WestJEM

Volume XIV, Number 5, September 2013 Open Access at www.westjem.org ISSN 1936-900X

Western Journal of Emergency Medicine:

Integrating Emergency Care with Population Health

DIAGNOSTIC ACUMEN

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Western Journal *of* Emergency Medicine:

Integrating Emergency Care with Population Health

JOURNAL FOCUS

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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Bronchopleural Fistula

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Supervising Section Editor: Sean O. Henderson, MD
Submission history: Submitted November 1, 2012; Revision received December 31, 2012; Accepted January 28, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.1.14561
[West J Emerg Med. 2013;14(5):409–410.]

A 58-year-old man presented to the emergency department with diffuse swelling and crepitus of his face, chest, and extremities due to subcutaneous air (Figure). The patient had a history of lung cancer and had undergone a video-assisted transthoracic surgery (VATS) with decortications. His airway was maintained, and the patient reported only minimal shortness of breath with change in his phonation. Computed tomography of the chest showed a tumor at the left lung and an associated pneumothorax, along with extensive subcutaneous emphysema and pneumomediastinum throughout the thorax. An air source was found from the left chest due to a bronchopleural fistula (BPF).

A BPF is often a fatal complication of lung surgery postoperatively. It is defined as an abnormal communication between the bronchial tree and the pleural space.[1-2] Air dissects along the bronchi and pulmonary vessels into the mediastinum, and may move into the subcutaneous space of the face and neck.[3] The fistula is usually very small (about the size of a pinhole). The incidence is around 1-4% in patients undergoing lung surgery. The mortality rate ranges from 16-72%.[4-6] Risk factors associated with the development of a BPF include diabetes, malignancy, and immunosuppressive therapy.[7] A BPF that occurs in the early postoperative period is thought to be due to incomplete stapling or suturing of the bronchial stump. A BPF that occurs after 7 days postoperatively is usually secondary to ischemia or necrosis due to a tumor or extension of an empyema.[2] Treatment includes suturing, omentopexy, and muscle plumbage. For small BPFs, minimally invasive techniques have also been used, such as a stent insertion, fibrin sealants, and one-way valve insertion.[1]

Subcutaneous emphysema usually resolves spontaneously, with minimal intervention. There are case reports of severe airway obstruction. If stridor develops, then upper airway obstruction is a possibility and endotracheal intubation should be done without delay.[8] In a patient requiring intubation, consideration should be given to placement of a prophylactic chest tube, as the positive intrathoracic pressure can worsen the subcutaneous emphysema.[9]

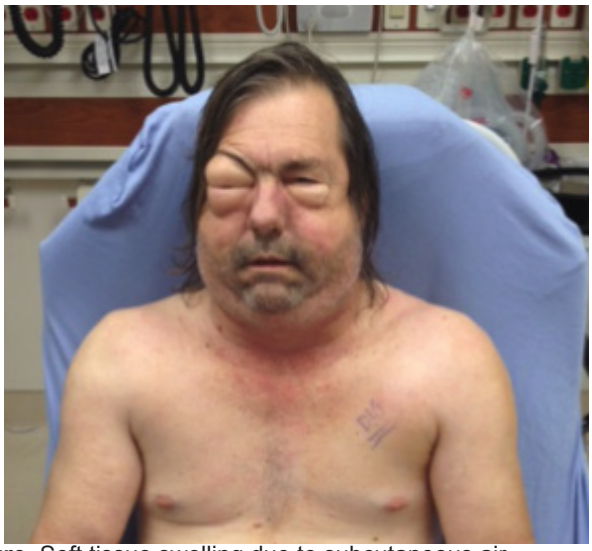

Figure. Soft tissue swelling due to subcutaneous air.

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

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Uterine Arteriovenous Malformation with Sudden Heavy Vaginal Hemmorhage

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Supervising Section Editor: Rick A. McPheeters, DO
Submission history: Submitted July 24, 2012; Revision received November 16, 2012; Accepted December 12, 2012
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2012.12.13025

Dysfunctional uterine bleeding (DUB) is a common presentation in the emergency department and has a wide differential. Most presentations of DUB are in hemodynamically stable patients and can be evaluated as an outpatient. Uterine arteriovenous malformation (AVM) is one presentation that can result in a life-threatening medical emergency with unexpected sudden and massive vaginal bleeding. We describe a case of a 24-year-old female with sudden heavy vaginal bleeding requiring a blood transfusion, ultrasound evidence of uterine AVM, and a treatment method of expectant management using an intrauterine device in an attempt to preserve fertility. [West J Emerg Med. 2013;14(5):411–414.]

CASE REPORT

A 24-year-old female, G3P0030 with a history of depression presented to the emergency department (ED) for evaluation of abrupt heavy vaginal bleeding. The patient noticed a sudden gush of blood between her thighs, prompting her visit to the ED. She had 2 days of light spotting preceding this sudden heavy bleeding, as well as irregular menses ever since a missed abortion 4 months prior. She had 2 elective terminations of pregnancies in the preceding year secondary to severe hyperemesis gravidarum. During this episode of sudden heavy vaginal bleeding, she also complained of mild suprapubic cramping, but no associated nausea, vomiting, dizziness, chest pain, or shortness of breath.

Upon presentation to the ED, approximately 30 minutes after the bleeding began, the patient's triage vital signs showed a blood pressure of 123/81 mmHg, pulse of 102, respiratory rate of 20, pulse oximetry of 100% on room air, oral temperature of 98.7°F, and a negative rapid urine pregnancy. Intravenous access was obtained and blood was drawn for laboratory analysis. Upon evaluation, she was awake, alert and oriented x3, and she was neither pale nor diaphoretic. She was bleeding through her sanitary napkins onto her

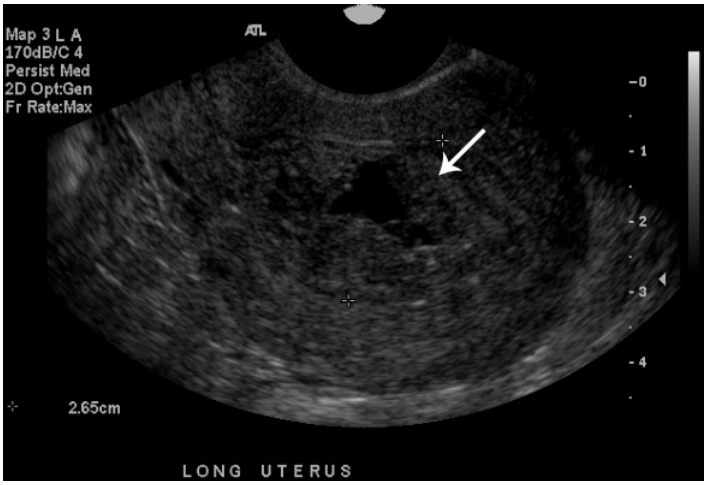

Figure 1. Ultrasonography of uterus in long axis showing enlarged endometrial cavity (2.65 cm) with irregular clot.

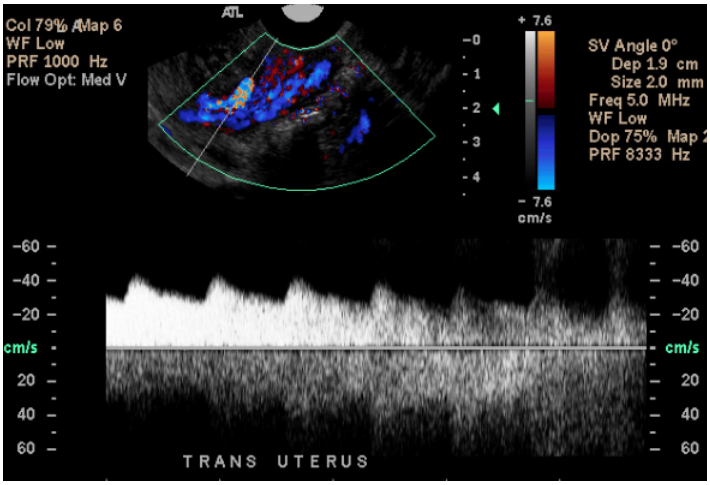

Figure 2. Ultrasonography of uterus in transverse axis with color doppler flow showing pulsatile flow inside the endometrial cavity.

clothes, but walked with ease to the exam table without any shortness of breath. Her abdomen had normoactive bowel sounds and was soft and non-tender. She had normal external genitalia with no signs of trauma. Her vaginal exam revealed copious dark blood and clots, with no trauma noted. There was approximately 300 mL of blood on the exam room floor. Her cervix had no lesions and clots were noted in the os. On bimanual exam, she had a closed cervical os, no cervical motion tenderness, and no adnexal tenderness.

Her laboratory studies, including a complete blood count (CBC), electrolyte panel, coagulation studies, and thyroid function tests ,were unremarkable. She had a hemoglobin (Hgb) of 12.1 g/dL and hematocrit (Hct) of 37.1%. A point-of-care ED transvaginal ultrasound showed an enlarged endometrial cavity containing irregularities with an area of pulsatile flow via Doppler, no free fluid, and normal ovaries. Despite receiving an initial 2-liter bolus of intravenous crystalloid, the patient developed symptoms of postural hypotension with average blood pressures at approximately 100/60 mmHg. Her heart rate remained in the nineties; however, she continued to have persistent heavy vaginal bleeding. The decision was made to admit the patient to the gynecology service for possible surgical intervention of massive dysfunctional uterine bleeding, and further evaluation of an enlarged endometrial cavity.

During her admission, and 9 hours after presentation, a repeat CBC due to heavy vaginal bleeding showed a 3-point drop in Hgb to 8.8 g/dL and Hct to 26.6%. She was transfused 4 units of packed red blood cells. On hospital day 2, her formal sonogram showed an enlarged endometrial cavity measuring 26 mm transversely with multiple hypertrophied vessels within the myometrium at the endometrial junction showing low resistance arterial flow, but no active flow within the endometrial cavity, suggesting a diagnosis of uterine arteriovenous malformation (AVM) (Figures 1 and 2). A magnetic resonance imaging angiogram (MRI/A) of the pelvis showed an amorphous collection of vessels arising from the pelvic arterial branches confirming the ultrasound diagnosis of multiple parametrial AVM or pseudoaneurysms (Figure 3).

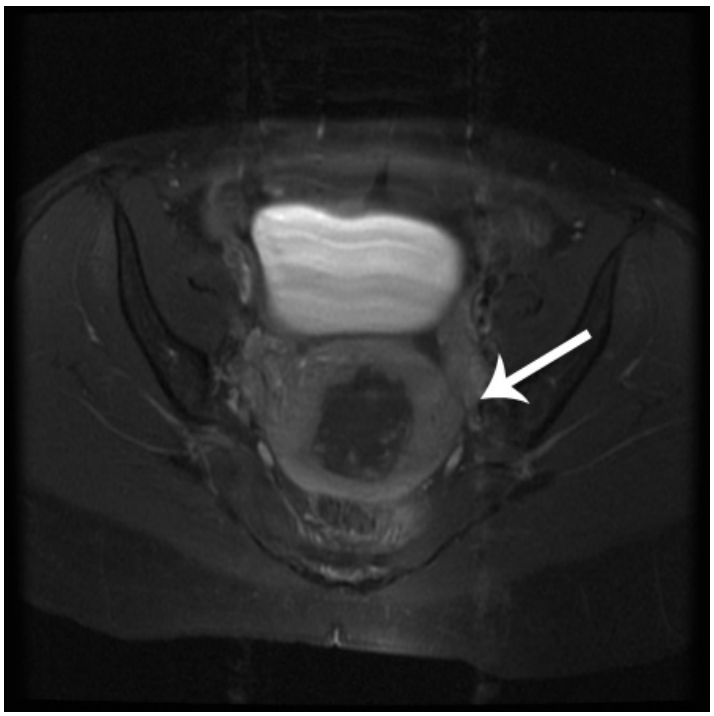

Figure 3. Magnetic resonance imaging of uterus in transverse axis demonstrating amorphous collection of vessels with fluid in the endometrial cavity.

On hospital day 3, she had minimal vaginal bleeding, normal vitals, and stable blood counts (Hgb 9 g/dL and Hct 27%). After a multidisiciplinary discussion involving gynecology and interventional radiology, the patient declined surgical intervention, including uterine embolization of the AVM, and preferred to try medical management in an attempt to preserve her fertility. A hormonal intrauterine device (IUD) was placed and the patient was discharged with strict instructions on when to return to the hospital if the bleeding returned.

DISCUSSION

Uterine AVMs are a rare cause of uterine bleeding with fewer than 100 cases reported.[1] The true incidence is unknown, but with increased use of ultrasound to evaluate abnormal vaginal bleeding, O'Brien et al[2] propose a rough predicted incidence of 4.5%. AVMs consist of an abnormal growth and connection between arteries and veins without a capillary bed, creating areas of high and low flow, which are fragile and prone to bleeding.[3] Uterine AVMs most commonly present with sudden heavy vaginal bleeding and can be congenital or acquired. Congenital AVMs form through disturbances in angiogenic development creating multiple connections between arteries and veins that tend to be deeper in surrounding tissue. Acquired AVMs form smaller arteriovenous fistulas that occur as a complication of uterine surgery or curettage, gestational trophoblast disease, choriocarcinoma, and infection.[4]

In a patient with massive vaginal bleeding, especially in the presence of hemodynamic instability, it is important to initiate aggressive resuscitation with intravenous fluids and early use of blood products.[5] Temporizing measures, such as intrauterine tamponade with a foley catheter, can be performed in the ED to treat life-threatening vaginal hemorrhage.[6] In the unstable patient, the treatment regimens include dilation and curretage (D&C), intravenous estrogen, uterine artery embolization, and hysterectomy.[7] Uterine AVMs frequently cause sudden massive bleeding, and in an unstable patient appropriate diagnosis is important because emergent treatment with D&C can worsen the underlying condition, leading to profuse uterine hemorrhage, shock, and potentially hysterectomy.[2]

Traditionally, uterine AVMs were diagnosed after hysterectomy with histopathologic evidence of the

arteriovenous fistulas.[3] In the present day, angiography has become the gold standard for diagnosis of uterine AVMs with the added benefit of the ability to deliver treatment through embolization.[8] Ultrasonography, computed tomography (CT) and MRI are being used more frequently as initial diagnostic modalities.[8] Ultrasonography is becoming the preferred method for diagnosing AVMs, reserving angiography for planned therapeutic embolization or prior to surgical intervention.

As ultrasonography is becoming more readily available in the ED, bedside ultrasonography by the emergency physician or consulting gynecologist can aid in the initial diagnosis of uterine AVMs. Gray scale ultrasonography will often show nonspecific heterogenous or anechoic tortuous spaces in the myometrium.[9] Color and spectral Doppler ultrasonography shows further detailing of a tangle of vessels producing a "color mosaic" pattern with multidirectional high and low velocity flow.[2,10] Ultrasonography has also been used to demonstrate the efficacy of treatment by evaluating for resolution of AVMs within 24 hours of embolization.[2]

Treatment of uterine AVMs remains controversial, often with great concern for fertility. Hysterectomy remains the definitive treatment, especially in a symptomatic patient without desired fertility.[4] A minimally invasive approach through angiographic embolization of the AVM, which has potential to preserve fertility, is currently the preferred treatment. In 1997, 10 years after the first successful uterine AVM embolization, there were only 5 pregnancies documented.[4] A review of current literature to 2004 shows slightly more successful pregnancies following embolization at a mere 10 pregnancies; however, this still does not demonstrate adequate fertility preservation.[8] Congenital AVMs tend to be treated with hysterectomy or embolization as they pose a higher risk of recurrent menorrhagia. And finally, in the correct clinical setting, conservative management is another treatment modality, typically offered to cases of acquired AVMs. Patients with one episode of bleeding and hemodynamic stability can be offered treatment with combined oral contraceptive pills (OCP).[11] Timmerman et al[12] report 8 cases of spontaneous resolution of acquired AVMs following OCP use or expectant management, improving the chances of preserved fertility. Even more case reports in the current literature show resolution of AVMs and successful pregnancies after conservative management.[13]

In this case report, a fertile female presented with sudden heavy vaginal bleeding in the setting of 2 recent D&Cs. The abrupt nature and volume of bleeding indicated the need to closely monitor for signs of hemorrhagic shock, and further evaluate for acquired uterine AVMs. The point-of-care ED ultrasound demonstrated a pulsatile mass in the endometrial cavity, prompting further workup for potentially life-threatening bleeding from a uterine AVM. Once hemodynamically stable, the patient opted for conservative medical management with an IUD to provide the highest probability of preserved fertility. IUDs have not been shown to reduce the size or risk of rupture of uterine AVMs, and there are no data to suggest that insertion is contraindicated. The patient was advised that her uterine AVM was likely acquired from her prior D&Cs and they could regress spontaneously or rupture again, possibly complicating future pregnancy. Her future might involve AVM embolization or hysterectomy as a last resort.

CONCLUSION

Dysfunctional uterine bleeding is a common complaint in the ED, and in the right clinical setting, can be life threatening. When faced with a patient with sudden and massive vaginal bleeding and a history of prior uterine instrumentation, the diagnosis of uterine arteriovenous malformation should be considered. Color or spectral Doppler ultrasonography should be used to confirm the diagnosis and provide the most accurate information to the consulting gynecologist.

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

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Appendicitis Diagnosed by Emergency Physician Performed Point-of-Care Transvaginal Ultrasound: Case Series

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Submission history: Submitted October 28, 2012; Revision received December 10, 2012; Accepted December 12, 2012
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2012.12.14430

Lower abdominal pain in females of reproductive age continues to be a diagnostic dilemma for the emergency physician (EP). Point-of-care ultrasound (US) allows for rapid, accurate, and safe evaluation of abdominal and pelvic pain in both the pregnant and non-pregnant patient. We present 3 cases of females presenting with right lower quadrant and adnexal tenderness where transvaginal ultrasonography revealed acute appendicitis. The discussion focuses on the use of EP- performed transvaginal US in gynecologic and intra-abdominal pathology and discusses the use of a staged approach to evaluation using US and computed tomography, as indicated. [West J Emerg Med. 2013;14(5):415–418.]

INTRODUCTION

Acute abdominal pain in female patients of reproductive age continues to present a diagnostic challenge for the emergency physician (EP). Abdominal pain accounts for 10% of all emergency department (ED) visits, and the abdominal and pelvic examinations are notoriously unreliable for differentiating between gynecologic and intraabdominal pathology.[1-3] Multiple advanced imaging and diagnostic options may be used to evaluate medical, surgical, or gynecologic pathology. Point-of-care ultrasound (US) allows for the rapid, accurate and safe differentiation of multiple diagnoses in the ED.[4-6] We present 3 cases of acute appendicitis diagnosed by EP point-of-care transvaginal ultrasonography.

Case 1

The first case involved a 20-year-old female who presented with 2 hours of sudden onset right-sided abdominal pain radiating to her groin. She had been undergoing treatment for a urinary tract infection with trimethoprim/sulfmethaxazole. The patient exhibited no nausea, vomiting, diarrhea, vaginal discharge or vaginal bleeding. Vital signs were within normal limits without fever. The abdominal examination revealed focal right lower quadrant abdominal tenderness without rebound, guarding or masses. Adnexal tenderness on the right was also noted, and there were no genital lesions, masses, vaginal discharge or cervical motion tenderness. The urine pregnancy test was negative. Laboratory evaluation was significant for a leukocytosis (white blood cell count=15.5 K/uL). A complete metabolic panel and urinalysis were within normal limits.

Initially, testing with point-of-care US was pursued to evaluate for appendicitis or gynecologic causes of pain. Using a high frequency linear array transducer (L8-3 linear array, Zonare Medical Systems Inc., Mountain View, CA, USA) transabdominal US was performed first. However, the appendix was not visualized. Next, a transvaginal US was performed using an E9-4 endocavitary probe (Zonare Medical Systems Inc., Mountain View, California). Findings included a left ovarian complex follicular cyst, small to moderate amount of free fluid, and ovaries with normal arterial and venous blood flow. Additionally, a tender, blind-ended, non-compressible, non-peristalsing, tubular structure measuring 7 mm was noted in the right adnexa consistent with acute appendicitis. A surgical consultation was called and the patient was admitted to the surgical service. The patient underwent laparoscopic resection and pathology confirmed the diagnosis of acute appendicitis.

Case 2

The second patient was a 20-year-old female complaining of right lower quadrant and suprapubic abdominal pain and nausea for 1 day. The patient denied fever, vomiting, diarrhea, vaginal bleeding or vaginal discharge. Past medical

history was significant for renal colic 1 year prior. Vital signs were again within normal limits without fever. The physical examination demonstrated a soft abdomen with right lower quadrant tenderness and rebound. No cervical motion or adnexal tenderness, masses, or discharge were noted on gynecologic examination. Laboratory evaluation was remarkable only for a leukocytosis of 18.2 K/uL. Urine pregnancy testing, complete metabolic panel and urinalysis were negative.

Transabdominal US was performed without visualization of the appendix. Transvaginal US was then performed by the EP, revealing a 3.8 cm right ovarian complex cystic structure. Bilateral ovarian stroma demonstrated normal echotexture with no signs of torsion. In the right adnexa, a 7 mm blind-ended, non-peristalsing, non-compressible, tubular structure with wall edema and surrounding free fluid was identified consistent with acute appendicitis (Figure 1). The patient was admitted to the surgical service for appendectomy. Laparoscopic resection was performed and pathology confirmed the diagnosis.

Case 3

The third case was an 18-year-old female with lower abdominal and pelvic pain for 1 week starting during her menstruation. She was afebrile with normal vital signs. Examination elicited right lower quadrant tenderness with guarding and no masses. Gynecologic examination demonstrated right adnexal tenderness without cervical motion tenderness, masses, lesions or discharge. Laboratory analysis was only pertinent for a leukocytosis of 12.1 K/uL.

