathic provider (9.7%). Of those who had public health insurance 41.6% went to an IESS facility, while the rest sought private care. None sought treatment at a MPH facility. Concerning the question of whether different actions would be taken if the emergency were to occur again, 33.3% (n=18) of interviewees stated they would make a different choice. Of those, the majority (n=14)

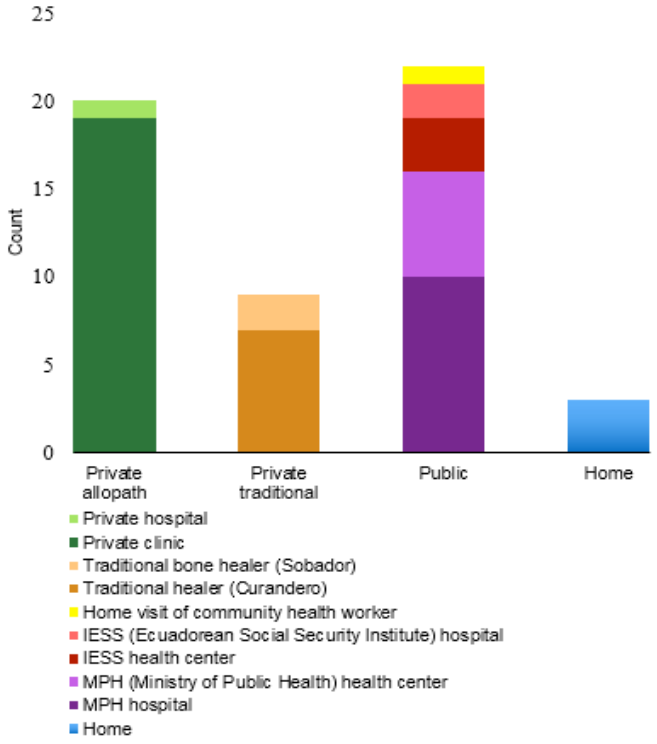

Figure 2. Initial management of the cases.

first had contact with a private provider (eight allopathic; six traditional). Those who saw an allopathic provider reported a range of different choices. Those who had visited a traditional healer showed a clear pattern to choose allopathic care if they were to experience the same emergency again.

Determinants of Healthcare-seeking Behavior

Table 3 displays variables grouped into Andersen's model and their influence on our utilization models 1-3. Due to the low number of observations, we applied wealth terciles. For the same reason, we grouped certain responses together such as cases perceived to be "life threatening" and "very serious"; regarding quality perception of the MPH system "bad" and "moderate" were grouped together. Statistically significant associations were found between seeking public care and membership in a community organization in models 1 and 3.

Health Expenditure

The Ecuadorean currency is the United States dollar (USD). Total costs ranged from 0-6,000 USD, the median was $88.00 USD, and the mean $305.30 USD. In comparison, total costs for the past ordinary illness (n=143) were between $0-7,000 USD, with a median of $13.00 USD, and mean of $135.80 USD. Comparing expenditure means in model 3, we found "all public" to be $145.40 USD vs. $387.60 USD in the "at least one private provider" group. However, the difference was not statistically significant.

In perceived emergencies, the most expensive items were medicine and medical materials (mean $58.2 USD), followed by nonmedical costs for food and accommodation (mean $32.60 USD), transport (mean $22.20 USD), imaging studies (mean $12.70 USD), laboratory (mean $8.30 USD), consultation with an allopath (mean $6.00 USD), and consultation with a traditional healer (mean $5.40 USD).

Catastrophic Health Expenditure

In the 41 cases for which expenditure data could be reliably collected, the mean household expenditure during the past month was $285.50 USD (95% CI [$204-366 USD]; median $213.50 USD). Table 4 displays the number and percentage of households exceeding different ATP cut-offs. Households at the 40% cut-off and above were analyzed further with regard to their healthcare utilization. Concerning utilization model 1, all but one household had contact with a private provider. In model 3, all households were in the "private" category. Due to the low number of observations, we did not analyze the determinants of catastrophic health expenditures (CHE).

DISCUSSION

In this explorative study in rural Ecuador we found that perceived emergencies occurred in at least 30.7% of households per year, corresponding to 90/1,000 inhabitants. As most emergency studies are hospital based, this investigation provides important insights into the realities of emergencies for rural households. The most frequent chief complaints including fever, traumatic injury, and abdominal pain are in line with study results from a neighboring province, in which a well-functioning ED run with foreign aid was studied.[34,43]

The absence of an association between hospitalization and perceived severity by the decision maker suggests that they have difficulties in assessing the severity of a health condition. These difficulties have also been documented in a high-income country context.[17] The percentage of hospital admissions is in line with results from the ED study mentioned above.[34]

Despite the national UHC policy, about half of all patients had their first contact with a private for-profit provider. The main reason for this was anticipated difficulties to be seen by a public provider. These difficulties include long wait times, possibly due to staff treating more severe cases. However, based on a study in Colombia other barriers for treatment in public EDs are likely to exist and would be worth investigating.[44]

Rather than being treated at the ED in the cantonal hospital most patients sought initial treatment at clinics and from traditional healers located in the same town or farther away, thus partly accepting longer travel distance. Others were taken to the nearby health center. These findings correspond with a study that reports low odds of use of hospital services for rural Ecuadoreans.[25] As mentioned, this might be attributed

Table 3. Determinants of healthcare seeking behavior in perceived emergencies.

		Model 1 (first contacted provider)				Model 2 (first contacted provider)				Model 3 (all contacted providers to cure the case)		
		Public %	Private (allopathic & traditional) %	Statistics		Public %	Private (allopathic) %	Statistics		All public %	At least one private provider %	Statistics
All cases	n=54	42.6	57.4	95% CI for private: 44-71%	n=45	51.1	48.9	95% CI for private: 34-64%	n=54	33.3	66.7	95% CI for private: 54-80%
Variable				p value comments				p value comments				p value comments
Predisposing factors												
Patient age (<18, >18 years)	<18 years	39.1	38.7	1.000		39.1	31.8	0.758		44.4	36.1	0.569
Patient sex (female, male)	female	43.5	45.2	1.000		43.5	54.5	0.556		44.4	44.4	1.000
Sex of decision maker (female, male)	female	45.0	25.0	0.216 6 cases missing		45.0	31.6	0.514 6 cases missing		40.0	30.3	0.527 6 cases missing
Marital status of the household head	married	26.1	12.9	0.351		26.1	18.2	0.401		22.2	16.7	0.806
	living w/ partner	69.6	74.2	0.351		69.6	63.6	0.401		72.2	72.2	0.806
	single*	4.3	12.9	0.351		4.3	18.2	0.401		5.6	11.1	0.806
Enabling factors												
Education of the household head (no formal schooling & primary not completed, primary completed & higher)	low	43.5	25.8	0.245		43.5	18.2	0.065		50.0	25.0	0.124
Education of the person who decided where to seek care (as above)	low	44.4	29.6	0.354 9 cases missing		44.4	22.2	0.289 9 cases missing		50.0	29.0	0.197 9 cases missing
Decision maker had experience with the type of emergency	yes	34.8	54.8	0.175		34.8	45.5	0.550		38.9	50.0	0.565
Patient having public health insurance	yes	21.7	24.1	1.000 2 cases missing		21.7	30.0	0.728 2 cases missing		16.7	26.5	0.507 2 cases missing

Comments: Statistically significant values are † ($p<0.05$); * = widowed, separated, divorced, single.
CI, confidence interval; *MPH,* Ministry of Public Health; *w/,* with.

Table 3. (Continued).

		Model 1 (first contacted provider)				Model 2 (first contacted provider)				Model 3 (all contacted providers to cure the case)		
		Public %	Private (allopathic & traditional) %	Statistics		Public %	Private (allopathic) %	Statistics		All public %	At least one private provider %	Statistics
All cases	n=54	42.6	57.4	95% CI for private: 44-71%	n=45	51.1	48.9	95% CI for private: 34-64%	n=54	33.3	66.7	95% CI for private: 54-80%
Variable				p value comments				p value comments				p value comments
Household head member of a community organization	yes	34.8	9.6	0.039†		34.8	9.1	0.071		38.9	11.1	0.029†
Wealth index (terciles)	low	26.1	32.3	0.940		26.1	31.8	0.804		22.2	33.3	0.668
	middle	30.4	29.0	0.940		30.4	36.4	0.804		27.8	30.6	0.668
	high	43.5	38.7	0.940		43.5	31.8	0.804		50.0	36.1	0.668
Environmental factors												
Perceived quality of the MPH system (good, moderate/ bad)	good	82.6	62.1	0.140 1 case missing		82.6	61.9	0.179 1 case missing		83.3	65.7	0.215 1 case missing
Seasons when the case occurred (rainy, dry)	rainy	26.1	35.5	0.560		26.1	31.8	0.749		33.3	30.6	1.000
Need factor												
Perceived severity of the case (not very serious, very serious/ life threat)	very serious/ life threat	63.6	87.1	0.055 1 case missing		63.6	90.9	0.069 1 case missing		64.7	83.3	0.167 1 case missing

Comments: Statistically significant values are † ($p<0.05$).
CI, confidence interval; *MPH,* Ministry of Public Health; *w/,* with.

Table 4. Prevalence of catastrophic health expenditures (CHE), different cut-off levels.