A point-of-care endovaginal US was performed to evaluate for gynecologic pathology. A large amount of free fluid was present. Upon scanning the right adnexa an irregular tubular structure, containing an appendicolith, with surrounding hyperemia was seen (Figure 2). There was exquisite tenderness over this non-compressible structure, which measured 2.02 cm. The appendix was not visualized with transabdominal imaging. The patient was admitted to the surgical service and the diagnosis of perforated appendicitis was confirmed.

DISCUSSION

The evaluation of lower abdominal pain in the female patient presents a diagnostic dilemma for the EP. After excluding pregnancy and its complications from the differential diagnosis, there are still multiple intra-abdominal and gynecologic pathologic processes that must be considered. In our cases, the patients presented with right lower quadrant abdominal pain, and US allowed for the rapid, safe and accurate evaluation of emergent conditions, including appendicitis, ovarian torsion, and tubo-ovarian abscess.[4-6] US was chosen as the initial imaging modality since it can be performed at the bedside rapidly. In addition, it allows for early initiation of appropriate treatment, consultation, and disposition.

Multiple gynecologic pathologies can be detected using US, including ovarian cysts, ovarian torsion, endometriosis, uterine fibroids and tubo-ovarian abscess. ED point-of-care US can evaluate for indicators of pelvic inflammatory disease and tubo-ovarian abscess.[6] This presentation can be similar to appendicitis with lower abdominal pain, fever, adnexal tenderness and leukocystosis.

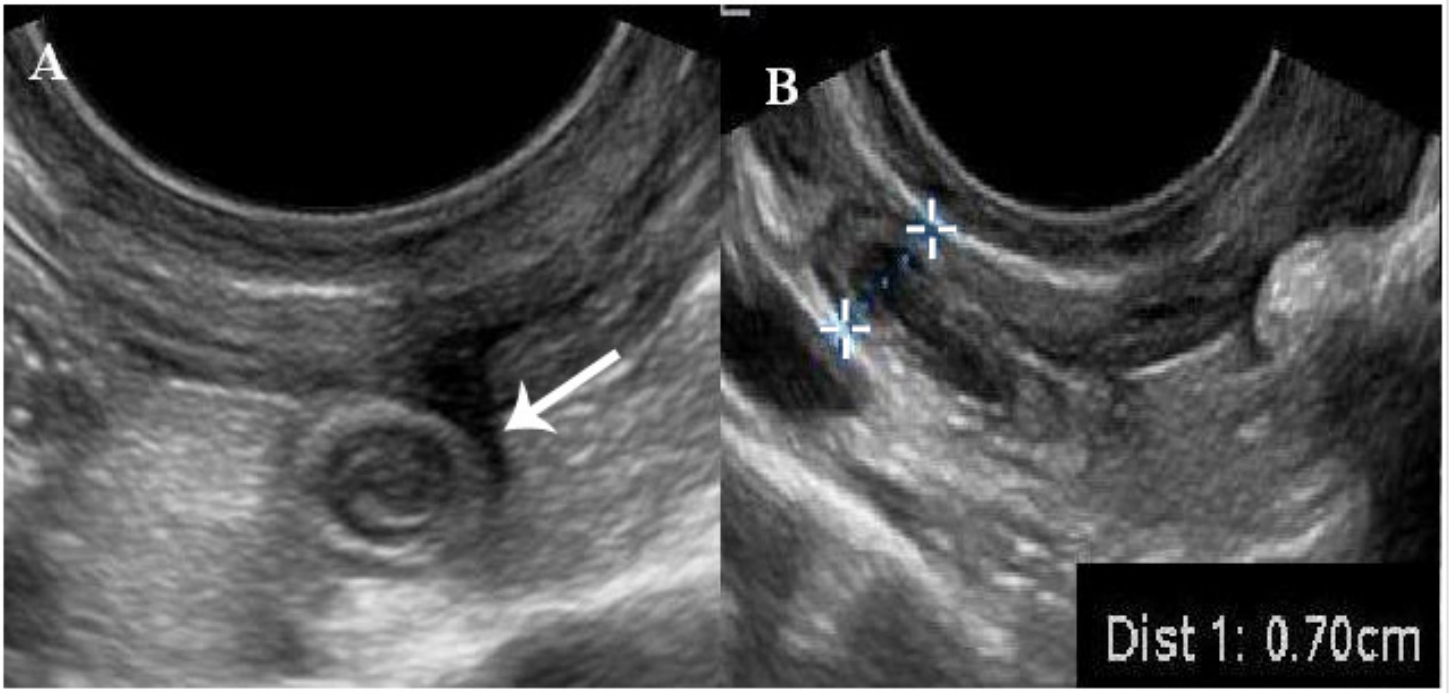

Figure 1. Transvaginal imaging of the right adnexa. (A) Transverse view of the appendix. (B) Long view of the appendix measuring 0.7 cm.

Ovarian torsion symptoms can also mimic acute appendicitis, with patients exhibiting lateralized lower quadrant abdominal pain with rapid onset.[7] Ovarian torsion occurs more commonly on the right, which further confounds the differentiation from appendicitis.[5] Multiple studies have stressed the importance of performing ultrasonograpy as the initial test of choice for patients presenting with lower abdominal and pelvic pain, as delay can lead to loss of the ovary in torsion, or unnecessary ionizing radiation exposure.[6,8] A 2001 study showed that appendicitis was the most common preoperative diagnosis in patients with torsion, and torsion was considered in the initial differential in less than half of the patients in the study group.[9]

In each of our cases, point-of-care US was pursued first, with a plan to proceed to computed tomography (CT) if the US was normal or nondiagnostic. By custom and practice transabdominal US is attempted initially by the EP followed by transvaginal imaging if nondiagnostic. Appendicitis was diagnosed based on visualization of a blind-ended, non-compressible (using the transvaginal transducer and the free hand palpating over the lower abdomen), non-peristalsing, tubular structure measuring ≥ 6 mm in the right lower quadrant. Other associated signs of appendicitis include hyperemia, a visualized appendicolith, or free fluid around the appendix.[6] Physical examination was not specific in our cases, as previously described in multiple cases of appendicitis diagnosed during evaluation for gynecologic pathology due to cervical motion or adnexal tenderness on examination.[2,3]

The staged approach of US for diagnosis of appendicitis followed by CT, as needed, is the path of choice. A 2010 study concluded that using a staged approach to imaging patients with suspected appendicitis, US had a negative predictive value of 97%, only 17% of patients required a CT, and the negative laparoscopy rate was 3%.[8] US diagnosis avoids nephrotoxic contrast agents and ionizing radiation, which increases the lifetime risk of developing cancer.[10] Using a staged approach, patients diagnosed by US alone had an acceptable 7% negative appendectomy rate and < 0.5% missed diagnosis rate, and with US followed by CT specificity was 91% and sensitivity was 99%.[6] In each of our cases early point-of-care US allowed for early diagnosis, initiation of treatment and surgical consultation. The surgical service wanted confirmatory CT, which confirmed the point-of-care US diagnosis in each case. We believe this to be due to the atypical way in which the diagnosis was made, as our surgeons typically operate on ED US-diagnosed appendicitis.

The use of US to diagnose appendicitis is widely discussed in the literature. US for appendicitis has sensitivity between 75-99%, specificity between 86-100%, positive predictive value of 90%, and a negative predictive value between 95-97%.[3,11-14] CT sensitivity for appendicitis is 92% and specificity is 96%.[15] Transvaginal US should be considered in females of child-bearing age with right lower quadrant abdominal pain for numerous reasons. Delayed diagnosis of torsion or tubo-ovarian abscess can lead to infertility, mortality, or chronic pelvic pain. In addition, in a study in which transabdominal and transvaginal US was performed, 24% of patients had appendicitis only diagnosed by transvaginal scanning.[16] ED performed endovaginal US was shown to modify clinician decision making when performed prior to or in lieu of CT imaging.[17] Our cases demonstrate point-of-care US should be encouraged among practitioners as

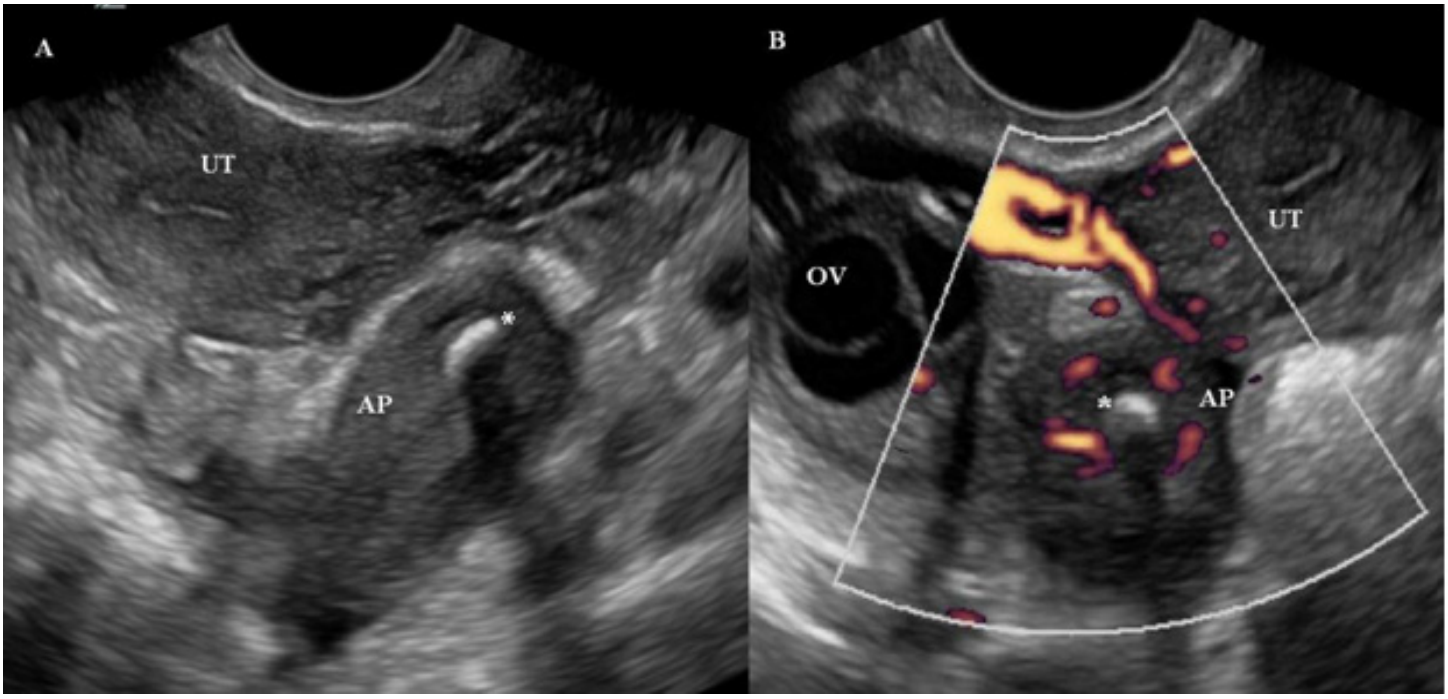

Figure 2. Transvaginal imaging of the right adnexa demonstrating appendicitis. (A) Enlarged appendix (AP) with appendicolith (*). The uterus (UT) is also seen. (B) Hyperemic appendix (AP) visualized in transverse, appendicolith (*), right ovary (OV), and uterus (UT) seen.

the initial modality. In suspicious cases, the appendix should be sought in addition to evaluating for other pelvic pathology as it can obviate the need for CT.

CONCLUSION

While abdominal pain in the reproductive female continues to present a diagnostic dilemma to the EP, point-of-care US contributes to the rapid and safe evaluation and disposition in these cases. US should be considered early in the evaluation, as part of a staged approach, to guide the overall management pathway or clinch the diagnosis. Practitioners performing point-of-care US should be alert to additional findings when performing transvaginal US as the appendix may be visualized, avoiding misdiagnosis or exposure to additional radiologic studies. Further research should aim to demonstrate the true reduction in CT use and change in disposition when US is used as a primary modality in this patient subset.

Video. Transvaginal imaging of the right adnexa demonstrating a non-compressing, enlarged appendix with an appendicolith (hyperechoic with posterior shadow)

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

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Cephalohematoma in a Patient with Ehlers-Danlos Syndrome

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Supervising Section Editor: Rick McPheeters, DO
Submission history: Submitted September 11, 2012; Revision received November 21, 2012; Accepted January 22, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.1.13409

Ehlers-Danlos syndrome is a rarely encountered connective tissue disorder characterized by skin hyper-elasticity, joint hyper-flexibility, and vasculature fragility. We report a 41-year-old female presenting with scalp swelling following minor head trauma. The patient presented with a large cephalohematoma that despite compressive measures and Factor IX administration continued to progress, necessitating transfer for definitive surgical intervention. The patient underwent surgical evacuation of approximately 1 liter of blood, followed by drain placement and compression dressing. This case underscores the importance for emergency physicians to recognize the potential vascular catastrophes these patients may present with following even minor injury. [West J Emerg Med. 2013;14(5):419–420.]

A 41-year-old female presented to the emergency department (ED) following a minor head injury 3 hours prior to arrival. She stated she was struck on the head by a falling broom handle and presented to the ED with a chief complaint of scalp swelling. She denied any loss of consciousness, but did report a past medical history significant for easy bruising and hematoma formation resulting from Ehlers-Danlos syndrome. The patient's past surgical history included numerous surgeries to remove hematomas from the chest wall and extremities resulting from her Ehlers-Danlos syndrome. Her family history was unknown as she was adopted. On initial presentation, the patient's vitals were within normal limits. Physical exam revealed a large scalp hematoma to the right side of the head extending down to the occipital region without evidence of focal neurological deficit. A stat computed tomography (CT) of the brain with angiographic study was ordered and is shown below (Figures 1 and 2). Upon returning from radiology, the patient's hematoma continued to progress into the facial tissues extending down to the level of the zygomatic arch, despite direct compressive measures. Laboratory results revealed a hemoglobin level of 9.3 g/dL, platelet count of 291,000, and an international normalized ratio (INR) of 1.39 sec. Factor IX complex was administered in the ED with a dosage of 1731 units given at 120 mL/hour, while direct pressure was continuously applied to the scalp and facial structures to prevent further progression of the hematoma. The case was discussed with the on-call neurosurgeon and subsequent transfer to a nearby trauma center was initiated. Prior to transfer, the patient's blood pressure had deteriorated to 90/60 mmHg with a pulse of 128 beats-per-minute, and the hematoma had progressed below the level of the chin into the cervical soft tissues. The patient was transferred 2 hours and 20 minutes after arrival.

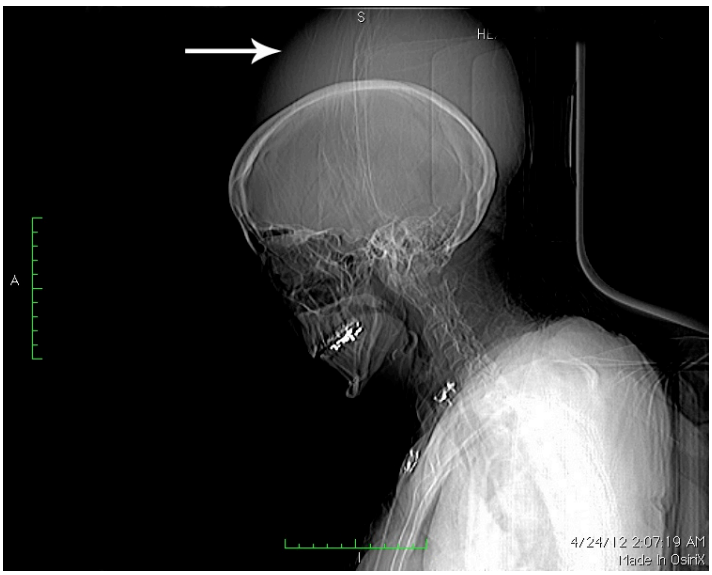

Figure 1. Computed tomography scout film demonstrating cephalohematoma.

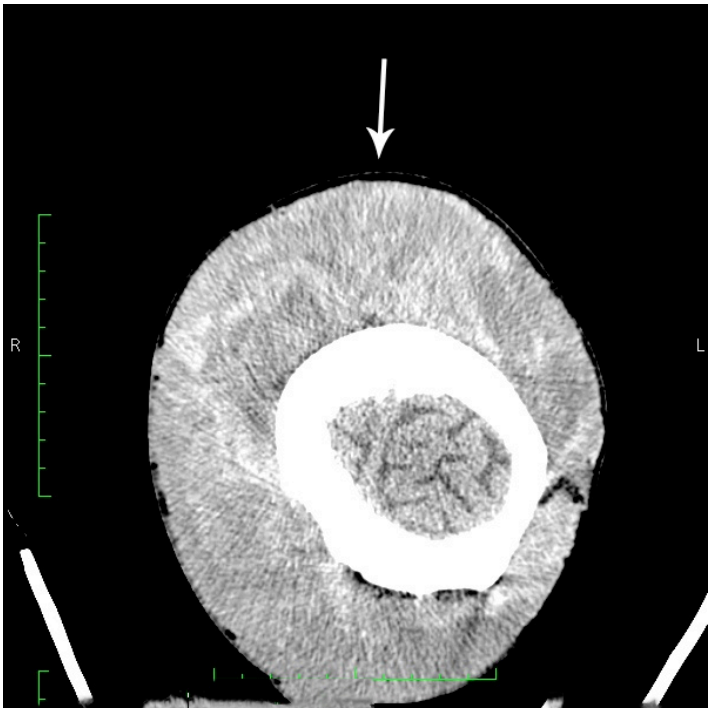

Figure 2. Computed tomography demonstrating extensive cephalohematoma in the soft tissues of the scalp.

Hospital Course

Upon arrival to the tertiary trauma center, the patient was taken emergently to the operating suite for evacuation of the cephalohematoma. Approximately 1 liter of blood was evacuated from the subgaleal space into a cell saver and subsequently returned to the patient intra-operatively. In addition, 4 units of packed red blood cells and 2 units of fresh frozen plasma were administered intra-operatively following a repeat hemoglobin level of 6.8 g/dL. Two Jackson Pratt drains were placed in combination with a pressure dressing after evacuation of the hematoma was completed. Following surgery the patient was left intubated until post-operative day number 7, but re-intubated shortly thereafter secondary to respiratory distress and subsequent development of pneumonia. The patient's hospital course was further complicated by necrosis of the overlying scalp necessitating a 14 x 13 cm abdominal wall skin graft. Thirty-one days following admission, the patient was discharged to a sub-acute rehabilitation facility.

DISCUSSION

First described by Job van Meekeren in 1682, Ehlers-Danlos is a rare connective tissue disease process resulting from abnormal collagen production.[1] Patients afflicted with the disorder suffer from a "classic" triad of hyperelasticity of the skin, hyperflexibility of the joints, and fragility of the skin and vessels.[2] Traditionally, the focus of emergency physicians has centered on the identification of life-threatening manifestations of the disease related to the great vessels (aneurysm, great vessel rupture, and dissection). The systemic nature of the disease, however, can lead to aneurysm formation and vessel wall fragility in areas outside of the great vessels, resulting in ecchymosis and hematoma formation following even minor trauma.

A review of the literature revealed only 1 prior reported case of cephalohematoma in a patient with Ehlers-Danlos syndrome published in the *British Journal of Neurosurgery*.[3] The patient, a 17-year-old male, presented with an occipital hematoma resulting from a minor trauma 3 days prior. The patient underwent needle aspiration, resulting in further expansion of the hematoma to encompass the scalp in its entirety. Subsequently, the patient was treated conservatively with pressure dressings, receiving 3 units of blood during his hospital course. Six weeks after the initial trauma, the patient had complete resolution of his symptoms. Unlike this case report, our patient's symptoms rapidly progressed from the onset of the initial trauma, and conservative treatment with compression dressings was unable to halt further progression of the hematoma. In both this prior case report and our patient's case, angiogram (CT in our patient's case) was unable to identify a culprit vessel responsible for the bleeding. Given our patient's hemodynamic instability, immediate transfer for definitive surgical treatment was deemed necessary. To date, there have been no published case reports evaluating the surgical management for cephahematoma in patients with Ehlers-Danlos syndrome.

Our patient's initial presentation resulting from an otherwise benign trauma highlights the importance of rapidly initiating aggressive treatment modalities when conservative measures fail. Although Ehlers-Danlos is a rarely encountered connective tissue syndrome, this case underscores the importance for emergency physicians to recognize the potential vascular catastrophes these patients may present with following even minor injury.

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

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Early Presentation of Buried Bumper Syndrome

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Supervising Section Editor: Rick McPheeters,DO
Submission history: Submitted January 9, 2013; Revision received February 16,2013 ; Accepted February 27,2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.2.15843

Percutaneous endoscopic gastrostomy (PEG) is a relatively safe and effective method of providing nutrition to patients with neurologic deficits or proximal gastrointestinal pathology. Complications that follow this common procedure include dislodgement, dysfunction, infection and aspiration. The "Buried Bumper Syndrome" (BBS) is an infrequent and late complication of PEG tubes that can result in tube dysfunction, gastric perforation, bleeding, peritonitis or death. The emergency physician should be aware of historical and exam features that suggest BBS and distinguish it from other, more benign, PEG-tube related complaints. We report a case of a woman presenting with BBS 3 weeks after having a PEG tube placed. [West J Emerg Med. 2013;14(5):421–423.]

CASE

A 76-year-old woman presented to the emergency department (ED) because of pain and drainage at her percutaneous endoscopic gastrostemy (PEG) tube site and inability to instill fluid. Three weeks prior, she had undergone a laryngectomy for recurrent laryngeal cancer. At the same time she had a tracheostomy and PEG performed. Three hours prior to arrival, she noticed peritubal leakage and localized discomfort with attempts to flush the tube. She denied prior complications with the tube.

On examination, the patient had normal vital signs and appeared comfortable. Her head, chest, and extremity exams were normal. Her neck showed a well-healing surgical incision. Her abdomen was soft with no appreciable tenderness. There was no evidence of distention or palpable masses. The patient's PEG site was not indurated and showed no erythema or drainage. The external bolster was approximately 1 centimeter from the skin surface. The tube was not mobile within the stoma.

Attempts to flush the tube with warm water and then soda resulted in peritubal leakage. It also caused the patient sharp, instantaneous abdominal pain at the site of the PEG. When the provider palpated the PEG site during flushing, transient distention and gurgling was felt within the abdominal wall.

A tube study was performed. Based on this study, a computed tomography (CT) was performed (Figure) to determine the exact location of the PEG tube as well as any secondary complications resulting from its misplacement.

General surgery was consulted for the malfunctioning PEG tube. The surgical attending recognized this as "Buried Bumper Syndrome," an uncommon and dangerous complication of PEG tube placement. The patient was admitted to the hospital for intravenous (IV) antibiotics and fluid hydration. Her PEG tube was removed operatively and was not replaced.

DISCUSSION

PEG tube placement is performed 250,000 times per year in the United States.[1] It permits enteral access for patients who

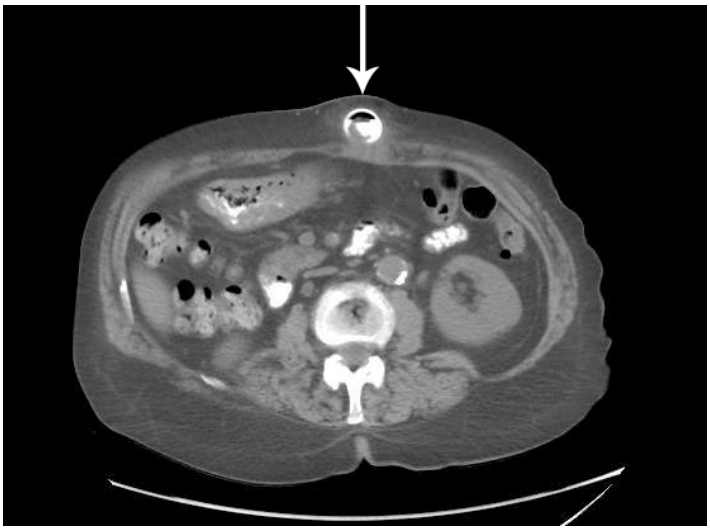

Figure. Axial contrast computed tomography demonstrates internal bolster in the subcutaneous tissue of the anterior abdominal wall without evidence of contrast extravasation.

are unable to take food, water and medications by mouth. It may be indicated in patients with a persistent neurologic deficit, a fistula or malignant obstruction proximal to the stomach, or for gastric decompression, such as with severe bowel dysmotility. The percutaneous technique in particular, introduced in 1980, permits non-surgical placement of enteral feeding tubes in a population of patients who are undernourished but are suboptimal candidates for laparoscopic feeding tube placement because they are likely to demonstrate poor wound healing.[2]

Overall, serious complications secondary to PEG tube placement are uncommon. Immediate complications from upper endoscopy or from the PEG tube placement itself, such as acute bleeding, esophageal perforation, or aspiration, are generally diagnosed prior to discharge and do not present to the ED.[3] However, other complications occur later, and it is not uncommon for patients to present to the ED with a complaint referable to their PEG tube weeks to months or even years after placement.[4]

BBS is a rare complication of PEG tube placement that occurs in 0.3-2.4% of patients. This phenomenon occurs when the bolster inside the stomach produces ischemic necrosis of the gastric mucosa and migrates into the gastric wall or subcutaneous tissue. Although this has been described in the gastroenterology literature as a late complication of PEG tube placement, it has been reported in 1 case to occur 8 days after placement.[5] In our patient, it occurred 3 weeks after her procedure. That said, the vast majority of cases present more than a year after PEG tube placement.[6,7]

The etiology of the syndrome appears to be related to traction on the internal bolster during placement, manipulation or when abdominal adipose sags in the upright posture. This traction creates pressure between the internal bolster and the gastric wall, ultimately leading to pressure necrosis. Recent studies have identified risk factors associated with BBS, including obesity, multiple gauze or other dressings between the external bolster and the abdominal wall, manipulation of the tube by inexperienced personnel, and even chronic cough.[8]

BBS may mimic stomal infection, uncomplicated tube leakage, or tube obstruction.[3,6] It may also present with peritonitis, gastrointestinal bleeding, or sepsis.[9] The most common symptom is pain, which may be persistent secondary to dissection of instilled feeds or medications within the abdominal wall or may be intermittent, as in our patient.[10] Early in the course of pathogenesis, the patient may not experience tube obstruction, but as the gastric mucosa slowly grows over the internal bolster, the device eventually becomes non-functional. Abscess and abdominal wall infections have also been reported as complications of BBS, and there has been a case report of death resulting from the syndrome.[9]

Although radiographic studies such as CT or tube studies may assist in finding the exact location of the PEG tube, the diagnosis of BBS is a clinical one.[11] Although its clinical presentation overlaps those of other PEG tube complications, a careful physical exam will reveal that the PEG tube cannot rotate within or slide through the stoma in patients with BBS.[10] This is because the buried bumper causes the tube to become fixed in place. This is in contrast to patients with localized wound infection, uncomplicated PEG tube leakage, and tube obstruction, in whom the PEG tube should be freely mobile in the stoma on physical exam and should not be painful with installation of fluids.

In the emergency setting, suspicion of this entity should prompt consultation with surgery and admission of the patient to the hospital. IV access should be obtained, and the patient should not be given any medications or fluids through the PEG tube. Some surgeons recommend patients receive antibiotics even in the absence of infectious symptoms, as the pathophysiology of this disease assumes abdominal wall contamination with tube feeds. The definitive treatment of BBS is removal of the PEG tube. This can be accomplished with surgery, endoscopy, or a combination of the two, depending on the location of the bumper and the complications encountered.[3]

CONCLUSION

Complications of PEG tubes are commonly encountered by the emergency physician. Although most complications are minor, BBS is a potentially life-threatening process that may mimic more benign conditions. The emergency physician should have a high index of suspicion for this entity, and should be aware of historical and physical exam features that suggest BBS. Early diagnosis and surgical consultation for the management of BBS may help avoid repeated ED visits and more serious complications.

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

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"I Can't Walk!" Acute Thrombosis of Descending Aorta Causing Paraplegia

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Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.2.15836

A 50-year-old man presented to the emergency department (ED) with acute, bilateral lower extremity weakness and loss of sensation, as well as absent pulses bilaterally. Computed tomography angiography showed complete occlusion of the aorta below the inferior mesenteric artery, extending to the iliac bifurcations. Echocardiographic findings showed severe systolic dysfunction (ejection fraction of 15%) and cryptic cardiogenic shock in spite of stable vital signs. Prior to early operative intervention, an early goal-oriented hemodynamic strategy of shock management resulted in the resolution of motor and sensory deficits. After definitive surgical intervention, the patient was discharged neurologically intact. Acute aortic occlusion is frequently accompanied by myocardial dysfunction, which can be from mild to severe. The most severe form can even occur with normal vital signs or occult cardiogenic shock. Early detection and goal-directed preoperative hemodynamic optimization, along with surgical intervention in the ED, is required to optimize outcomes. [West J Emerg Med. 2013;14(5):424–427.]

INTRODUCTION

Sudden bilateral lower extremity weakness can be the cardinal sign of a complete occlusion of the abdominal aorta. Multiple case reports reveal that myocardial dysfunction leading to global tissue hypoperfusion and shock frequently accompanies this disorder, which is associated with a mortality of 38%.[1-19] Therefore, early recognition and therapeutic intervention, aimed at the restoration of tissue perfusion using a goal-directed approach, is paramount to maximize outcomes.

We report the case of a patient presenting with sudden bilateral lower extremity weakness and loss of pulses due to a complete occlusion of the infra-renal abdominal aorta, extending in the bilateral iliac arteries complicated by cardiogenic shock. Early recognition and treatment of these conditions in the emergency department (ED) before surgery can significantly improve survival.

CASE REPORT

A 50-year-old man presented to the ED after sudden onset of bilateral lower extremity weakness. The patient developed lower back pain and tingling in both lower extremities which progressed to complete paralysis within two hours after onset of the symptoms.

His medical history was significant for diet-controlled diabetes mellitus, systolic heart failure, hypertension, prior myocardial infarction, stroke, and prostate cancer. His medications included furosemide, digoxin, carvedilol, lisinopril, clopidogrel, and aspirin. He received hormonal therapy for his prostate cancer within the last year. His social history included 1 pack per day of cigarettes and a remote history of intravenous drug abuse.

At ED arrival, he was found to have a blood pressure of 127/47 mmHg (mean arterial pressure [MAP] of 74 mmHg). Upon physical exam, the patient was alert and oriented to self, time and place. Strength in lower extremities was 0/5 bilaterally, with no sensation from the distal one third of thigh and below bilaterally. Cardiovascular exam revealed regular rate and rhythm, S1, S2, and no pedal edema. However, femoral, dorsalis pedis and posterior tibialis pulses were absent bilaterally, in addition to poor rectal tone. There was mottling over the knees bilaterally, and they were cool to touch.

Laboratory work-up revealed moderately elevated blood urea nitrogen (BUN) and creatinine, 50 and 2.5 mg/dL respectively, a creatine phosphokinase of 323 IU/L, a pH of 7.50 and a troponin of 0.7 mg/mL. Because of the physical exam findings of decreased perfusion and new onset renal failure, a serum lactate was ordered and found to be elevated to 5.6 mmol/L.

The history of prostate cancer led to the inclusion of acute spinal cord compression in the differential diagnosis. Consequently, contrast computed tomography (CT) of brain, thoracic and lumbar spine were ordered, all of which were unremarkable. Due to the absence of pulses in the lower extremities, additional CT angiogram was ordered, which showed a complete occlusion of the distal aorta below the inferior mesenteric artery, extending to the common iliac bifurcations (Figure). To rule out a cardiac source for the thrombus, an echocardiogram was performed and showed an ejection fraction (EF) of 15 %, indicating severe systolic dysfunction. Clinical and laboratory evidence of global tissue hypoperfusion (shock) led to the conclusion that the patient was in need of intensive or invasive hemodynamic monitoring to guide his resuscitation.

Paralleling vascular surgery consultation, a central venous catheter was placed and a goal-directed hemodynamic optimization was performed before the necessary surgical intervention. This included optimization of preload, afterload and contractility to increase systemic oxygen delivery to meet demands and eradicate global tissue hypoperfusion. This was achieved with the use of the central venous pressure, (CVP), MAP, $ScvO_2$ and clearance of lactate levels. During the 3 hours of ED stay prior to surgical intervention, Dobutamine was started at 2.5 mcg/kg/min and raised to 5 mcg/kg/min by the second hour. During this time, CVP decreased from 28 to12 cmH_2O and $ScvO_2$ increased from 48 to 74 %, while lactate levels decreased from 5.2 to 1.0 mmol/L. During this period MAP was maintained between 75-88 mmHg, and the heart rate ranged from 72 to 81 beats per minute. These findings indicated the initial presence of global tissue hypoxia and its resolution during the goal-directed resuscitation. Severe global tissue hypoxia was present with normal vital signs.

After improvement in hemodynamic status, he underwent an open aorto-ilaic embolectomy and bilateral lower extremity 4-compartment fasciotomies to prevent the expected reperfusion injury and compartment syndrome. The patient was transferred to the surgical intensive care unit after the procedure for continued monitoring, resuscitation and systemic anticoagulation with heparin.

He continued to improve post-operatively and was discharged on anticoagulation. At follow-up evaluation in the vascular surgery clinic, 13 days after hospital discharge, the patient reported full return of lower extremity sensation and was able to ambulate without assistance.

DISCUSSION

Acute aortic occlusion is an infrequent surgical emergency, but should be considered as part of the differential diagnosis in the ED in patients presenting with bilateral loss of motor

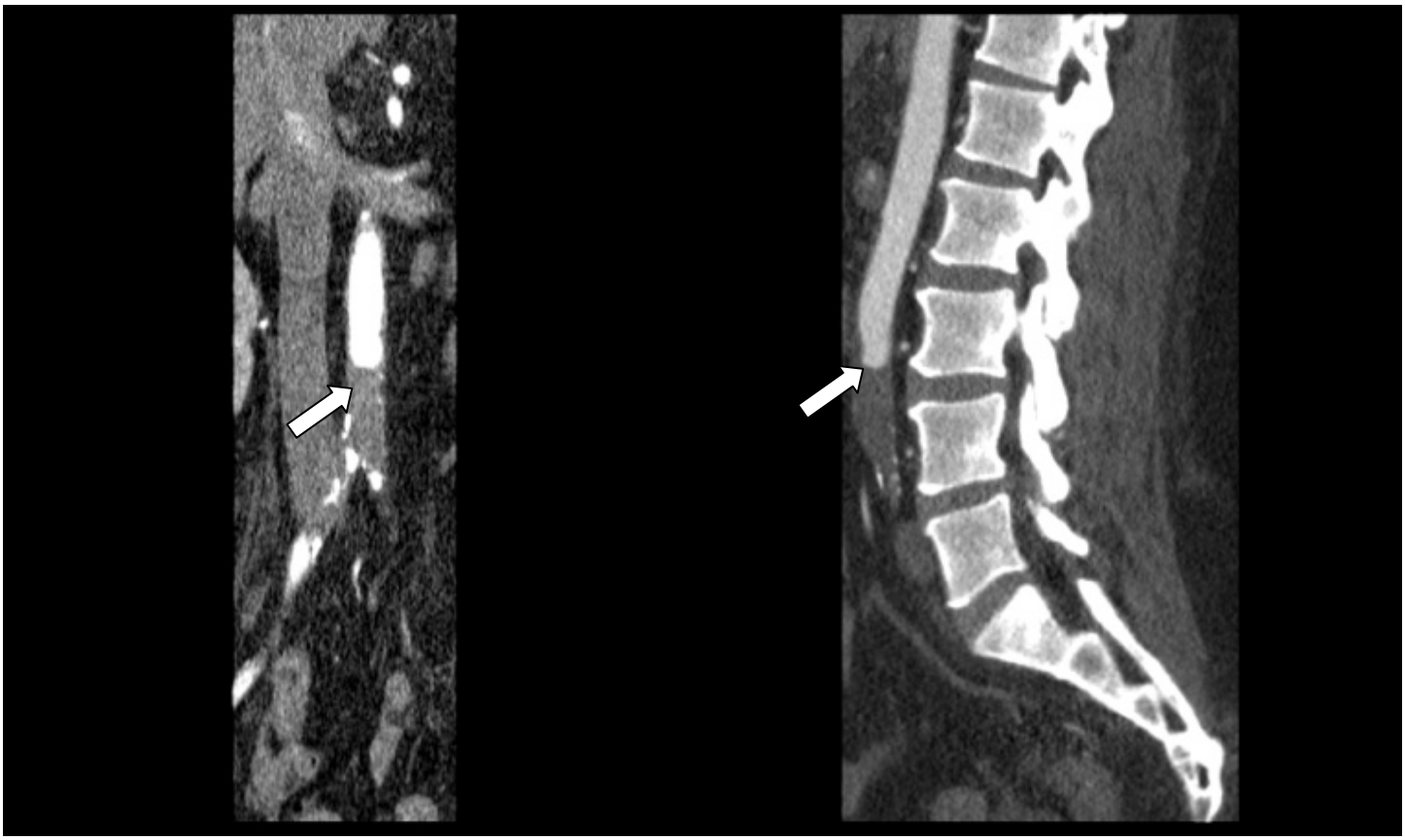

Figure. Computed tomography angiography of the thorax and abdomen shows a complete thrombosis of the distal aorta below the inferior mesenteric artery, extending to the common iliac bifurcations.

function, sensation and pulses.[2-4,6,10] The differential in this case also includes spinal cord compression from prostate cancer or a spinal abscess (history of intravenous drug abuse).[1,4] In this case, the physical exam findings of the bilateral absent pulses in the lower extremities led to the suspicion of a vascular cause.

An important clinical caveat in this case relates to the early detection of global tissue hypoperfusion as a paralleling insult to the physical examination. These findings can be occult (with normal vital signs), especially in patients with pre-existing myocardial disease. Thus, the additional findings of mottling, acute renal failure, lactate elevation and severe systolic dysfunction by echocardiogram suggests global tissue hypoperfusion and necessitates early and aggressive hemodynamic optimization.[1,4]

In a review of the literature, a common feature is cardiac dysfunction, which can be present as a result of the acute process or exacerbated from pre-existing disease, such as congestive heart failure (CHF).[2-4,10] Bell et al[2] noted that this "unstable cardiac output*"* resulted in a failure of the surgical efforts to restore circulation, and ultimately led to an adverse outcome of 100% mortality (6/6 patients died). Dossa et al[4] suggested that the decrease in mortality from 40% to 24% observed over the last 40 years might be related to improved perioperative recognition and hemodynamic optimization. Pre-operative cardiac optimization improves the tolerance to a sustained increase in cardiac afterload following the acute aortic occlusion, which further stresses an already compromised myocardium.[4] Babu et al[1] noted similar findings as baseline mortality increased from 52 % to 85% when pre-existing myocardial dysfunction accompanied this disorder.

Large case series reported by Babu and Dossa[1,4] describe the importance of perioperative management with not only systemic anticoagulation and hydration, but also a comprehensive optimization of cardiac function for successful outcomes. Appropriate assessment of cardiac dysfunction in these case series was only possible with invasive monitoring, such as pulmonary and radial artery catheterization. The importance of perioperative restoration of cardiac function is further highlighted by the fact that patients, who did not normalize their left ventricular function (LVF), had worse outcomes. In these studies, 83% of patients with compromised LVF died compared to 23% with improved LVF.[1]

The compromised cardiac function in patients with acute aortic occlusion, if not recognized and addressed early, can progress in these patients to cardiogenic shock. These findings of cardiac decompensation are observed not only in acute aortic occlusion, but also in chronic occlusions as described by Danto[3] in 1997, where the slowly developing chronic aortic occlusion was associated with the cardiac decompensation in a majority of cases with a reported mortality of 25% in the study's 9 patients.

Patients with known CHF present frequently to the ED with exacerbation of their CHF[20] as a medical emergency. These patients can present with normal vital signs, such as MAP and heart rate, as in this presented case. Clinicians confronted with such patients might underestimate the illness severity and the developing cardiogenic shock. As highlighted by Ander, several reports show that in patients with decompensated CHF, global tissue hypoxia secondary to inadequate systemic oxygen delivery (DO_2) can exist with normal vital signs.[20] Ander calls this occult cardiogenic shock, mandating that once these patients are identified, a targeted optimization of hemodynamic parameters should include lactate, CVP and $ScvO_2$ to improve morbidity and mortality.

The present case of a combination of the acute aortic occlusion with a possible further acute decompensation of the cardiac function leading to cardiogenic shock needs to be addressed by a structured approach to achieve an optimal outcome.

CONCLUSION

This case and the review of the literature highlight that acute aortic occlusion represents a combination of acute neurologic, vascular and hemodynamic emergencies. The combination of a structural lesion causing acute occlusive ischemia is frequently confounded by a decrease in systemic oxygen delivery (DO_2), secondary to decreased myocardial function. This myocardial dysfunction can range from mild to the most severe degree of illness severity (cardiogenic shock). Cardiogenic shock can occur with normal vital signs. It has been shown that addressing occult tissue hypoperfusion is associated with decreased morbidity and mortality.[20] This highlights the need for emergency hemodynamic recognition and treatment of shock while employing a surgical remediation to this disease process. While the diagnosis of aortic occlusion was notable on CT in the reported case, the underlying occult shock state could have gone unrecognized, possibly leading to increased morbidity and mortality.

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

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Pylephlebitis in a Previously Healthy Emergency Department Patient with Appendicitis

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Supervising Section Editor: Rick McPheeters, DO
Submission history: Submitted November 25, 2012; Revision received December 29, 2012; Accepted January 22, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.1.15353

Pylephlebitis is a septic thrombophlebitis of the portal vein that is associated with multiple suppurative abdominal infections, such as diverticulitis, appendicitis, cholangitis, and cholecystitis. We describe a case of pylephlebitis in a patient with fever and diffuse, poorly localized abdominal pain who was eventually diagnosed with appendicitis. We aim to increase awareness of this condition among emergency physicians, as timely initiation of antibiotics and expedited surgical resection may improve outcomes in this potentially fatal disease. [West J Emerg Med. 2013;14(5):428–430.]

CASE REPORT

The patient, a 27-year-old Hispanic male with no past medical or surgical history, presented to the emergency department (ED) with a chief complaint of fevers, chills and intermittent epigastric pain for 5 days. He stated that this pain started acutely, 30 minutes after eating dinner (steak and beans), was burning in quality, non-radiating and lasted approximately 20 minutes. This pain recurred several times over multiple days. Two days prior to arrival in the ED, the patient began experiencing subjective fevers and chills. He also reported having a single episode of vomiting, but denied diarrhea, sick contacts, recent travel, dysuria, hematuria, chest pain or shortness of breath.

On the initial physical exam the patient was found to be tachycardic (122 beats per minute), but afebrile (98.2°F) and relatively normotensive (106/59 mmHg). He was diaphoretic, but otherwise in no significant distress. His skin was mildly jaundiced and his sclera was icteric. His lungs were clear to ausculation and his cardiac exam was negative for murmurs, rubs, or gallops. His extremities were within normal limits, with no evidence of edema or rash. The patient was mildly tender in the epigastrium, but his abdomen was soft and non-distended. He had no rebound tenderness, no involuntary guarding, no Rovsing's, Obturator or Murphy's signs. The remainder of his abdomen was non-tender. Labs were significant for a leukocytosis of 16,000 with toxic granulations and a neutrophilic predominance. The patient was thrombocytopenic with a platelet count of 20,000/μL. His D-dimer and fibrinogen were elevated at 1428 mg/dl and 864 mg/dl, respectively. Finally, his liver function tests revealed an elevated total biliruben of 2.9 mg/dL and an elevated alkaline phosphatase of 278. The patient also received a chest radiograph and electrocardiogram, which were free of abnormalities.