Cut-off (of ability-to-pay)	Number of households	% of total households (n=41)
20%	15	36.6
30%	13	31.7
40%	10	24.4
50%	10	24.4
60%	10	24.4
70%	9	22.0
80%	8	19.5

to long ED wait times, which could be addressed with effective triage. If appropriate, cases could then be redirected to the appropriate provider, a system that works in a hospital in the neighboring province.[34]

An interesting finding concerning the first provider contact is that about one third of those who chose a private provider opted for a traditional healer, stating trust in traditional medicine as the reason. However, the majority of these respondents said they would choose allopathic care next time, indicating the learning process as described by Andersen.[35]

Analyzing determinants of HCSB, we found few statistically significant associations between our variables and public vs, private providers. This absence of statistically significant associations might be a reflection of the loss of power when performing sub-group analyses.

According to Andersen, services received for more serious health problems are primarily explained by need and demographic characteristics.[35] Concerning perceived need, we found a trend between higher perceived severity and care seeking at private facilities. Comparing this to the reasons for seeking private care, a possible explanation may be that decision makers want to secure quick medical attention, and therefore disregard possible negative financial consequences. Membership in a community organization was significantly associated with seeking public care, likely indicating trust in public organizations.

About one quarter of all households had IESS public health insurance. An association between positive IESS status and use of IESS facilities could have been expected, but was surprisingly not found (models 1-3). Despite having insurance the majority of patients had contact with at least one private provider (model 3). This may indicate that the IESS does not provide services of the quality and timeliness that the decision makers desired. In fact, they were willing to pay despite the availability of free services. The timely provision of quality healthcare was what mattered to the population when choosing a service provider. Consequently, the free governmental services available to the study population did not properly protect households from out-of-pocket spending. This fact has also been reported in a CHE analysis across Latin America.[45]

We found high out-of-pocket expenditures for perceived emergencies compared to ordinary illness. The absence of a significant difference in expenditures between the public and private group in model 3 might depend on the weakness of the model. Nonmedical costs were the second and third most expensive items, which can be explained by the remote location of the study area and the number of contacted providers. Another study performed in a different rural Ecuadorean area, documented that the opening of a local hospital could substantially lower such costs.[46] All but one of the households in the study that incurred CHE reported initial contact with a private provider, which suggests that private healthcare might contribute to the occurrence of CHE.

The prevalence of 24.4% of catastrophic health expenditure at the 40% ATP cut-off level and 31.7% at the 30% level is high. Knaul et al. report a prevalence of about 15% of CHE in rural Ecuador at the 30% cut-off level.[45] However, this is not directly comparable as our results are only based on the past perceived emergency and exclude expenditures for other health problems. Nevertheless, our findings suggest that households that seek care for perceived emergencies face a high risk of financial catastrophe. Adequate financial protection for emergency patients is needed, especially for poor households.[1]

LIMITATIONS

Due to the cross-sectional study design only self-reported outcomes and no clinical or longitudinal data were collected. Recall bias might have played a role regarding less severe cases, thus under-reporting is possible. Selection bias is believed to be minimal due to the 85% response rate, but not entirely absent. A possible confounder was households that had been established in the area within the 12-month recall period and reported emergencies from their time living elsewhere. However, other households may have moved away, thus we believe the impact on our results to be small. Our finding that many would not choose traditional healers again may be influenced by respondents wanting to please interviewers. Underestimation of total health expenditures is possible as some interviewees could not remember detailed cost information. Our proxy for ATP does not capture fluctuations of income over longer time periods; thus, over- and underestimations are possible. The calculation of CHE does not take loss of income due to inability to work into account. Furthermore, the calculation assumes that households facing high health expenditure can consume less essential goods, but leaves out coping mechanisms such as spending savings, selling assets etc.[45] These shortcomings may have affected the results, but most likely not to the extent that our conclusions from the study are jeopardized.

CONCLUSION

Perceived emergencies were found to be a frequent problem, occurring to 90/1,000 inhabitants in the past year. These events force the decision maker to quickly choose the "right" provider. In approximately half of all cases private for-profit providers were chosen. Health expenditure was found to be substantial even when compared to normal illness. The prevalence of catastrophic health expenditure was high. Our findings suggest that the provision of free health services may not be sufficient to reach UHC for patients with perceived emergencies. Changes in the organization of public EDs and improved financial protection for patients with emergencies may improve the situation. Further research should examine the options for financial protection in these conditions at a larger scale.

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This Article Corrects: "Systemwide Clinical Ultrasound Program Development: An Expert Consensus Model"

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Erratum in
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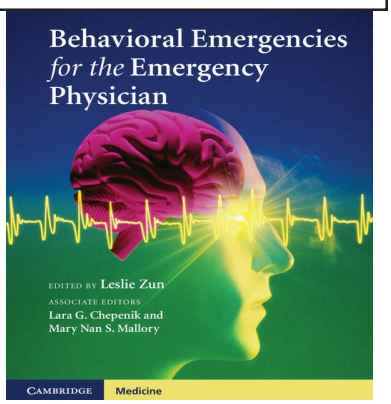

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