The patient was treated for severe sepsis vs. septic shock. He received multiple boluses of normal saline, in addition to broad-spectrum antibiotics to cover for a suspected intra-abdominal infection. The patient responded well to these interventions, his vital signs began to normalize, and he stated that he was feeling better.

An abdominal ultrasound was ordered for further evaluation, given the patient's epigastric pain and abnormal liver function tests. On this study, the liver appeared normal, with no intra- or extra-hepatic ductal dilatation. The kidneys, aorta, spleen and pancreas all appeared within normal limits. The gallbladder contained no stones or sludge, but the gallbladder wall was mildly thickened at 5mm. There was no evidence of peri-cholecystic fluid.

At this time, a surgical consult was placed for evaluation of possible acute cholecystitis/cholangitis. During his evaluation, the surgeon found no tenderness or distension on physical exam, but noted the abnormal lab findings, as well as the gallbladder wall thickening on ultrasound. He stated that it might have been an atypical case of acute cholecystitis, but given the constellation of abnormal lab values, he recommended a computed tomography (CT) of the abdomen/pelvis and further medical workup.

The patient was subsequently admitted to the medical intensive care unit for continued antibiotic therapy and

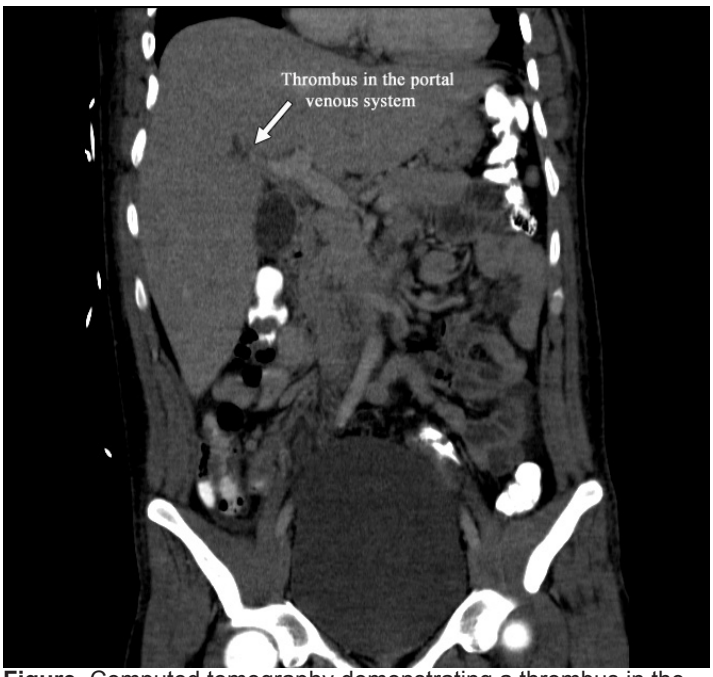

Figure. Computed tomography demonstrating a thrombus in the portal vein and therefore pylephlebitis

diagnostics. In addition to a standard infectious workup, the patient received testing for a variety of multi-systemic infections including influenza, viral hepatitis, HIV, malaria and tularemia. On hospital day 2, 2 of the 4 blood cultures grew *E. coli*. The patient's antibiotics were tailored for more specific therapy and a CT of the abdomen and pelvis was obtained on hospital day 3. A preliminary report noted a dilated and thick walled retrocecal appendix with adjacent inflammation and free fluid, consistent with acute appendicitis. The radiologist noted inflammation of the gallbladder wall, but suspected that this was secondary to the adjacent inflamed appendix.

On hospital day 4, the final CT abdomen/pelvis read was submitted, which confirmed the patient's diagnosis of appendicitis, and also noted small, branching, hypodense, tubular lucencies in the right lobe of the liver consistent with pylephlebitis (Figure). The patient was subsequently taken to the operating room for a laproscopic appendectomy. The procedure was performed without complications. Intravenous antibiotics were continued until hospital day 6 when the patient was discharged. There was no mention of pylephlebitis in the primary team notes, or in the surgical consult notes. Antibiotics were discontinued upon discharge, despite an elevated white blood cell count of 15.1 x 10^3/μL (16.1 x10^3/μL on admission). The patient's total bilirubin remained elevated as well (3.0 mg/dL), compared to his admission value of 2.9 mg/dL.

One week later, the patient was seen in surgery clinic. He stated that he was feeling better, with minimal pain at the surgery site, and that he was able to eat and drink without issue. His staples were removed and he was told to return as needed. He was then lost to follow up.

DISCUSSION

Pylephlebitis is defined as a septic thrombophlebitis of the portal vein and its tributaries. While diverticulitis is thought to be the leading cause of this disease, it has also been described in appendicitis, cholecystitis, hemorrhoidal disease, necrotizing pancreatitis, and various other suppurative intra-abdominal infections.[1] The disease was first described by Waller in 1846 as a source of pyogenic intrahepatic abscesses.[2] Prior to the advent of antibiotics, this condition was almost universally fatal. Even today, mortality from pylephlebitis can range anywhere between 30-50%. This high mortality rate is likely related to delayed diagnosis, given the low incidence of suspicion and atypical findings.[3]

The clinical presentation of pylephlebitis is frequently non-specific. Fever is the most common presenting symptom, followed by abdominal pain, which is often vague and poorly localized.[1,2] Nausea, vomiting, scleral icterus and a tender, enlarged liver may also be present in some cases, especially in those complicated by liver abscesses.[1,4] In approximately 80% of patients, blood cultures will be positive, with the most common organism being *Bacteroides fragilis*, followed by *E. Coli* and *Steptococcus* sp.[1,2,4] Liver function tests may be abnormal in some cases, but are generally normal. Leukocytosis is typical, but may be absent in neutropenic patients with hematologic malignancies, who are potentially at an increased risk for pylephlebitis given their immuno-compromised and hypercoagulable states.[5]

The diagnosis of pylephlebitis is generally made through either doppler ultrasound or CT. Ultrasound with color doppler is a fairly sensitive test for thrombosis of the portal vein. Typical sonographic features include echogenic material in the lumen of the vein, as well as distension of the thrombosed segment. Ultrasound may also be used as a follow-up exam to demonstrate recanalization. As with all ultrasonagraphic studies, however, the diagnostic accuracy is generally operator dependent.[5,6] CT is the most-used diagnostic modality for this disease, with typical findings being a suppurative source, in addition to a thrombus in the portal vein or its tributaries.[2,5] In certain cases, serial CTs have been used to assess clot resolution and guide treatment duration. Of note, in certain circumstances, no suppurative source will be found and patients will be treated for presumed pylephlebitis, given the presence of portal vein thrombi and clinical/laboratory evidence of infection.[7]

Early treatment of pylephlebitis is essential given the high incidence of mortality when treatment is delayed. Many patients will present in a distressed state, with approximately 20% presenting in sepsis.[1] Fluid resuscitation, broad-spectrum antibiotics and eradication of the suppurative source are the mainstays of treatment. Antibiotic coverage should be targeted towards gram negative and anaerobic organisms until culture and sensitivity results are available. Antibiotic coverage for 4 to 6 weeks is generally advised, or until complete resolution of the thrombus is confirmed by ultrasound or CT.[7-9]

The use of anticoagulation in cases of pylephlebitis continues to be controversial. A small retrospective case report by Baril et al is generally cited in the recommendation of anticoagulation. This study concluded that anticoagulation was indicated for those patients with documented coagulation disorders, or in patients with hypercoagulable states, such as cancer or hematological disease. Anticoagulation is given, in theory, to avoid the more devastating complications of portal vein thrombosis, such as portal hypertension and bowel ischemia. Some investigators note, however, that these complications are rare, given that portal vein thrombosis from pylephlebitis is thought to be non-obstructive.[1,6] Although there are multiple case studies that recommend for or against anticoagulation, no study to date clearly demonstrates an advantage in terms of clot resolution or mortality.

In conclusion, we would like to stress the importance of early diagnosis and treatment in cases of pylephlebitis. In the case of our patient, the diagnosis was elusive and delayed until we obtained definitive imaging. Furthermore, even after the diagnosis was made through CT, the primary and consulting teams either missed or dismissed this potentially fatal disease. Luckily, however, appropriate antibiotics were instituted and the suppurative source was removed before further complications arose. Likely, this missed diagnosis was due to a general lack of awareness and understanding of pylephlebitis. Although this is a rare disease, the high mortality that accompanies it necessitates that we keep it in our differential when examining an ED patient with poorly differentiated abdominal pain and fever.

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

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Parenteral Hydrocarbon Injection and Associated Toxicities: Two Case Reports

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Supervising Section Editor: Rick McPheeters, DO
Submission history: Submitted December 16, 2012; Revision received: March 12,2013; Accepted March 19, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.3.15678
[West J Emerg Med. 2013;14(5):431–434.]

INTRODUCTION

Many cases of hydrocarbon toxicity occur annually due to oral or inhalational exposure. Rarely are hydrocarbons injected subcutaneously or intravenously. These parenteral routes of exposure, however, can have a wide range of consequences ranging from mild skin irritation to tissue necrosis, pulmonary injury, neurologic consequences, cardiovascular collapse, and death. WD-40™ is a commonly used household hydrocarbon containing aliphatic hydrocarbon (45 – 50%), low vapor pressure aliphatic hydrocarbon (12 – 18%), petroleum-based oil (<25%), carbon dioxide (2-3%), surfactant (<2%), and other "non-hazardous ingredients" (<10%).[1] We present a pair of cases and associated visual images of complications from intravenous (IV) and subcutaneous (SC) WD-40 injection. Additionally, we will discuss complications from parenteral hydrocarbon exposures, in particular pulmonary injury and local tissue reactions as observed in our cases.

CASE REPORTS

Case 1

A 23-year-old male injected himself with WD-40™ in a suicide attempt approximately 12 hours prior to presentation in the emergency department (ED). The patient stated he was feeling more depressed due to social situations of being unemployed and living out of his car with his fiancée. In a suicide attempt with his fiancée (Case 2), he injected WD-40™ intravenously via the right basilic vein. The couple sprayed the WD-40™ into a cup and used an insulin syringe to aspirate the hydrocarbon to inject 1 mL at a time. He self-injected nearly 15 times (15 mL) throughout the night until roughly 12 hours later he began to feel "heavy in the lungs" and then called Emergency Medical Services (EMS). He complained of nausea with 4 episodes of emesis, difficulty breathing, headache and diffuse joint pain. Past medical history is significant for IV heroin use and he does not take any prescription medications. Vital signs on arrival included a temperature of 101.7 °F, blood pressure of 120/57 mmHg, pulse of 116 beats per minute (bpm), respiratory rate of 20 breaths per minute, and oxygen saturation (SpO2) of 93% on room air. Physical exam noted rales in the right lung base, but no respiratory distress or retractions, and bilateral antecubital skin injection sites with track marks but no overlying skin irritation. Laboratory evaluation revealed a white blood cell count (WBC) of 11.2 k/mm,^{3} hemoglobin 14 g/dL, serum creatinine 1.39 mg/dL, and arterial blood gas (ABG) on room air with pH 7.45, pCO_2 32.8 mmHg, pO2 51 mmHg, HCO_3 23 mmol/L, and oxygen saturation of 88%. Urine qualitative drug screen was positive only for opiates. Additionally, serum ethanol, acetaminophen, and aspirin concentrations were non-detectable. Chest radiograph (CXR) in the ED demonstrated pulmonary edema with right lower lobe infiltrate (Figure 1). Radiograph of the patient's right elbow over the injection site did not demonstrate foreign body or subcutaneous emphysema. The patient was treated with supplemental oxygenation via non-rebreather mask, 40 mg of IV furosemide, 1 gm of ceftriaxone, 800 mg of ibuprofen, and 1 gm of acetaminophen. His maximum temperature was 103.3 °F in the ED. With supplemental oxygenation, the patient's SpO2 improved to 99%. The patient was admitted to the intensive care unit (ICU). By hospital day 2, his pulmonary

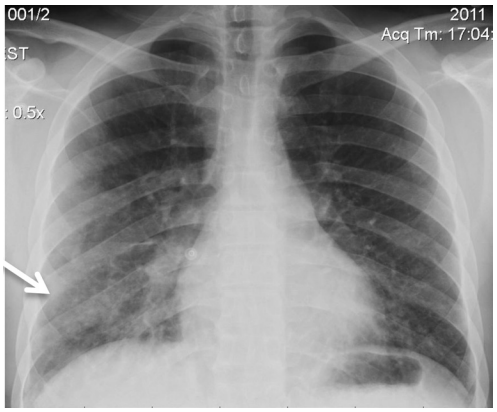

Figure 1. Chest radiograph of Patient 1 on presentation shows pulmonary edema and right lower lobe infiltrate (arrow).

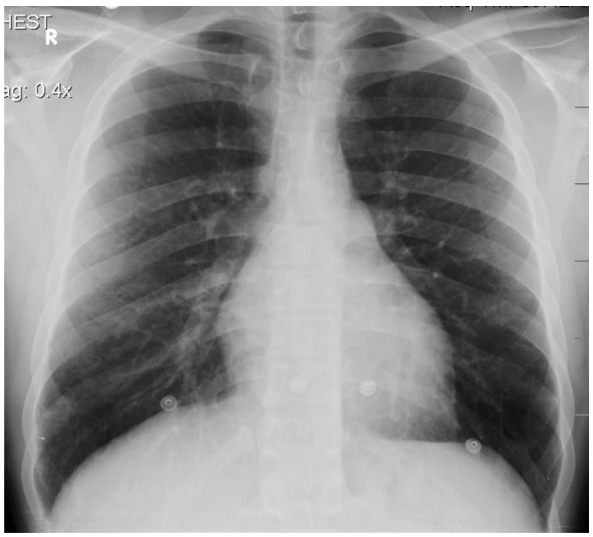

Figure 2. Repeat chest radiograph shows resolution of infiltrates and edema of Patient 1.

edema and chemical pneumonitis improved with supplemental oxygenation and methylprednisolone 125 mg IV once daily. He did not require additional doses of diuretics.

He developed cellulitis of the right upper extremity near the injection site in the right antecubital fossa on the second hospital day and was started on 1 gm of vancomycin and 3.375 gm piperacillin/tazobactam. Repeat laboratory studies on hospital day 2 demonstrated increasing leukocytosis with WBC 16.4 k/mm^3 with 5% band neutrophils and 76% segmented neutrophils. The cellulitis progressed into an abscess and on hospital day 7, the patient was taken to the operating room for incision and drainage. The procedure demonstrated liquefied necrotic subcutaneous tissue, which was debrided and excised, and the wound was packed with iodoform gauze. Culture of the abscess revealed no growth of any organisms. After incision and drainage, the patient improved clinically with reduction in pain and redness in his right upper extremity. CXR findings resolved (Figure 2) by hospital day 3, and he was discharged after 9 days to inpatient psychiatric care.

Case 2

A 29-year-old female injected herself with WD-40™ in a suicide attempt with her fiancé (Case 1) approximately 12 hours prior to seeking medical attention. She injected herself in the dorsal aspect of her right hand and the palmar aspect of her right wrist. As this patient had "hard-to-find veins," she did not inject herself as frequently as her fiancé and subsequently injected SC despite attempting the IV route. She complained of pain at the injection site that slowly progressed over the 12 hours prior to calling EMS. She denied shortness of breath, nausea, vomiting, or systemic symptoms. Her history is only significant for IV heroin use. Vital signs included a blood pressure of 104/66 mmHg, pulse of 94 bpm, temperature of 97.5 °F, and SpO2 of 98% on room air. Physical exam demonstrated significant swelling and erythema of her right hand, wrist and forearm with lymphangitic streaking to the proximal forearm and extreme tenderness to palpation. Radial and ulnar pulses were obtained via Doppler probe. Laboratory evaluation revealed a WBC of 19.2 k/mm^3 with 34% band neutrophils. Urine qualitative drug screen was positive only for opiates. Additionally, serum ethanol, acetaminophen, and aspirin concentrations were non-detectable. Radiograph of the right hand and wrist demonstrated subcutaneous emphysema (Figure 3). She was given 600 mg of clindamycin and 1 gm of vancomycin and admitted to the ICU. Infectious Disease was consulted for further antibiotic recommendations and 3.375 gm of piperacillin/tazobactam was added for extended coverage. She had severe persistent pain in her right hand and wrist and the surgical service determined the patient had developed compartment syndrome. She was taken to the operating room on hospital day 3. Fasciotomy of the extensor, flexor, and interosseous compartments of the right upper extremity were performed revealing a moderate amount of tissue and fat necrosis (Figure 4). Necrotic tissue was debrided and irrigated without evidence of abscess or progressive infection and the incisions were closed. Wound cultures were negative for growth of any organisms. The patient's pain improved, and after hospital day 11, she was transferred to an acute inpatient psychiatry unit.

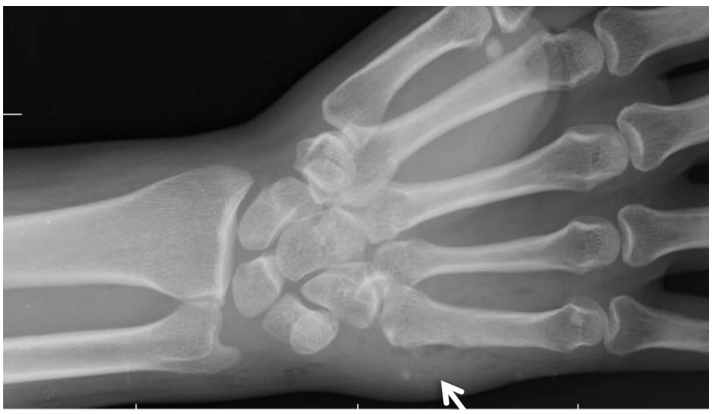

Figure 3. Right upper extremity of Patient 2. Wrist radiograph demonstrates subcutaneous emphysema (arrow) extending from injection site and hand down to forearm.

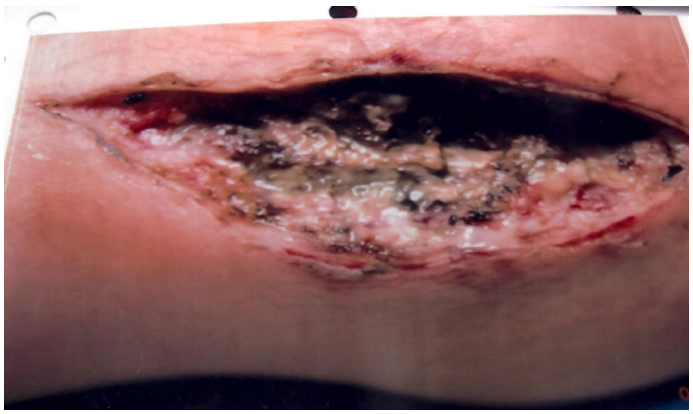

Figure 4. Fasciotomy of forearm shows diffuse fat necrosis of Patient 2.

DISCUSSION

Hydrocarbons naturally occur in crude oil and are a primary energy source in fuel combustion. Household products containing hydrocarbons are typically used as lubricants, automotive chemicals, and degreasers. WD-40™ is one common household hydrocarbon typically used as a lubricant. According to the 2011 National Poison Data System (NPDS), single substance hydrocarbon exposures accounted for 37,194 (1.78%) of total exposures with 17 (3.48%) deaths and 11,512 (1.04%) of pediatric (< 5 years old) exposures with a total of 4 (11.76%) pediatric deaths.[2] Reviewing those deaths demonstrates that all had inhalation or ingestion as route of exposure.[2] Of the 37,194 single substance hydrocarbon exposures, lubricants (such as WD-40™) accounted for 3933 exposures with 79 moderate effects and 3 major effects but no deaths.[2] Unfortunately, it is difficult to discern what those moderate and major effects are and just how many of those were parenteral exposures.

Due to the volatility and surface tension of a particular hydrocarbon, oral ingestion may have a high risk of aspiration. Highly volatile hydrocarbons with low viscosity carry a higher aspiration risk. Fortunately, most unintentional oral exposures do not result in significant complications.[3] Suicidal patients, however, pose a different risk given their intent and that they often use greater amounts of a particular substance in comparison to accidental exposures. Additionally, suicidal patients will attempt different routes of exposure than commonly encountered for an accidental exposure. Most reports of parenteral hydrocarbon exposure occur in patients with intent to harm or accidental occupational injury.

Clinical effects vary greatly depending on route of exposure. Oral hydrocarbon exposure classically causes toxicity to the pulmonary system, mostly from inhalation and aspiration. Symptoms include respiratory distress, pleurisy, hypoxemia, and a potentially hemorrhagic pneumonitis.[4-6] Inhalational hydrocarbon exposure has caused cardiovascular collapse with sudden sniffing death syndrome.[7] Central nervous system effects vary greatly and range from mild euphoria to lethargy and seizures.[4,8] Hematologic effects may include intravascular hemolysis and significant leukocytosis.[5,9,10,11] Intravenous hydrocarbon exposure has caused respiratory failure with chemical pneumonitis and interstitial pulmonary edema with hypoxia.[15] It has also been associated with multi-organ dysfunction and with renal and hepatic involvement.[12] Local injection site reactions occur and can result in cellulitis, fat necrosis, and abscess formation, which tend to be sterile.[4,13,14] Subcutaneous injection has resulted in compartment syndrome and the need for fasciotomy.[10,13] In particular, WD-40™ subcutaneous exposure is a rare occurrence, yet small volume injection (0.5 mL) has been associated with significant local skin reaction with cellulitis and profound leukocytosis as observed in our cases.[15]

These 2 cases highlight the possible major effects physicians will encounter from intravenous or subcutaneous hydrocarbon exposure. Although parenteral hydrocarbon exposures are described in the literature, images associated with the outcomes from these parenteral methods rarely accompany reports. The practicing physician should be aware of the potential complications associated with parenteral hydrocarbon exposure. Although no specific antidote or therapy exists for hydrocarbon toxicity, symptom-based goal-directed supportive care remains the mainstay of therapy.

CONCLUSION

Intravenous and subcutaneous hydrocarbon exposures are rare occurrences. We report a pair of cases with these rarely encountered avenues of exposure. The first case involved intravenous WD-40™ exposure in a man that developed pulmonary edema and subsequent cellulitis with sterile abscess at the injection site. The second case was a female with subcutaneous WD-40™ injection that resulted in compartment syndrome requiring a fasciotomy. Both patients fully recovered; however, these cases provide insight and corresponding images for the potential deleterious outcomes associated with these two unique routes of hydrocarbon exposure.

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

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Diaphragmatic Rupture Secondary to Blunt Thoracic Trauma

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Supervising Section Editor: Sean Henderson, MD
Submission history: Submitted January 6, 2013; Revision received January 28, 2013; Accepted April 22, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.4.15826
[West J Emerg Med. 2013;14(5):435–436.]

We present a case of a 71-year-old male that was involved in a high-speed motor vehicle collision, as an unrestrained back seat passenger. On primary survey, decreased breath sounds and bowel sounds were auscultated in the left thorax. Secondary survey was positive for left anterior chest wall tenderness. Chest radiograph demonstrated multiple rib fractures, hemothorax, and diaphragmatic rupture with herniation of bowel loops into the chest cavity (Figure 1). Upon insertion of a nasogastric tube, repeat radiograph demonstrated the nasogastric tube to be in the left upper abdomen (Figure 2). The patient underwent emergency laparotomy for repair of his injury. Incidentally, a splenic laceration was identified intraoperatively. Successful repair of the diaphragmatic injury as well as splenectomy was achieved.

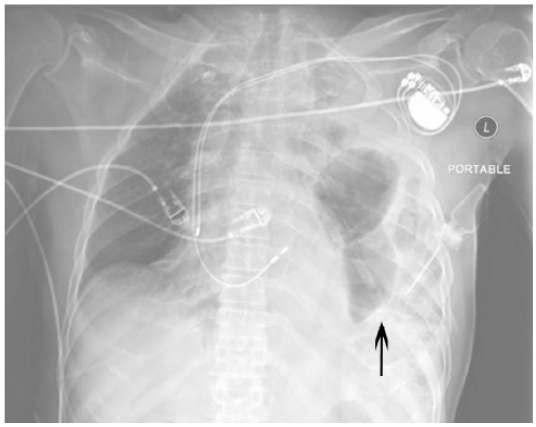

Figure 1. Portable anteroposterior chest x-ray demonstrating left rib fractures, hemothorax and left diaphragmatic rupture (arrow). Biventricular pacer is also noted.

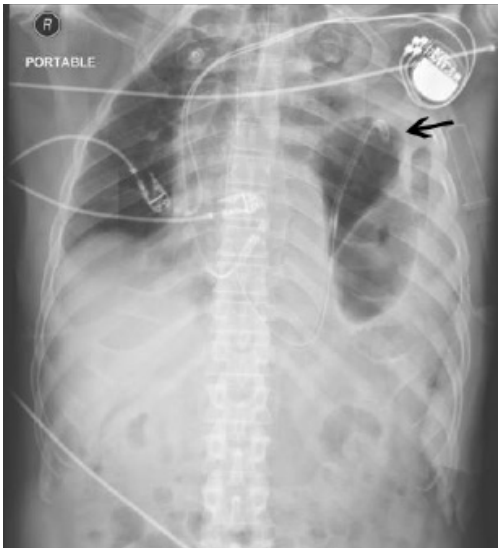

Figure 2. Portable anteroposterior chest x-ray demonstrating successful nasogastric tube insertion with tip extending above ruptured diaphragm into thorax (arrow).

DISCUSSION

Diaphragmatic rupture is a relatively rare injury with a reported incidence of 1 to 7% of all patients following significant blunt trauma.[1] In a review of 1589 patients, Asensio et al[2] reported that 75% had left sided injuries, 23% had right-sided injuries, and 2% had bilateral injuries. This preponderance for left-sided injuries is thought to be related to the protective effect of the bare area of the liver in contact with the diaphragm in the right thorax.[3] The pathophysiology in blunt trauma is due to the abrupt change in intraabdomonial pressure that is thought to cause the majority of injuries, although shearing and/or avulsion can also occur especially following lateral trauma.[4] The differential includes: pneumothorax, hemothorax, liver injury, bowel injury, rib fractures, splenic injury and kidney injury. Radiographically, the diagnosis is made via chest radiograph demonstrating: nasogastric tube in the chest, herniated loops of bowel within the chest, with or without focal constriction of the viscus.[4] The gold standard of treatment is emergent laparotomy.[2] The prompt and accurate diagnosis of diaphragmatic rupture is paramount for optimal patient outcome.

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

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Vaginal Foreign Bodies and Child Sexual Abuse: An Important Consideration

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Supervising Section Editor: Rick McPheeters, DO
Submission history: Submitted August 25, 2012; Revision received November 26, 2012; Accepted January 28, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.1.13347

Vaginal foreign bodies are a complaint occasionally encountered in pediatric clinics and emergency departments, and when pediatric patients present with a vaginal foreign body sexual abuse may not be considered. We describe two children with vaginal foreign bodies who were found to have been sexually abused. Each child had a discharge positive for a sexually transmitted infection despite no disclosure or allegation of abuse. We recommend that all pre-pubertal girls who present with a vaginal foreign body should be considered as possible victims of sexual abuse and should receive a sexual abuse history and testing for sexually transmitted infections. [West J Emerg Med. 2013;14(5):437–439.]

INTRODUCTION

Child sexual abuse is a significant problem in the United States. Estimates are that each year approximately 1% of children will experience some form of sexual abuse, which will result in up to 25% of girls and 10% of boys being victimized by an inappropriate sexual experience.[1] Children who have been exposed to sexual abuse are known to exhibit a greater number of sexualized behaviors, such as masturbating with an object or inserting objects into the vagina or anus.[2]

It has been reported that approximately 4% of pre-pubertal girls with a genital complaint will have a vaginal foreign body, and that a vaginal foreign body will be found to be the cause of the complaint in 18% of those with a vaginal discharge and up to 50% with vaginal bleeding.[3] The majority of vaginal foreign bodies are found between the ages of three and nine, and the most common object identified is a wad of toilet paper, which is found in up to 80% of cases.[4] The classic symptoms of vaginal foreign bodies are vaginal bleeding and a blood-stained vaginal discharge. The history is rarely helpful because the insertion is frequently not witnessed by an adult nor does the child usually disclose putting an object into the vagina. Foreign bodies have been reported to be inserted by children because the genital area may be pruritic, the children may be exploring their bodies, or it is a behavior related to sexual abuse.[5]

Sexually transmitted infections (STI) are a rare cause of vaginal discharge in pre-pubertal girls. Estimates are that 5% of at risk children will be infected with an STI. In sexual abuse cases, *Neissesia gonorrhoeae* has been estimated to be found in 3.3%, *Chlamydia trachomatis* in 3.1%, *Trichomonas vaginalis* in 5.9% and *Treponema pallidum in* 0.3%.[6] In cases presenting as suspected sexual abuse, it is common practice to obtain studies to evaluate a vaginal discharge for an STI; however, there are no current recommendations to obtain cultures of the vaginal discharge associated with vaginal foreign bodies.[1]

We describe 2 cases of patients with vaginal foreign bodies who were found to have positive cultures for an STI. In both cases, the children initially presented to the pediatric emergency department (PED) with a chief complaint of a vaginal discharge, and in neither case was sexual abuse a parental concern.

CASE REPORTS

Case 1

A 4-year-old girl presented to the PED at the University of Maryland Children's Hospital (UMMC) with a chief complaint of vaginal itching for 2 weeks and a vaginal discharge for 2 days. When directly questioned by her mother and the emergency physician (EP), the girl denied being touched in the genitourinary area. Her mother reported that the discharge was initially white, but over the next two days it became malodorous and green.

Her physical examination in the PED was noteworthy for erythema of the labia majora and a copious greenish-white vaginal discharge. A foreign body was suspected, and vaginal

irrigation revealed a small piece of foreign material, believed to be toilet tissue, which was removed. Chlamydia and gonorrhea cultures of the vaginal discharge were obtained, and the child was discharged from the PED with instructions to follow up with her pediatrician if the discharge persisted.

Six days later the PED was notified that the culture of the vaginal discharge was positive for *N. gonorrhea*. The family was contacted and the child was referred to the Sexual Abuse & Rape Assessment (SARA) Center at the UMMC for further evaluation and treatment. Further history revealed persistence of the vaginal discharge, which had now taken on a more prominent greenish color. Her exam was otherwise unchanged from the initial presentation, and the child was treated with a single dose of IM Ceftriaxone. The case was then referred to the local child advocacy center (CAC) for further evaluation of sexual abuse.

Case 2

A 6-year-old girl presented to the PED with a chief complaint of a green vaginal discharge for 6 days. The girl's father reported that 6 days prior to the evaluation, the child complained of pain and itching in the vaginal area and developed a yellowish-brown vaginal discharge. Over the course of the week, the discharge had changed in color from yellowish-brown to green but had no odor. When directly questioned by her father and the EP, the girl denied any inappropriate touching.

Her physical examination in the PED was noteworthy for vulvar erythema and a copious, milky, yellow-green discharge. In addition, a whitish foreign body, which appeared to be a wad of toilet tissue, was visualized and extracted from the vagina. Cultures of the vaginal discharge were obtained, and the child was discharged from the PED with instructions to follow up with her pediatrician if the discharge persisted.

Four days later the PED was notified that the culture of the vaginal discharge was positive for *N. gonorrhea*. The family was contacted and the child was referred to the SARA Center at the UMMC for further evaluation and treatment. Further history revealed persistence of the vaginal discharge, which was now more yellow in color, and the child was treated with Ceftriaxone. The case was then referred to the local CAC for further evaluation of sexual abuse.

DISCUSSION

The 2 children described above presented to the PED because of a vaginal discharge associated with a vaginal foreign body. In both cases, cultures of the vaginal discharge were positive for *N. gonorrheae* and the foreign bodies were determined to be associated with sexual abuse. Despite having forensic interviews at the CAC, neither child provided details on how the foreign body entered the vagina, and both children denied any history of sexual contact.

It has been estimated that 4 to 5% of all pre-pubertal girls who present for medical care with a vaginal complaint will have a vaginal foreign body.[3] The most common vaginal foreign body in a pre-pubertal girl is toilet tissue; however, toys, safety pins and other small objects have been reported.[7-9] Foreign bodies in the vagina can cause intense local irritation and inflammation, producing the classic symptoms of vaginal bleeding and a foul smelling, often greenish or blood-tinged vaginal discharge.[7,10] Of the classic symptoms, vaginal bleeding has been reported to be the most sensitive and specific symptom for a vaginal foreign body, with reports indicating that 93% of pre-pubertal girls with a vaginal foreign body will present with vaginal bleeding or a blood-tinged vaginal discharge, and 82% of pre-pubertal girls with vaginal bleeding will have a vaginal foreign body.[7]

Vaginal discharge is also a common finding in patients with a vaginal foreign body occurring in more than 18% of patients.[7] However, vaginal discharge as a general complaint is a common gynecologic problem in pre-pubertal girls, accounting for more than 70% of all gynecologic concerns in young girls.[4] Because pre-pubertal girls are not naturally exposed to STI, pediatricians and EPs often do not consider them as a possible cause for a vaginal discharge.

Children rarely recount how the foreign body was inserted, who inserted it, or what motivated the insertion.[11] Reports have previously stated that the majority of these objects are inserted by the child during natural exploration of the body or during masturbatory play.[7,12,13] Normal masturbation, however, is believed to involve clitoral and labial manipulation, not penetration of the vagina by objects.[14] In addition, the pre-pubertal hymen is very sensitive to touch, and inserting an object past the hymen is likely to cause pain and discomfort. It is also known that children who have been exposed to sexual abuse will exhibit a greater number of sexualized behaviors, including inserting objects into the vagina or anus.[2,10] Therefore, the presence of any vaginal foreign body in a pre-pubertal girl should elicit concern for sexual abuse.

The majority of the review articles on vaginal foreign bodies and the major emergency medicine, pediatric emergency and gynecology texts have limited the discussion to the types of foreign bodies and methods of extraction rather than etiologies, such as sexual abuse.[5,15,16] A report by Herman-Giddens found that 11 of the 12 pre-pubertal girls being evaluated for vaginal foreign bodies were either suspected or confirmed victims of sexual abuse. In that report, 8 of the girls were able to identify specific perpetrators.[11] Strickler stated that "sexual abuse must be considered when it is not known who inserted the foreign body." In Strickler's report, more than 1 in 4 of the vaginal foreign bodies were found to be inserted by someone other than the patient.[10] Our report is different from previous studies in that these children presented directly to an ED, not a CAC, for evaluation of the vaginal discharge, and none of the foreign bodies visualized were sexual in nature.

The ideal evaluation of children who are suspected of having been sexually abused has been well documented in

practice statements developed by the American Academy of Pediatrics. Testing pre-pubertal children for STIs is indicated when a victim is symptomatic (ex. discharge or lesions), a history of genital to genital contact has occurred, or if the perpetrator is known to have a sexually transmitted infection.[1,17-19] Unfortunately, the ideal evaluation of children who present with symptoms consistent with a vaginal foreign body and a vaginal discharge is less well documented. In the Herman-Giddens study, they did a retrospective review of all English-language vaginal foreign body case reports over the preceding 100 years and found more than 109 cases of vaginal foreign bodies involving 100 pediatric patients; however, only two of the patients in the reports were evaluated for sexual abuse.[11] From this data it could be speculated that despite a clear association between vaginal foreign bodies and sexual abuse, the majority of clinicians (both pediatric and emergency) do not consider sexual abuse when evaluating vaginal foreign bodies.

RECOMMENDATIONS

An association exists between child sexual abuse and vaginal foreign bodies, and the traditional assumption that pre-pubertal girls naturally place foreign bodies in the vagina may not be valid. Pediatricians and emergency clinicians need to be alert to this high risk possibility and should consider all pre-pubertal girls who present with a vaginal foreign body to be potential victims of sexual abuse. These pediatric patients should receive a thorough history for sexual and psychosocial factors, with potential consultation with child sexual abuse experts. In addition, all pre-pubertal patients with a vaginal foreign body should be tested for STIs using the most sensitive and specific methods available, as diagnostic results of an STI may be the only indicator that sexual abuse has occurred.

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

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Complication with Intraosseous Access: Scandinavian Users' Experience

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Submission history: Submitted February 19, 2012; Revision received December 11, 2012; Accepted January 29, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.1.12000

Introduction: Intraosseous access (IO) is indicated if vascular access cannot be quickly established during resuscitation. Complication rates are estimated to be low, based on small patient series, model or cadaver studies, and case reports. However, user experience with IO use in real-life emergency situations might differ from the results in the controlled environment of model studies and small patient series. We performed a survey of IO use in real-life emergency situations to assess users' experiences of complications.

Methods: An online questionnaire was sent to Scandinavian emergency physicians, anesthesiologists and pediatricians.

Results: 1,802 clinical cases of IO use was reported by n=386 responders. Commonly reported complications with establishing IO access were patient discomfort/pain (7.1%), difficulties with penetration of periosteum with IO needle (10.3%), difficulties with aspiration of bone marrow (12.3%), and bended/broken needle (4.0%). When using an established IO access the reported complications were difficulties with injection fluid and drugs after IO insertion (7.4%), slow infusion (despite use of pressure bag) (8.8%), displacement after insertion (8.5%), and extravasation (3.7%). Compartment syndrome and osteomyelitis occurred in 0.6% and 0.4% of cases respectively.

Conclusion: In users' recollection of real-life IO use, perceived complications were more frequent than usually reported from model studies. The perceived difficulties with using IO could affect the willingness of medical staff to use IO. Therefore, user experience should be addressed both in education of how to use, and research and development of IOs. [West J Emerg Med. 2013;14(5):440–443.]

INTRODUCTION

Intraosseous access (IO) is indicated in critically ill patients if vascular access cannot be quickly established.[1] Complication rates with IO are estimated to be low, a notion that seems to come mainly from small patient series, model or cadaver studies, and case reports.[2-10] By convention, these studies often define "success rate" as insertion rate, i.e. the proportion of needles that penetrate the cortex. This success rate is usually high, 71-100%.[2-10]

IO is a relatively rare occurrence in many settings, and healthcare staff might be inexperienced in the procedure or unfamiliar with the available IO device. Using IO in real-life situations could pose a different set of challenges (e.g., moving patient, high-stress situation, not much room to work around, many people involved in resuscitation) compared to the often controlled settings of small patient series, model or cadaver studies. Therefore, it is possible that the rate of experienced complications is much higher in real-life emergency situations than described in small patient series, model or cadaver studies.

Users' recollection of complications with using a medical device will influence their willingness to use it in the future. Thus, information on users' experience with complication rates in real-life use of IO could be used to identify issues for improvements in education and device design. For this purpose, we collected information on what Scandinavian emergency physicians, anesthesiologists and pediatricians experienced with real-life IO use.

METHODS

We collected cases of users' experiences with cases of IO use by distributing a link to an online survey via e-mail to members of the Danish Society for Emergency Medicine (DASEM) (n=394 members). Responders were asked to recall all the cases where they had used IO in a clinical situation. Thus, the survey focused on the users' recollection of IO use. It did not involve review of patient charts, and it was not a prospective registration of cases. We used the survey software LimeSurvey (freely available at http://www.limesurvey.org). Additional responses were obtained by asking other Scandinavian emergency medicine, pediatric and anesthesiology societies and interest groups to distribute a link to the questionnaire to their members. These were the Danish Society for Anaesthesia and Critical Care, the Danish Paediatric Society, the Norwegian Society for Anaesthesiology, the Norwegian Society of Paediatricians, clinical staff at the Norwegian Air Ambulance, Norwegian Association on Trauma, Emergency and Disaster Medicine, the Swedish Society for Emergency Medicine, and the Swedish Society for Anaesthesia and Intensive Care.

The survey was designed to collect detailed information on all clinical cases where the responders personally had used IO. We included responders in this analysis if they had real-life experience with IO (i.e., they had themselves placed or tried to place an IO). The responders were given detailed questions on successful and unsuccessful IO attempts, type of IO device used in each case, and complications or technical difficulties with the specific device. The questionnaire also included sections on training in IO and barriers to IO use in clinical settings; results on these aspects are published elsewhere.[11,12] We designed the survey so that no single patient could be identified from the data entered. Therefore, data on age groups, anatomical sites used and indication for IO placement were not available for all cases. The questionnaire had been tested by 5 doctors working in emergency care prior to distribution. None of them was involved in the research group. We used their feedback to improve the design of the survey.

The survey did not fall under jurisdiction of the Danish Act on Processing of Personal Data and - as it was not a clinical trial - approval of an ethics committee was not relevant.

We performed statistical analysis with Chi-test for trend and Fisher's Exact Test.

RESULTS

We received 761 responses to the questionnaire; n=388 responders met the inclusion criteria. We excluded 2 of these due to gross inconsistencies in the answers. The response rate for DASEM members was 37.3%.

Perceptions of IO use in Scandinavia

The 386 responders reported a total of 1,802 clinical cases of IO use. Information on age of the patient was available for 1,719 cases. Of these, 774 (45.0%) were pediatric patients (under age 15) and 380 (49.1% of pediatric patients) were less than 2 years old. The ratio of needle use per patient was 1.17 for adults (15 years or older), 1.19 for children between 6 to 14 years (both inclusive), 1.18 for children between 2 and 5 years (both inclusive), and 1.14 for children under 2 years. (Chi square for trend did not detect a significant difference: p=0.98.)

The indications for IO use were as follows: Cardiac arrest (28.4%; n=486), hemorrhage (23.4%; n=407), dehydration (16.7%, n=286), sepsis (13.4%, n=230), convulsions (2.7%; n= 46), poisoning (2.2%, n=37), and other clinical situations (12.8%, n=219). Information on indication for IO use was available for 1,711 cases (95.0%).

IO had been placed in the tibia in 1,420 cases (89.7%), in the humerus in 54 cases (3.4%), in the iliac crest in 34 cases (2.1%), in the sternum in 27 cases (1.7%), in the femur in 20 cases (1.3%), and other sites in 28 cases (1.8%). Information on anatomical site was available for 1583 cases (87.8%).

The IO-devices used were the following: EZ-IO in 861 cases (47.8%), Cook-Surfast in 418 cases (23.2%), B.I.G. in 255 cases (14.2%), and unspecified equipment in 268 cases (14.9%).

Users' recollection of complications

Table shows the overall frequency of reported complications and complication rates listed by device. In addition to Table, users reported "Miscellaneous complications" in n=36 cases (not specified).

DISCUSSION

In this study, IO users reported complications with real-life IO use from a multitude of settings, including prehospital, emergency departments (ED) and intensive care units. The rate of many of these complications will not be revealed in the controlled environment in simulation and cadaver studies for example, because they lack the difficulties with assembling equipment in extremely stressful situations and cannot be assessed for infection rates. Therefore, reports from a large number of cases of IO use are useful to get an estimate of complication rates in real-life situations (with the limitations of the study in mind, discussed below). More importantly, the users' recollection of difficulties with IO use could affect the willingness to use IO in future cases – even if the users don't recall every detail of the previous cases.

Healthcare staff reported a wide range of difficulties with the use of IO. These difficulties might render the IO useless in an emergency situation. For example, the penetration through the cortex might have been successful, but the IO itself could be useless because of immediate dislocation. Thus, IO might not always be experienced as a straightforward procedure by healthcare staff when it is performed in real-life emergency situations.

The study supports 2 common notions about IO. Firstly, that the rate of serious, late complications (i.e. compartment syndrome and ostemyolitis) is low. Indeed, the rate of 0.4-

Table. Complication rate with intraosseous access (IO) reported by Scandinavian users - listed by device.

IO-equipment used	All	%	EZ-IO	B.I.G	Cook	Others	p-value*
Cases reported	1,802	100.0	861	255	418	268	
Start complications							
Equipment difficult to assemble	36	2.0	4	21	5	6	< 0.0001
Difficult to identify correct anatomical site	57	3.2	28	17	5	7	0.0013
Bended or broken needle	72	4.0	11	17	20	24	< 0.0001
Patient discomfort / pain	128	7.1	73	13	20	22	0.0663
Difficult to penetrate the periosteum	186	10.3	18	56	51	61	< 0.0001
Difficult to aspirate bone marrow	221	12.3	92	51	38	40	< 0.0001
Complications in use							
Difficult to inject fluid and drugs	133	7.4	59	33	27	14	0.0026
Slow infusion despite use of pressure bag	159	8.8	77	32	34	16	0.0610
Displacement after insertion	153	8.5	47	50	38	18	< 0.0001
Extravasation	66	3.7	25	12	17	12	0.4089
Late complications							
Compartment syndrome	10	0.6	6	1	1	2	0.796
Osteomyelitis	7	0.4	4	1	1	1	1.000
Skin infection	6	0.3	4	1	1	0	0.829

B.I.G, bone injection gun
*The p-value is the probability of error in saying that at least one of the four categories is actually different from the others.

0.6% is remarkably close to the rates found in the 2 previous large-scale studies using this as a primary end-point. Secondly, that needle insertion rates per se can be tranferred from IO model or simulation studies to real-life situations: In about 90% of the reported cases in this study only 1 needle was used which corresponds to the needle insertions success rate often reported from model and cadaver studies

The findings have implications for future education, design and research in IO usage. Doctors might be reluctant to use IO again if they remember earlier cases of IO use as difficult or as resulting in unexpected complications. Therefore, the difficulties reported by IO users should be considered when training healthcare staff in IO. It is the impression of the authors that many IO courses focus on the insertion step of the procedure. But perhaps educators to a wider extent should prepare healthcare staff for the most common difficulties in the later parts of the procedure as well and focus on measures to prevent and deal with these issues. Furthermore, as can be seen from the table, specific types of IO device designs seem to be prone to certain types of complications. Optimally, designers of IO devices should learn from these differences. In addition, the relatively high rate of difficulties after insertion should be kept in mind when doing research in IO, including simulation studies. Measuring IO success rate merely as "penetration through cortex" could miss clinically relevant complications.

LIMITATIONS

The response rate for this questionnaire was 37% for DASEM members. This was estimated by comparing e-mail addresses from the survey with the membership register of DASEM. Some responders did not wish to state their e-mail address, so the response rate is a minimum estimate. For the rest of the societies a response rate could not be reliably estimated for reasons discussed elsewhere.[11] A low response rate could give a risk of selection bias, but a response rate of around 40% is actually considered average for e-mail surveys.[15]

Because this study was founded on users' recollection of events rather than a review of patient databases or charts there was an obvious risk of recall bias. Thus, the complication rates reported by the users are not necessarily identical to the complication rates that would have been found in a prospective study or even in a retrospective study of patient charts. This was especially true for late complications, e.g., infections, since a doctor placing the IO in the prehospital setting or the ED often will have limited information on long-term complications. However, the data still accurately represent how users recall the cases.

CONCLUSION

In users' recollection of real-life IO use, the overall rate of complications was higher than usually reported from model and cadaver studies. The relatively high rate of difficulties after

insertion should be addressed when the procedure is taught. Research on IO devices should focus on all stages of IO use. Focus only on "penetration through cortex" as a measure of IO success rate could miss clinically relevant complications.

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

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Uterine Rupture Due to Invasive Metastatic Gestational Trophoblastic Neoplasm

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Supervising Section Editor: Rick McPheetors, DO
Submission history: Submitted January 13, 2013; Revision received April 9, 2013; Accepted April 11, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.4.15868

While complete molar pregnancies are rare, they are wrought with a host of potential complications to include invasive gestational trophoblastic neoplasia. Persistent gestational trophoblastic disease following molar pregnancy is a potentially fatal complication that must be recognized early and treated aggressively for both immediate and long-term recovery. We present the case of a 21-year-old woman with abdominal pain and presyncope 1 month after a molar pregnancy with a subsequent uterine rupture due to invasive gestational trophoblastic neoplasm. We will discuss the complications of molar pregnancies including the risks and management of invasive, metastatic gestational trophoblastic neoplasia. [West J Emerg Med. 2013;14(5):444–447.]

INTRODUCTION

Invasive, metastatic gestational trophoblastic disease (GTD) is very rarely seen in the emergency department (ED), but it must be recognized and treated appropriately and immediately to prevent serious complications. Gestational trophoblastic disease is a term that comprises multiple different disease processes, including hydatidiform molar pregnancy, choriocarcinoma, persistent/invasive gestational trophoblastic neoplasia (GTN), and placental site trophoblastic tumors (PSTT).[1] It can present with a wide variety of symptoms depending on the site of metastasis or the extent of invasive growth, but this disease process is very rarely documented in the emergency medicine literature. We present a case of a young woman who presented 30 days after evacuation of a molar pregnancy with invasive and metastatic GTN complicated by a uterine rupture and hemoperitoneum.

CASE REPORT

A 21-year-old woman presented to the ED with a 4-day history of increasing abdominal and pelvic pain associated with nausea, generalized fatigue, and orthostatic light-headedness. She denied fever, chills, emesis, syncope, dyspnea, chest pain, or vaginal bleeding, and she had no urinary symptoms. Her past medical history was significant for an evacuation of a complete hydatidiform molar pregnancy 1 month prior to presentation. The pathology report from her surgery showed gestational trophoblastic disease consistent with a 46-XX hydatidiform mole. Her initial pre-operative human chorionic gonadotropin (HCG) level had been >225,000 mIU/mL and had fallen post-operatively but had not yet reached zero by her report. She denied tobacco, alcohol, or drug use, and she had no medications or allergies.

Physical examination revealed an ill-appearing young woman who was anxious and uncomfortable. Her vital signs were a pulse of 126 beats per minute, temperature of 36.5 °C (97.7 °F), respiratory rate of 18 breaths per minute, blood pressure of 116/82 mmHg, and an oxygen saturation of 98% on room air. The remainder of her physical examination was unremarkable with the exception of the abdominal and pelvic examinations. Her abdomen was non-distended with bilateral inferior quadrant tenderness to palpation and mild guarding without rebound. Her pelvic examination showed scant brown fluid in the vaginal vault with diffuse and significant uterine and adnexal tenderness to palpation.

Laboratory testing demonstrated a quantitative serum HCG level of 14,552 mIU/mL. Her complete blood count was normal with the exception of a hemoglobin of 10.9 g/dL (reference range 11.7–16.1 g/dL). A bedside focused abdominal ultrasound was performed and demonstrated peri-cystic free fluid without evidence of free fluid elsewhere in the abdomen. Subsequently, a computed tomography (CT) with intravenous (IV) contrast of her chest, abdomen, and pelvis showed pelvic fluid consistent with blood surrounding a thickened and heterogeneous uterus. There was active peri-uterine contrast extravasation concerning for neoplastic

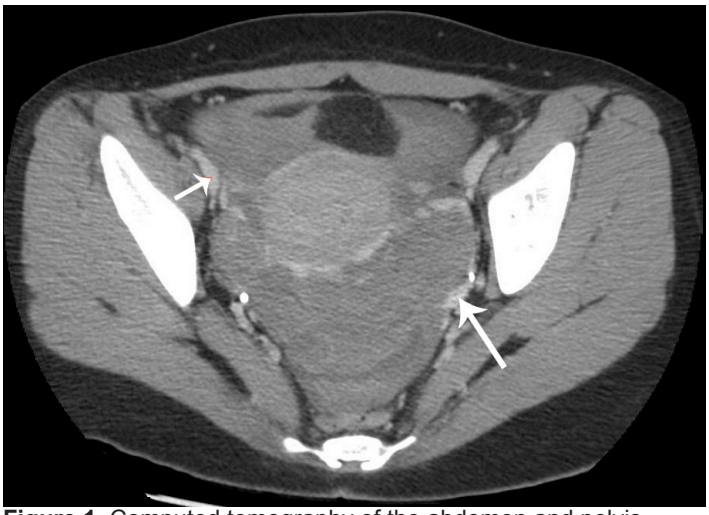

Figure 1. Computed tomography of the abdomen and pelvis with intravenous contrast showing free fluid in the pelvis and active peri-uterine contrast extravasation (arrows) concerning for neoplastic process eroding into the uterine vasculature.

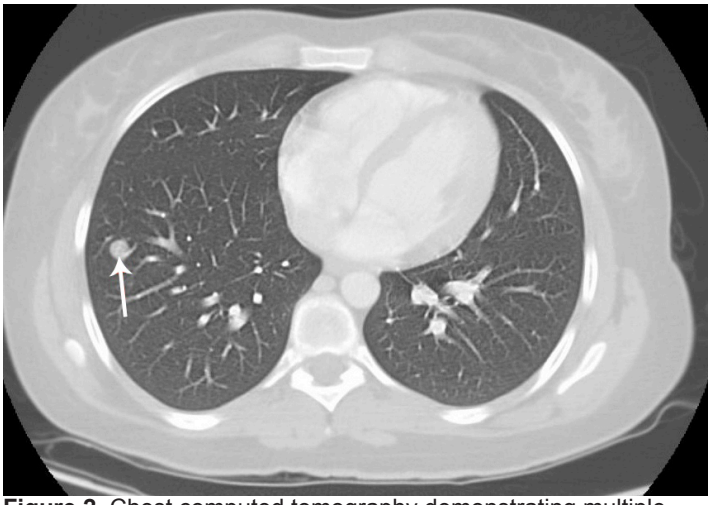

Figure 2. Chest computed tomography demonstrating multiple discrete pulmonary nodules (arrow).

process eroding into the uterine vasculature (Figure 1), and 20 discrete pulmonary nodules were seen (Figure 2).

Resuscitation with 2 liters of IV normal saline and supportive care were provided in the ED. The patient's pulse remained tachycardic between 100-120 beats per minute, but she never became hypotensive in the ED. Large bore access was obtained bilaterally and a type and cross was sent in the ED, but the transfusion was not given until she was in the operating room. Gynecology consultation was emergently obtained, and the patient was taken directly to the operating room where she required a hysterectomy and 4 units of packed red blood cells. Her pathologic specimen demonstrated an invasive complete hydatidiform mole with foci of trophoblastic proliferation within the uterus and in the pelvis concerning for choriocarcinoma. She was started on a chemotherapy regimen post-operatively for her metastases. She did not require further surgical intervention and her choriocarcinoma went into complete remission as of follow up 6 months after chemotherapy.

DISCUSSION

Gestational trophoblastic neoplasia (GTN) comprises a group of aggressive fertilization disorders characterized by invasion of the uterine endometrial and myometrial layers by malignant trophoblastic cells. GTN includes 4 distinct pathologic diseases: choriocarcinoma, persistent/invasive hydatidiform mole, placental site trophoblastic tumor, and epithelioid trophoblastic tumor.[2,3] GTN most commonly develops following a complete hydatidiform molar pregnancy, but can potentially occur after any form of pregnancy (live birth, miscarriage, or termination) and very rarely without a documented preceding gestation.[2,4]

The majority of cases of malignant GTN occur following a complete molar pregnancy. Persistent/malignant GTN following a complete hydatidiform mole occurs in 10-28% of cases even after surgical evacuation.[1] The risk for malignant sequelae after a partial molar pregnancy is significantly less at 3-5%.[5] Invasive GTN invades the myometrium or adjacent structures and can penetrate the uterine mantle causing uterine rupture and hemoperitoneum, as it did in our patient. Metastatic GTN, however, is rare after the complete evacuation of a molar pregnancy (4%), and while it only occurs in approximately 1 in 30,000 non-molar pregnancies, it is overall seen more frequently after a non-molar pregnancy.[6,7]

Risk factors for post-molar GTN include an HCG level greater than 100,000 mIU/mL, large theca lutein cysts (>6cm), age over 40, a history of previous GTD, and excessive uterine enlargement for presumed dates.[8-10] Many patients with these risk factors for GTN are recommended for post-evacuation chemoprophylaxis, although it is not recommended for all patients unless they are known to be at high risk.

In order to monitor persistent GTN following evacuation in low risk patients, levels should be followed weekly until 3 consecutive normal values are obtained. The HCG level should return to zero in non-molar pregnancies and abortions within 2-4 weeks.[11,12] HCG levels return to normal for approximately half of molar pregnancy patients within 6-14 weeks.[13] It is currently recommended that monthly HCG levels are checked for 6 months after the level has returned to zero because of the risk of persistent disease. GTN should be suspected and further investigated in the setting of a preceding molar pregnancy when post-evacuation HCG levels plateau or rise. The vast majority of these cases of GTN are invasive moles with choriocarcinomas comprising less than 10% of cases.[14]

Our patient presented with post-partum vaginal bleeding and peritonitis secondary to a ruptured uterus and blood in her pelvis. When cases like these occur, they tend to happen when a patient does not adhere to the strict follow-up regimen.[15] Because most patients with a known molar pregnancy have regular HCG testing, those with malignant GTN are often

diagnosed before symptoms occur or when repeat HCG levels are abnormal. However, if symptoms occur, or the patient had a non-molar gestation and was not being monitored post-partum, the most common symptom is post-partum (or post-operative) menorrhagia.[2] In women of reproductive age with abnormal vaginal bleeding more than 6 weeks post-partum, persistent GTN should be considered.[16] Uterine and adnexal enlargement on pelvic examination may also be present, and peritoneal signs are possible with the presence of intra-abdominal bleeding.

If there are metastases at the time of presentation, the symptoms will vary depending on the location of the metastatic disease. Metastatic GTN is almost always due to choriocarcinoma,[4] as our patient had. Lung metastases are the most common site, occurring in up to 80% of metastatic choriocarcinoma cases. Other less common sites include the vagina, pelvis, liver, and brain, but concurrent lung metastases frequently are present as well.[17] Metastatic GTN is often asymptomatic,[17] but because this disease may metastasize quickly, some patients may present with cough, dyspnea, or hemoptysis as a result of lung metastases or from embolization of molar/trophoblastic tissue during or after evacuation which leads to extensive infiltrates and respiratory distress.[18]

Diagnostic imaging may begin with an initial ultrasound of the pelvis, but CT of the abdomen and pelvis is recommended to evaluate for the extent of the disease.[19,20] Imaging of other symptomatic systems is appropriate, particularly if there is concern for choriocarcinoma, which frequently present with metastases. Typically, a screening chest radiograph is sufficient to determine the presence of metastases initially in the ED, but chest CT will find metastases that are not seen on plain radiograph.[19] Magnetic resonance imaging is also of particular importance in assessing for cerebral metastases and for help with staging lesions in the abdomen and pelvis.[20]

Management of this disease in the ED is largely supportive and requires immediate gynecologic consultation so that treatment can begin immediately. Our patient is the first reported case in the emergency literature of uterine rupture as the presenting symptoms, but it is a known potential complication of invasive and highly vascular malignant GTN. If there is significant enough malignant invasion to cause severe uterine bleeding or rupture, a hysterectomy may be emergently required to control potentially life-threatening hemorrhage.[21] Long-term treatment involves chemotherapy and possible surgical resection of the other metastatic lesions as indicated.

The prognosis for malignant GTN is dependent upon the type of GTN and the stage of invasion and degree of metastasis.[3] Overall, the prognosis for properly treated metastatic choriocarcinoma is worse (80-90% survival) than other types of GTN (almost 100% survival).[3] Early recognition and treatment in the asymptomatic post-molar patient is the key to the high rate of cure, which approaches 100% in early stages.[3] Because many choriocarcinoma patients present initially with metastatic disease, the prognosis is worse.

CONCLUSION

Metastatic GTN in the form of choriocarcinoma is a rare diagnosis to make primarily in the ED because the patients at risk for this disease are often diagnosed during routine screening. Persistently elevated HCG levels are the hallmark laboratory finding of this disease. Emergency physicians should be aware of the risk of metastatic GTN following molar pregnancies and non-molar pregnancies when there is significant post-partum vaginal bleeding or unexplained uterine or adnexal enlargement. Recognition of metastatic GTN and screening for other locations of metastases should be performed in the ED as well as supportive and resuscitative care if life threatening complications occur, such as our patient's ruptured uterus. Overall, definitive care for GTN is the purview of the gynecologist, although emergency physicians should be aware of the risks for and be able to recognize the patient with this potentially lethal disease.

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

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Levamisole Contaminated Cocaine Induced Cutaneous Vasculitis Syndrome

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Supervising Section Editor: Sean O. Henderson, MD
Submission history: Submitted February 23, 2013; Accepted March 25, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.3.16184
[West J Emerg Med. 2013;14(5):448–449.]

A 40-year-old woman presented to the emergency department with a chief complaint of a painful rash. She had noticed lesions on her skin accompanied by burning pain that intensified over a 24-hour period. The patient admitted to smoking "crack" cocaine 4 days prior to presentation. She reported having similar symptoms previously. Her complicated past medical history was significant for hepatitis C, anti-phospholipid antibody syndrome, migraine headaches, and chronic lower back pain. She endorsed smoking cigarettes and polysubstance abuse (marijuana, heroin, and daily cocaine use). The patient's exam was notable for retiform purpuric skin lesions with eschar on her left external pinnae (Figure 1), tongue, roof of her mouth, and bilaterally on her upper and lower extremities (Figure 2). Pus was expressible on palpation of the tibial skin lesions. Laboratory evaluation revealed a white blood cell count of $3.1x10^9$ cells/L and a positive urine toxicology screen for cocaine. A biopsy obtained from her right thigh during a prior similar presentation showed luminally-thrombosed fibrin-containing small vessels surrounded by neutrophils and nuclear dust. The adjacent dermis contained extravasated erythrocytes.

A vasculitic syndrome associated with levamisole-adulterated cocaine has become increasingly recognized. This syndrome is characterized by purpuric lesions in a retiform pattern that may become necrotic and are commonly distributed on the ears, face, and extremities,[1] as evidenced by our patient. Typical laboratory findings include agranulocytosis, leukocopenia, and the production of anti-neutrophil cytoplasmic antibodies.[1] There is no evidence for the optimal treatment of levamisole-induced cutaneous vasculitis syndrome. Steroids have been used, but have an unclear benefit.[2] Permanent discontinuation of levamisole-adulterated cocaine use should be advocated. When appropriate, surgical debridement has been used to contain the progression of necrotic tissue spread.[2]

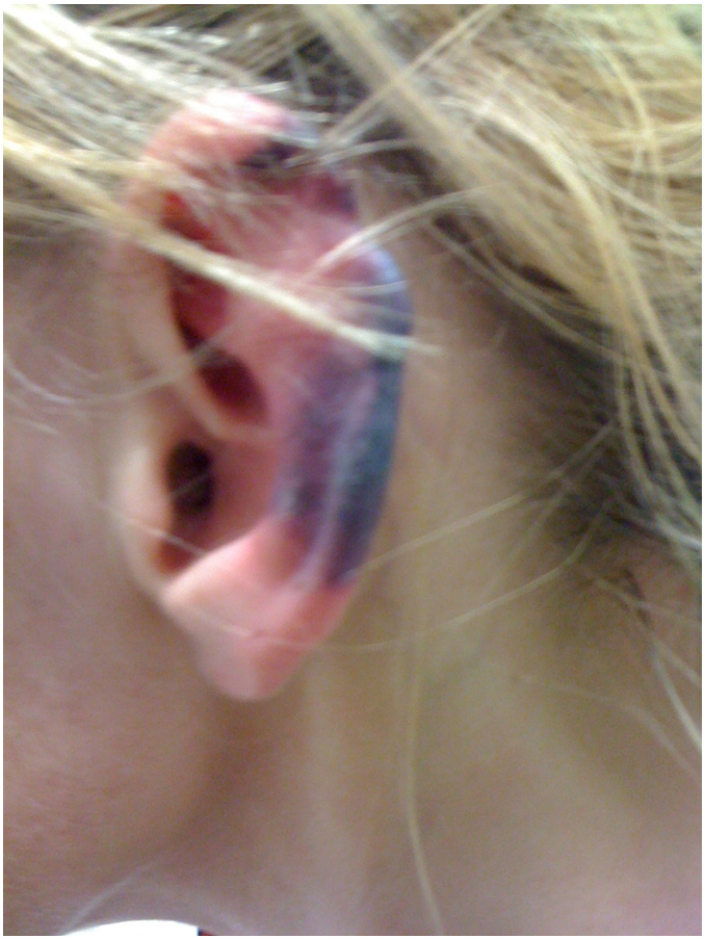

Figure 1. Retiform purpuric skin lesions with eschar on pinnae.

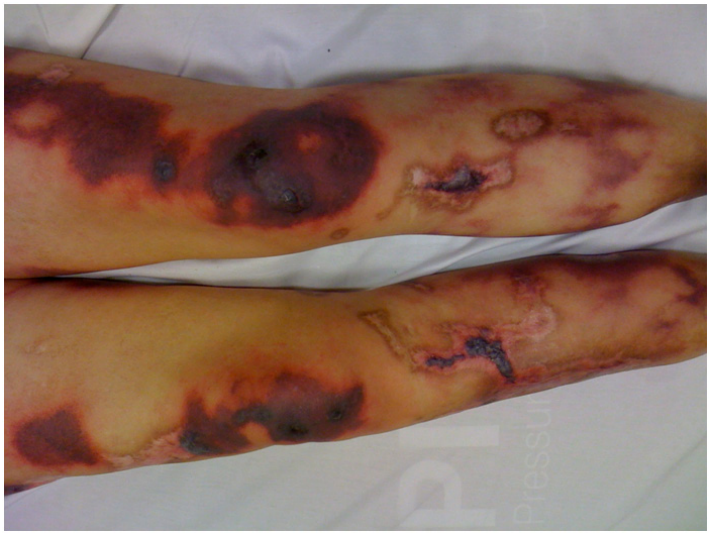

Figure 2. Retiform purpuric skin lesions with eschar on lower extremities.

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

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Bullous Lung Disease

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Supervising Section Editor: Sean Henderson, MD
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Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.3.16276
[West J Emerg Med. 2013;14(5):450–451.]

A 34-year-old black man presented to the emergency department with right-sided pleuritic chest pain, productive cough, low grade fever, and dyspnea. He had a history of emphysema, deep vein thrombosis, protein C and S deficiency, and inferior vena cava filter. His physical exam was significant for fever, tachypnea, tachycardia, and decreased breath sounds over the right upper and middle lung fields. We obtained a chest radiograph (Figure 1).

DIAGNOSIS

Giant emphysematous bulla is defined as air-filled spaces that occupy more than one-third of the hemithorax and develops in a lung destroyed by generalized emphysema.[1] Treatment typically involves surgery, although a variety of procedures have been proposed, including local excision of the bullae, plication, stapler resection, lobectomy, and videothoracoscopy.[2] Surgical therapy is indicated when patients have incapacitating dyspnea or for patients who have complications related to bullous disease, such as infection or pneumothorax.[3] Most patients with bullae have a significant cigarette smoking history, although cocaine smoking, pulmonary sarcoidosis, alpha1-antitrypsin deficiency, 1-antichymotrypsin deficiency, Marfan's syndrome, Ehlers-Danlos syndrome and inhaled fiberglass exposure have all been implicated.[4] Additionally, marijuana smoking has resulted in extensive emphysematous bullous disease seen in many young patients.[5]

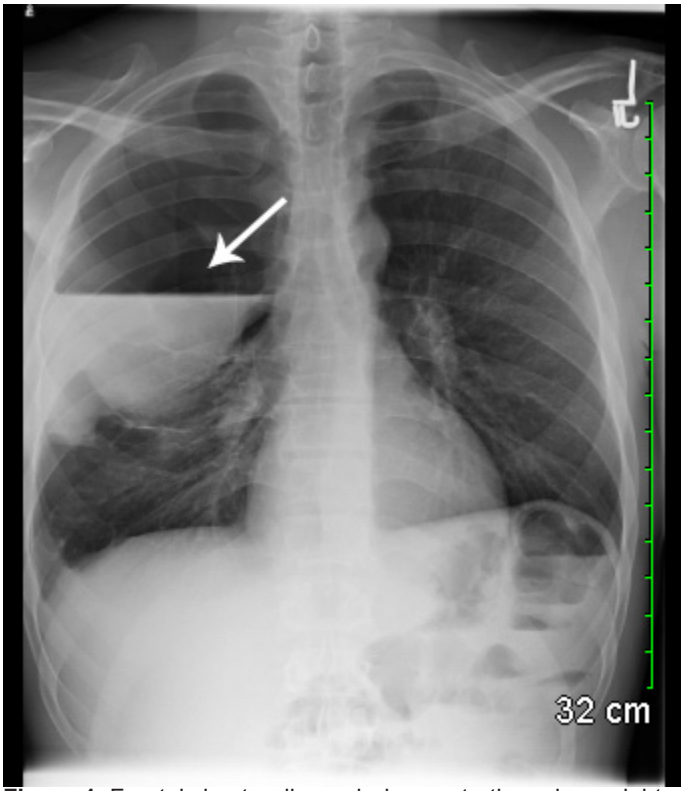

Figure 1. Frontal chest radiograph demonstrating a large right upper lung bulla with internal layering of fluid.

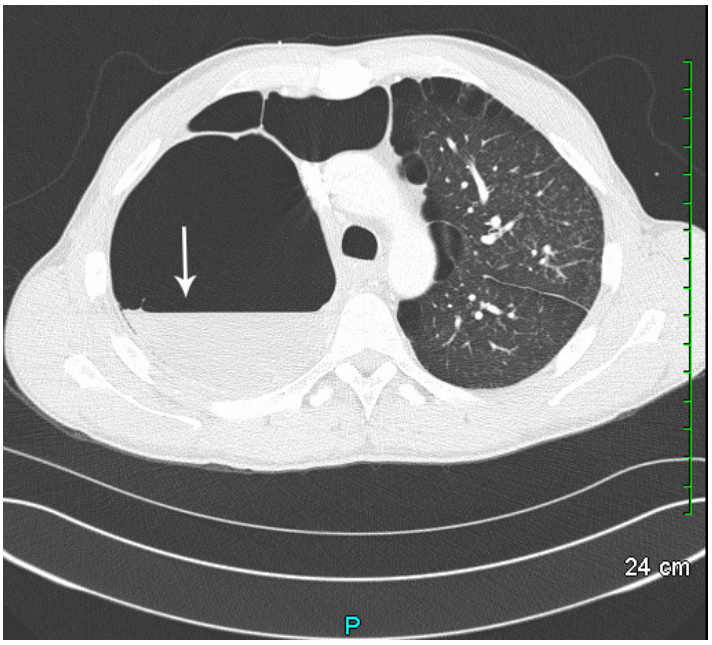

Figure 2. Coronal chest computed tomography demonstrating extensive bullous disease of the lungs with a prominent bulla in the right upper lobe containing an air fluid level.

In our patient with an infected, fluid-filled bulla, surgical intervention was indicated and a pulmonary drain was placed into the bulla by computed tomography (CT) guidance. It

should be realized that the initial chest radiograph could wrongly lead the emergency provider to place a chest tube, causing significant complications. A case published by Bourgouin et al[6] reports 2 patients with bullous lung disease wrongly receiving chest tube placement. In patients with severe bullous lung disease CT (Figure 2) will differentiate emphysematous bullae from pneumothorax and save the patient an unnecessary and potentially dangerous procedure.[7] Our patient was further evaluated with pulmonary function testing and eventually underwent video-assisted thorascopic surgery.

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

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Asymmetrical Bilateral Hip Dislocation

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Supervising Section Editor: Sean O. Henderson, MD
Submission history: Submitted January 22, 2012; Accepted February 11, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.2.15968
[West J Emerg Med. 2013;14(5):452–452.]

A previously healthy 36-year-old male who was a restrained driver presented with bilateral hip pain after a motor vehicle collision (MVC) put his vehicle in a ditch. On examination, the patient was alert and oriented with stable vitals. His right hip was externally rotated and abducted, and his left hip was internally rotated and adducted. Distal sensation and motor function were intact in both lower extremities. A plain radiograph of his pelvis showed an anterior right hip dislocation and a posterior left hip dislocation with an acetabular fracture (Figure). Patient was taken to the operating room where he underwent successful closed reduction under general anesthesia.

Traumatic hip dislocations are often due to high impact forces, such as occur in a MVC. Posterior hip dislocations are more common (90% of hip dislocations) and occur when force is applied to a hip when adducted, internally rotated and flexed. Anterior dislocations (10% of hip dislocations) are subdivided into inferior and superior. Anterior-inferior hip dislocations (90% of anterior dislocations) occur when force is applied to a hip that is abducted, externally rotated and flexed, whereas anterior-superior hip dislocations (10% of anterior dislocations) occur similarly but with the hip in extension.[1]

Bilateral hip dislocations are unusual and are thought to be associated with a high force of impact in one direction. When asymmetrical dislocations occur, one posterior and one anterior, it is believed that forces in two opposite directions are needed, making it an extremely rare injury.[2, 3]

Once a hip dislocation is diagnosed, closed reduction should be attempted. If closed reduction is unsuccessful, open reduction should be performed. Avascular necrosis of the femoral head and major nerve injury, such as sciatic or peroneal can occur, but are more likely to occur if reduction is delayed.[4]

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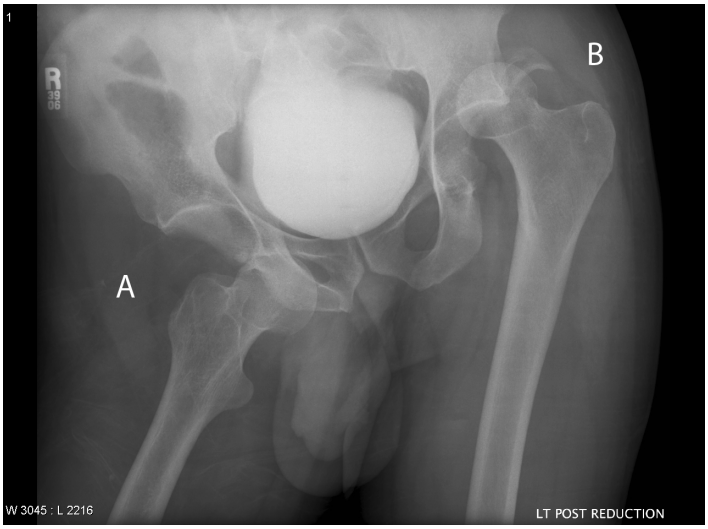

Figure. Right anterior hip dislocation (A) and left posterior hip dislocation (B) with acetabular fracture.

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

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Predictive Value of Initial Triage Vital Signs for Critically Ill Older Adults

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Supervising Section Editor: Teresita M. Hogan, MD
Submission history: Submitted Septempber 13, 2012; Revision received April 24, 2013; Accepted May 21, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.5.13411

Introduction: Triage of patients is critical to patient safety, yet no clear information exists as to the utility of initial vital signs in identifying critically ill older emergency department (ED) patients. The objective of this study is to evaluate a set of initial vital sign thresholds as predictors of severe illness and injury among older adults presenting to the ED.

Methods: We reviewed all visits by patients aged 75 and older seen during 2007 at an academic ED serving a large community of older adults. Patients' charts were abstracted for demographic and clinical information including vital signs, via automated electronic methods. We used bivariate analysis to investigate the relationship between vital sign abnormalities and severe illness or injury, defined as intensive care unit (ICU) admission or ED death. In addition, we calculated likelihood ratios for normal and abnormal vital signs in predicting severe illness or injury.

Results: 4,873 visits by patients aged 75 and above were made to the ED during 2007, and of these 3,848 had a complete set of triage vital signs. For these elderly patients, the sensitivity and specificity of an abnormal vital sign taken at triage for predicting death or admission to an ICU were 73% (66,81) and 50% (48,52) respectively (positive likelihood ratio 1.47 (1.30,1.60); negative likelihood ratio 0.54 (0.30,0.60).

Conclusion: Emergency provider assessment and triage scores that rely primarily on initial vital signs are likely to miss a substantial portion of critically ill older adults. [West J Emerg Med. 2013;14(5):453–460.]

INTRODUCTION

Accurate triage of older adults in the emergency department (ED) is important both because of the high frequency of life-threatening illness in this population and the attendant need for resource-intensive care provided to these patients.[1,2] Existing evidence suggests that elderly patients are frequently under-triaged,[3-5] that serious medical conditions may go unrecognized at the time of their triage,[6] and that the Emergency Severity Index (ESI) triage instrument may not be adequately calibrated for use in older adults.[4] Under-triage of patients may result in failure to implement critically important care and may lead to an increase in adverse outcomes; conversely, over-triage may result in inappropriate resource use and the diversion of care from other patients in

more need.[5] Triage, itself, has been recognized as critical to patient safety and experts in the field of emergency medicine have called for the development of a research agenda for its systematic study,[7] as well as identified high yield research opportunities for future investigation in this area.[8]

The clinical assessment of patients in the ED is based in part upon the measurement and interpretation of initial vital signs. Emergency providers and nurses may use vital signs as markers of the presence of severe illness, upgrading triage designations and directing more immediate attention to those patients with abnormal vital signs.[9] For older patients in particular, the ability of vital signs to indicate the severity of a patient's illness has not been conclusively demonstrated, as some studies have suggested that vital signs may not accurately reflect the severity of dehydration or pneumonia in elderly patients,[10,11] while other work has suggested that blood pressure changes on standing may reliably indicate dehydration in older adults.[12] To our knowledge, however, no research performed to date has evaluated the relationship between initial triage vital signs and the presence of severe disease among elderly patients presenting to the ED. Therefore, we examined among elderly adults the relationship between initial vital signs taken at the time of triage and the presence of severe illness or injury, defined as death in the ED or admission from the ED to an intensive care unit (ICU).

METHODS

Study Design

We conducted a retrospective study of consecutive ED visits by patients aged 75 and older during a 1-year period in order to evaluate the association between initial triage vital sign abnormalities and severe illness and injury. The selection of this age cohort was made so as to parallel the oldest age cohort analyzed in the National Hospital Ambulatory Medical Care Survey.[13] The institutional review board of the University of North Carolina approved this study with a waiver of informed consent.

Study Setting and Population

The site of this study was the University of North Carolina Hospitals ED (Chapel Hill, NC), a tertiary-care, Level 1 trauma center serving rural and urban populations with 61,200 ED visits in 2007.

Selection of Subjects

The electronic charts of all patients aged 75 and above presenting to the study ED from January 1, 2007 to December 31, 2007 were selected for inclusion in the study.

Study Protocol and Measurement

We obtained data from the ED's computerized patient record system (The T-System® EV, version 2.5, 2000-2005; T-System Inc., Dallas, TX) and Webcis, the electronic medical record system developed and used by the University of North Carolina Hospitals. To avoid manual chart review and possible disagreement among chart reviewers, data were abstracted electronically[14] from the hospital medical record system to the study database for the patients' race, insurance status, and vital signs while data were electronically abstracted from the ED record system to the study database for each patient's age, sex, disposition (admitted to the hospital floor, admitted to the ICU, transferred, discharged, or died), ESI score and chief complaint. We defined severe illness or injury as either admission to an ICU or death in the ED because they are extreme and concrete outcomes that are unlikely to be biased in a retrospective review. Vital signs are taken at the time of triage by a nurse or if the patient is placed directly into a bed by that patient's nurse. In view of the lack of a general consensus as to what constitutes a normal set of vital signs, we defined normal vital signs as follows: systolic blood pressure from 100 to 200 mm Hg, heart rate from 60 to 100 beats/minute, respiratory rate from 8 to 20 breaths/minute, temperature from 36 to 38 degrees Celsius, and oxygen saturation of 90% or above. These normal ranges were selected to mirror the upper bounds for heart rate and respiratory rate used in the ESI triage algorithm (version 4).[15] The upper range for blood pressure reflects the boundary at which the Emergency Medicine Cardiac Research Group (EMCREG) has recommended beginning outpatient blood pressure lowering therapy in asymptomatic ED patients.[16] We added additional basement parameters to these vital sign measurements and included boundaries for oxygen saturation (irrespective of supplemental oxygen provision) and temperature based on our clinical practice.

Data Analysis

In the primary analysis for elderly patients, we evaluated the predictive value of initial triage vital signs in terms of the sensitivity and specificity of the presence of any abnormal vital sign for predicting severe illness. Because some patients contributed multiple visits, the estimates of sensitivity, specificity, and other performance parameters were obtained by fitting statistical models appropriate for repeated binary measures; specifically, we relied on generalized logistic-linear models with subject-specific random effects. We performed supportive auxiliary analyses to evaluate the robustness of the primary results and conclusions to choice of statistical methods and to evaluate the impact of including patients with incomplete sets of vital signs. To evaluate whether missing vital signs had a potential effect on our results, we performed analyses for 5 groups of data each defined by the number of vital signs that were missing: 1) those visits in which all 5 vital signs were recorded (3848 visits), 2) those visits with 0 or 1 vital sign missing (4702 visits), 3) those with 0 to 2 vital signs missing (4771 visits), 4) those visits with 0-3 missing (4779 visits), and 5) those visits with 0-4 missing (4780 visits). In sensitivity analyses, we explored the impact of subjects who had multiple visits, in particular to evaluate

Table 1. Demographic and presenting characteristics of patients aged 75 and above.

Characteristic	All visits (N=4873)	Visits with severe illness* (N=244)	Visits without severe illness* (N=4629)
Sex—no. (%)			
Male	1909 (39.2)	96 (39.3)	1813 (39.1)
Female	2964 (60.8)	148 (60.7)	2816 (60.8)
Age—mean, yr	82.9	82.3	82.9
Race or ethnic group—no.(%)†			
Black or African American	893 (18.3)	40 (16.4)	853 (18.4)
White	3452 (70.8)	182 (74.6)	3270 (70.6)
Hispanic or Latino	40 (0.8)	4 (1.6)	36 (0.8)
Asian	25 (0.5)	1 (0.4)	24 (0.5)
American Indian/Alaska Native	3 (<0.1)	1 (0.4)	2 (0.0)
Unknown or not reported	460 (9.4)	16 (6.7)	444 (9.6)
Insurance status—no.(%)			
Medicare	3857 (79.2)	189 (77.5)	3668 (79.2)
Medicaid	576 (11.8)	26 (10.7)	550 (11.9)
Initial vital signs—mean (N)			
Systolic blood pressure—mmHg	143 (4707)	136 (202)	144 (4505)
Diastolic blood pressure—mmHg	74 (4703)	71 (202)	74 (4501)
Pulse—beats/min	81 (4771)	90 (209)	81 (4562)
Respiratory rate—breaths/min	19 (4748)	19 (206)	19 (4542)
Oxygen saturation—%	97 (4215)	96 (200)	97 (4015)
Temperature—°C	36.5 (4455)	36.4 (168)	36.5 (4287)
ESI level‡—mean	2.7	1.8	2.8

*Severe illness or injury defined by occurrence of intensive care unit admission or death in the emergency department.
†Race or ethnic group as recorded in the patient's chart.
‡ESI is the emergency severity index score which has five levels; 1=most acute and 5=least acute

whether patients with more visits might be more likely to have an incomplete set of vital signs. Finally, secondary analyses were performed to characterize the predictive value of each individual vital sign in elderly patients. All statistical computations were performed using SAS System Software (version 9.2, SAS Institute, Cary, NC).

RESULTS

During calendar year 2007, there were 4,873 visits by 3,079 patients aged 75 and above to the study site ED. Of these visits, 228 resulted in admission to an ICU while 16 patients died in the ED. Table 1 lists the characteristics of these visits according to outcome of interest, including demographic information, ESI triage score, and vital signs taken at triage. A complete set of initial vital signs including blood pressure, pulse, respiratory rate, temperature, and oxygen saturation were available for 3,848 visits (79.0%), although almost all patients had at least some vital signs recorded. Pulse was recorded for 4,771 visits (97.9%), complete blood pressure readings were available for 4,703 visits (96.5%), respiratory rate for 4748 visits (97.4%), temperature for 4455 visits (91.4%), and oxygen saturation for 4215 visits (86.5%). The primary results were not sensitive to incomplete recording of vital signs (Table 2).

The presence of any vital sign abnormality was associated with severe illness or injury in elderly patients (odds ratio [OR] 2.48, confidence interval [CI] 1.50-3.30). However, the sensitivity (%) and specificity (%) of any abnormal vital sign as a predictor of severe illness or injury were only 73 with CI (66,81) and 50 with CI (48,52) respectively (Table 2.), based on visits with complete vital sign data. Practically identical sensitivities and specificities, 72 with CI (65,79) and 53 with CI (51,55) respectively, were obtained for any vital sign abnormalities when less than 4 of the vital signs were missing. The estimate of serial correlation for repeated visits was small (r=0.14 to 0.24 depending on model and completeness of vital signs).

For the secondary analyses of the predictive value of individual vital signs, Table 3 lists the odds ratios for a given vital sign abnormality and its association with severe illness. The following vital sign abnormalities were associated with an increased risk of ED death or ICU admission: systolic blood pressure <100 mm Hg, heart rate >100 beats/minute, respiratory rate <8 breaths/minute or >20 breaths/minute, and

Table 2. Vital signs for prediction of death or intensive care unit admission in patients aged 75 and above.

Characteristic	No vital signs missing	0 or 1 vital sign missing	0, 1 or 2 vital signs missing	0, 1, 2 or 3 vital signs missing†
Sensitivity*	73.2% [65.5, 80.8]	72.1% [65.2, 78.9]	72.2% [65.4, 78.9]	72.2% [65.4, 78.9]
Specificity	50.0% [48.0, 52.0]	52.4% [50.5, 54.2]	52.6% [50.8, 54.4]	52.7% [50.8, 54.5]
Positive predictive value	4.6% [2.2, 6.8]	4.1% [1.9, 6.3]	4.5% [2.3, 6.5]	4.5% [2.3, 6.6]
Negative predictive value	98.1% [97.0, 99.2]	98.4% [97.3, 99.3]	98.2% [97.2, 99.2]	98.2% [97.2, 99.2]
Positive likelihood ratio	1.47 [1.30, 1.60]	1.51 [1.30, 1.60]	1.52 [1.30, 1.60]	1.53 [1.30, 1.60]
Negative likelihood ratio	0.54 [0.30, 0.60]	0.53 [0.40, 0.60]	0.53 [0.40, 0.60]	0.53 [0.40, 0.60]
Odds ratio	2.48 [1.50, 3.30]	2.60 [1.70, 3.40]	2.61 [1.70, 3.40]	2.61 [1.70, 3.40]
Subjects included	2580 (83.8%)	2980 (96.8%)	3007 (97.7%)	3011 (97.8%)
Visits included	3848 (79.0%)	4702 (96.5%)	4771 (97.9%)	4779 (98.1%)
Visits excluded	1025	171	102	94
Patients with 1 visit	1846 (71.6%)	2053 (68.9%)	2062 (68.6%)	2064 (68.5%)
Patients with 2 visits	449 (17.4%)	523 (17.6%)	530 (17.6%)	531 (17.6%)
Patients with 3 visits	167 (6.5%)	216 (7.2%)	219 (7.3%)	219 (7.3%)
Patients with 4 visits	56 (2.2%)	101 (3.4%)	105 (3.5%)	106 (3.5%)
Patients with 5+ visits	62 (2.4%)	87 (2.9%)	91 (3.0%)	91 (3.0%)
Maximum visits	14 visits	17 visits	17 visits	17 visits

* Estimates with 95% confidence intervals were obtained by fitting a generalized logistic-link regression model with a subject-specific random effect.

† Identical results were obtained for "0, 1, 2, 3 or 4 vital signs missing."

oxygen saturation <90%. Low temperatures were associated with slightly increased odds of suffering a serious outcome; however, temperature abnormalities in general were not strongly predictive of serious injury or illness.

DISCUSSION

Our results demonstrate that a substantial portion of elderly patients presenting to the ED with severe illness or injury have normal initial vital signs. Secondarily, we find that not all initial vital signs are equally useful for predicting severe illness or injury. For example, hypotension, tachycardia, hypoxia, and high or low respiratory rate were associated with increased risk of ED death or ICU admission, whereas other initial vital sign abnormalities were not. In total, however, the presence or absence of one or more abnormal initial vital sign, as defined in our study, is not a reliable marker for severe illness or injury in the elderly patient. The positive and negative likelihood ratios associated with any initial vital sign abnormality are not of sufficient magnitude to accurately predict severe illness or death in the ED.

A previous study of elderly patients in the ED of one academic center has suggested that the ESI triage score, which incorporates vital signs into its algorithm, accurately assesses the risk of elderly patients for hospitalization, resource use, and mortality.[17] However, the ESI performed better at predicting hospitalization in this original study[17] (AUC score 0.77) than it did when we examined it in our own academic setting (AUC score 0.68).[18] Neither algorithm, however, provides sufficient accuracy to reliably predict individual patient outcomes. Indeed, work from our center has suggested that the ESI triage score may not be the best predictor of admission to the hospital from the ED and that an algorithm

Table 3. Odds ratios for the association of abnormal vital signs with severe illness or injury.

Condition	Odds ratio [95% CI]	Included[1]
Low systolic blood pressure (<100 mmHg) versus normal SBP	4.53 [2.50, 6.50]	96.5%
High systolic blood pressure (>200 mmHg) versus normal SBP	1.78 [0.60, 2.90]	96.5%
Any abnormal (low or high) systolic blood pressure versus normal SBP	3.59 [2.20, 4.90]	96.5%
Low heart rate (<60 beats/min) versus normal HR	1.17 [0.60, 1.70]	97.9%
High heart rate (>100 beats/min) versus normal HR	3.42 [2.20, 4.60]	97.9%
Any abnormal (low or high) heart rate versus normal HR	2.72 [1.90, 3.50]	97.9%
Low respiratory rate (<8 breaths/min) versus normal RR[2]	384.0 [-560, 1320]	97.4%
High respiratory rate (>20 breaths/min) versus normal RR	2.04 [1.30, 2.70]	97.4%
Any abnormal (low or high) respiratory rate versus normal RR	2.50 [1.60, 3.30]	97.4%
Low temperature (<36°C) versus normal temperature	1.55 [0.90, 2.20]	91.4%
High temperature (>38°C) versus normal temperature	0.95 [0.00, 1.90]	91.4%
Any abnormal (low or high) temperature versus normal temperature	1.47 [0.80, 2.00]	91.4%
Low oxygen saturation (<90%) versus normal oxygen saturation	3.49 [1.50, 5.40]	86.3%
Normal oxygen saturation (90-100%) versus abnormal oxygen saturation	0.29 [0.10, 0.40]	86.3%
Any abnormal vital sign versus all vital signs normal	2.48 [1.50, 3.30]	79.0%

[1] Percent of visits included. Visit excluded if the vital sign was missing.
[2] Low respiratory rates were recorded in 9 patients.

for prediction of admission in elderly patients depends on vital signs only to a small degree.[18] Further investigation has also suggested that the ESI scoring system does not adequately identify those patients 75 years of age and older who are in need of an immediate life-saving intervention.[4]

Although our study is the first, to our knowledge, to examine the ability of abnormal initial vital signs taken at ED triage to predict severe illness or injury in the elderly, it adds to the substantial literature that has called into question the reliability or usefulness of vital sign measurements in clinical practice, either due to problems in the reproducibility of readings or due to their failure to predict dire clinical outcomes. Previous studies have challenged the ability of respiratory rate to predict respiratory failure [19,20] and highlighted the substantial dependency of respiratory rate measurement on provider technique.[19-21] Moreover, in the ED, considerable interobserver variability exists in the measurement of vital signs, with measurement by sequential observers differing as little as 10 to 15% for heart rate and as much as 35% for respiratory rate.[22] Finally, beyond all of these valid concerns, it has been noted that changes in anatomy and physiology associated with aging may affect the expected physiological response to injury or illness in older adults.[23] It is not known, however, at this time how initial vital signs perform as predictors of severe illness in younger cohorts of patients.

In sum, given the challenges of appropriately triaging older adults in the ED, the problems inherent in vital sign measurement, and the central role that triage vital signs play in the initial assessment of patients by emergency providers, our work suggests that there may be some value to the development of alternative indicators of life-threatening disease in older patients upon which more accurate triage can be based. While functional status has been shown to be associated with prognosis in some cancer treatments,[24] these types of assessments are not easily performed in the busy ED environment given current resources and are probably not sufficient for identifying patients with life-threatening conditions. When treating older adults with certain diseases, condition-specific assessment scales have been developed that predict severity of illness, of which the Pneumonia Severity Index (PSI) is one prominent example;[25] however emergency physicians frequently do not follow its recommendations for a variety of reasons.[26]

Future tools for geriatric triage may include biomarkers,[27-30] but the challenges of identifying a single biomarker or a panel of biomarkers to accurately predict grave outcomes in older adults presenting to the ED with undiagnosed illness are challenging.[31] Therefore, it seems, at least for the present, prudent to consider redesigning the triage of elderly patients so that physicians will have earlier contact with these patients in the course of their ED visit, as has been suggested previously.[32-34] Though the effect of such a redesign upon mortality or morbidity in this population of older adults has yet to be evaluated, its further study is warranted.

LIMITATIONS

Our work was limited in that it was collected from one study site, which may constrain the generalizability of its results. It does provide, however, an analysis of all patients aged 75 and above who were seen at our ED in a complete calendar year.

In this study, we have directly investigated only the relationship between initial vital signs and subsequent dire outcomes. Our results relate to the potential under-triage of older adults only in so much that vital signs are an important component of many triage schemes and under-triage is a concern in the care of older ED patients.[4]

Our study relied on retrospective data, rather than data collected prospectively from a cohort. We based our analyses, however, on the hard endpoints of death and admission to an ICU, 2 outcomes that we believe are likely to be free of bias and that have been used previously in the trauma literature among older adults.[35] For these reasons, we submit that it is unlikely that a prospective approach would yield substantially different results. The presence of a "Do Not Resuscitate" order (DNR) was not included in our analysis, as a DNR order in our hospital does not preclude the admission of a patient to our hospital's ICU and only influences medical "efforts at cardiopulmonary resuscitation" and "does not affect other medically indicated" acute care.[36] However, it should be acknowledged that the care of patients receiving palliative services may influence the life-saving care that is received in the ED.

While ED death and ICU admission are relatively uncommon events in our study, these are proximal outcomes with very little ascertainment bias that are more likely to be related to initial vital signs and severity of illness than other considered outcomes, such as death during hospitalization or admission to a telemetry bed. Further, the low prevalence of the outcomes in the study should not affect the performance characteristics of the test in question (vital signs), as these test characteristics will remain independent of disease prevalence in this case where disease status has been strictly dichotomized and is not believed subject to misclassification bias.[37] The relatively low number of events of interest, however, will be reflected in the precision of our estimates, as seen in our reported confidence intervals and p-values. Finally, to avoid the bias that is inherent in manual chart abstraction, we abstracted numerical values of vital signs contained in the electronic medical record by computer.

The available retrospective computerized records did not provide information about the several potential reasons for incomplete recording of initial vital signs. We acknowledge the potential confounding of our analysis due to the lack of a complete set of vital signs in nearly 20% of our sample. However, our sensitivity analyses indicate that the predictive accuracy of an initial set of vital signs in predicting dire outcomes was robustly invariant to the number of missing vital signs. It is also unlikely that 100% of patients presenting to an ED will either receive or need a full set of vital signs. We assume that failure to record initial vital signs may occur by chance due to logistical or administrative errors unrelated to the patient's condition. This cause of missing data does not induce any selection biases when visits with missing vital signs are omitted from statistical analysis. We conjecture that initial vital signs will tend to be missing for visits in which the patient is obviously extremely ill or perhaps obviously well. Omission of such visits from statistical analysis, due to missing initial vital signs, may indeed induce selection bias by under-representation of those clearly in need of urgent medical care. We note, however, that for the elderly patient who is not breathing, the triage conclusion is already obvious and use of vital signs for predicting whether the patient may be seriously ill would be pointless. In sum, we conjecture that the patients who are in a position to benefit from vital sign triage will tend to have complete initial vital sign data. It would follow that the analyses using only the visits with complete initial vital sign data would be unbiased for making inferences about the visits of interest.

Our results are specific to our choices for what constitutes an abnormal initial vital sign. As there is little literature from which to base the assignation of "cut-offs" for individual vital signs, especially in older patients, we used the upper boundaries for heart rate and respiratory rates used with the ESI scoring (Version 4)[15] and chose other boundaries for other initial vital signs based upon the medical literature for hypertension, temperature, and oxygen saturation in healthy adults and our clinical practice. It is possible that an alternate choice for values of abnormal initial vital signs would have yielded slightly different numerical results in our analysis; however, more lenient "cut-off" values are likely to increase the sensitivity at the expense of specificity. Our analyses also do not account for patients' medications, supplemental oxygen, or the presence of pacemakers that may influence patients' vital signs. Further, we do not stratify our results by the patient's chief complaint or presenting illness, as this was not a pre-specified analysis agreed upon by our research group and the low number of outcomes of interest precludes this type of sub-group analysis.

Finally, our purpose in this work was to examine the predictive value of a reasonable set of initial vital signs criteria and not to develop the most useful set of vital sign parameters to assess clinical outcomes, since regression analysis has indicated that vital signs used even as continuous variables by themselves are poorly predictive of hospitalization in elderly adults.[18] Further, although we recognize that clinicians may have multiple sets of vital signs as well as other clinical data available to them when they assess a patient, emergency providers and nurses frequently use initial triage vital signs to determine the initial resources provided to a patient[9] early on in their ED course.

CONCLUSION

Our work demonstrates that initial vital sign abnormalities,

while associated with increased risks of severe illness or injury, are neither sensitive nor specific for these outcomes in elderly patients presenting to the ED and do not produce positive or negative likelihood ratios of sufficient magnitude to shape clinical decision making. Thus, triage systems and clinical assessments that rely heavily upon initial vital sign abnormalities for the evaluation of disease severity are likely to be incorrect in many cases. As a result of the high rates of cognitive impairment[38-42] and incomplete information in older adults,[43-46] the potential for adverse outcome due to under-triage is probably greatest in this population. Further studies are needed to discover if modifications to the definitions of normal vital signs or the use of alternative indicators of disease severity can substantially strengthen the initial ED triage and clinical assessment of this vulnerable population.

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

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Sexual Assault Training in Emergency Medicine Residencies: A Survey of Program Directors

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Supervising Section Editor: Beau Briese, MD, MA
Submission history: Submitted March 25, 2012; Revision received February 13, 2013; Accepted February 15, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.2.12201

Introduction: There is currently no standard forensic medicine training program for emergency medicine residents. In the advent of sexual assault nurse examiner (SANE) programs aimed at improving the quality of care for sexual assault victims, it is also unclear how these programs impact emergency medicine (EM) resident forensic medicine training. The purpose of this study was to gather information on EM residency programs' training in the care of sexual assault patients and determine what impact SANE programs may have on the experience of EM resident training from the perspective of residency program directors (PDs).

Methods: This was a cross-sectional survey. The study cohort was all residency PDs from approved EM residency training programs who completed a closed-response self-administered survey electronically.

Results: We sent surveys to 152 PDs, and 71 responded for an overall response rate of 47%. Twenty-two PDs (31%) reported that their residency does not require procedural competency for the sexual assault exam, and 29 (41%) reported their residents are required only to observe sexual assault exam completion to demonstrate competency. Residency PDs were asked how their programs established resident requirements for sexual assault exams. Thirty-seven PDs (52%) did not know how their sexual assault exam requirement was established.

Conclusion: More than half of residency PDs did not know how their sexual assault guidelines were established, and few were based upon recommendations from the literature. There is no clear consensus as to how PDs view the effect of SANE programs on resident competency with the sexual assault exam. This study highlights both a need for increased awareness of EM resident sexual assault education nationally and also a possible need for a training curriculum defining guidelines for EM residents performing sexual assault exams. [West J Emerg Med. 2013;14(5):461–466.]

INTRODUCTION

In 2009 more than 125,000 sexual assaults were reported in the United States (U.S.).[1] Emergency physicians (EP) work closely with law enforcement as victims often present to emergency departments (ED) for evaluation, and physician documentation and testimony in sexual assault cases is valuable for the prosecution of offenders. Studies show that accurate and thorough documentation of injuries correlates with higher rates of charges filed and successful conviction of perpetrators.[2,3]

The American Board of Emergency Medicine's Model of Clinical Practice of Emergency Medicine includes sexual assault patient assessment and the completion of the sexual assault examination as integral topics and skills, but there are no recommendations regarding the number of hours or content dedicated to resident training in assessment of

Table 1. Descriptive statistics of study population.

Descriptive statistic	Number of respondents (%)
3-year residency program*	45 (63%)
4-year residency program*	26 (37%)
SANE program at institution	56 (79%)
24-hour SANE coverage	43 (61%)
SANE elective available	13 (18%)

SANE, sexual assault nurse examiner
*Given the anonymity of respondents, program directors of 2-4 year programs may have identified themselves as either a 3-year or 4-year program.

Table 2. Number of resident-performed sexual assault exams required for procedural competency as reported by program directors.

Number of required sexual assault exams	Number of respondents (%)
None	22 (31%)
1-5	27 (38%)
>5	2 (3%)
Did not know	20 (28%)
Observation only	29 (41%)

Table 3. How resident requirements for sexual assault exams were established as reported by program directors.

Basis of resident requirement	Number of respondents (%)	95% CI
Literature-based recommendation	1 (1%)	
SANE-based recommendation	11 (15%)	8-26%
Do not know	37 (52%)	40-64%

CI, confidence interval; *SANE*, sexual assault nurse examiner

sexually assaulted patients.[4] While EPs remain the initial primary providers treating victims of violent crimes, many are not properly trained to care for sexual assault patients. Guidelines providing educational direction for emergency medicine (EM) residency forensic training and sexual assault training are sparse.[5]

Over the last 35 years, sexual assault nurse examiner (SANE) programs, sometimes referred to as sexual assault forensic examiner programs (SAFE) or sexual assault response teams (SART) have improved the quality of care for sexual assault victims. (We collectively refer to these programs as SANE programs for simplicity).[3,6] There are now over 600 SANE programs in the U.S. and associated territories; these programs are quickly becoming the model of care for assault victims.[3,7] While the creation of SANE programs has improved patient care, it is unclear how these programs impact EM resident training at academic institutions.

The purpose of this study is two-fold: to gather information from the program directors (PDs) of U.S. EM residency programs' regarding the current training of EM residents in the care of sexual assault patients, and to survey what PDs think has been the overall impact of SANE programs on EM resident training.

METHODS

This is a cross-sectional survey of current program directors of U.S. EM residency training programs. The survey was available over a 3-month period from June 16 to September 16, 2010. No identifiable information was requested in the survey; responses were submitted electronically, anonymously, and voluntarily. Approval for this study was obtained from the Colorado Multiple Institutional Review Board; no informed consent was required.

We generated a list of current PDs from the 152 approved EM residency training programs from the Society of Academic Emergency Medicine residency catalog. A survey was developed by consensus of the authors of this paper and piloted to non-PDs for comment. We then circulated electronically a final survey consisting of 15 questions via Zoomerang (MarketTools Company, San Francisco, CA). The survey is included as the Figure.

We conducted participant recruitment via an electronic invitation that described the intent of the project. Various Dillman techniques, including the use of a shorter questionnaire, regular follow-up via email, and university sponsorship were used to strengthen the response rate.[8]

We aggregated data into an Excel database (Microsoft Corporation, Redmond, WA) that was then transferred into SAS or Stata formats using translational software (dfPower/DBMS Copy, DataFlux Corporation, Cary, NC). We performed all statistical analyses using SAS Version 9.2 (SAS Institute, Inc., Cary, NC) or Stata Version 10 (Stata Corporation, College Station, TX). Descriptive statistics for continuous variables were expressed as medians with interquartile ranges and proportions as percentages with 95% confidence intervals (CIs).

RESULTS

Of the 152 EM programs asked to complete the survey, 62 PDs completed the survey in its entirety, and 9 completed a portion of the survey for a total of 71 respondents (47%). The primary investigator reviewed the survey results, and answers to questions by partial responders were manually added into the overall data set.

Among the 71 who responded, the majority (79%) have a SANE program at their institution and a majority (61%) note that their residents work in hospitals offering 24-hour SANE coverage. Descriptive statistics of those responding to the survey are included in Table 1. Descriptive data about the implementation of SANE programs at institutions with residency programs are included in the Figure (questions 9,12, and 13).

When PDs were asked about their residency programs' requirements in sexual assault education, the majority of responding PDs (41%) reported their residents are required only to observe sexual assault exam completion. Of those reporting required demonstration of exam performance, most PDs (38%) note their residents are required to perform 5 or

Survey Item	N	(%)
1) Is your residency a 3 or 4 year program?		
3 year	45	(63%)
4 year	26	(37%)
2) How many sexual assaults (SA) present to your ED each year?		
<100	22	(31%)
100 – 300	24	(34%)
301 – 500	7	(10%)
501 – 700	0	(0%)
701 – 900	0	(0%)
>900	0	(0%)
Unknown	18	(25%)
3) Are your residents required to perform or observe the SA exams. Or can they do both? (Check all that apply)		
Perform only	27	(38%)
Observe only	29	(41%)
Both perform and observe	15	(21%)
4) How many SA exams are your EM residents required to do for procedural competency?		
None	22	(31%)
1 – 5	27	(38%)
6 – 10	2	(3%)
11 – 15	0	(0%)
16 – 20	0	(0%)
>20	0	(0%)
Do not know	20	(28%)
5) How did you decide on the number needed for procedural competency? (Check all that apply)		
Literature based recommendation	1	(1%)
SANE (Sexual Assault Nurse Examiner) based recommendation	11	(15%)
Do not know	37	(52%)
Other, please specify		
6) How many hours of didactic education on Sexual Assault do your residents receive during residency?		
None	1	(1%)
1 – 5	49	(69%)
6 – 10	12	(17%)
11 – 20	1	(1%)
21 – 40	1	(1%)
<40	1	(1%)
Do not know	6	(8%)
7) What are the didactics offered on this topic? (Check all that apply)		
Lecture provided by Emergency Medicine Attendings	56	(79%)
Lecture provided by SANE nurse	47	(66%)
Elective time	6	(8%)
Simulation	5	(7%)
Other, please specify		
8) Do you have a SANE program at your institution? If no, go to conclusion of survey.		
Yes	56	(79%)
No	15	(21%)

Questions 9 – 15 were only answered by those respondents who indicated that they have a SANE program at their institution (n = 56)

Survey Item	N	(%)
9) If Yes, how long have you had a SANE program?		
<1 year	3	(5%)
1 – 3 years	6	(11%)
4 – 10 years	20	(36%)
11 – 15 years	11	(20%)
16 – 20 years	1	(2%)
>20 years	1	(2%)
Do not know	10	(18%)
10) Does your program offer a SANE (Sexual Assault Nurse Examiners) resident elective?		
Yes	13	w/ SANE (23%) overall (18%)
No	35	(63%)
Other, please specify		
11) Does your SANE program offer 24-hour coverage?		
Yes	43	w/ SANE (77%) overall (61%)
No	9	(16%)
12) How many sexual assault exams did residents do per year PRIOR to the SANE program being instituted?		
None	1	(2%)
1 – 5	7	(13%)
6 – 10	9	(16%)
11 – 15	2	(4%)
16 – 20	5	(9%)
>20	2	(4%)
Do not know	26	(46%)
13) How many sexual assault exams do residents do per year AFTER the SANE program was instituted?		
None	7	(12%)
1 – 5	23	(41%)
6 – 10	2	(4%)
11 – 15	1	(2%)
16 – 20	1	(2%)
>20	1	(2%)
Do not know	17	(30%)
14) How has the SANE program impacted resident education?		
Improved Only	15	(27%)
Hindered Only	10	(18%)
Both Improved and Hindered	2	(4%)
No change	25	(45%)
15) If you answered improved or hindered in the above question, please explain.		See Table 5

Figure. Survey distributed to program directors and associated responses.

Table 4. Overall program director opinion of sexual assault nurse examiner effect on resident education of sexual assault exams

Program director opinion	Number of respondents (%)	95% CI
Improved	15 (27%)	16-40%
Hindered	10 (18%)	9-30%
Both improved & hindered	2 (4%)	0.4-12.3%
No effect	25 (45%)	31-59%

CI, confidence interval

Table 5. Themes generated from Program Director comments of question: 'How has the sexual assault nurse examiner (SANE) program impacted resident education?'

Thematic category	(% responding) N=22
Improved:	
Residents learn the SANE standard of care	8 (36%)
Awareness of SANE role	2 (9%)
Hindered:	
Decreased Clinical Exposure/Experience	7 (32%)
Difficulty in performing a thorough exam independently	1 (5%)
View SA exams as SANE responsibility	1 (5%)
Other:	
Residents are able to see other patients	43 (61%)
Residents are less likely to testify in court	13 (18%)

SA, sexual assault

fewer sexual assault exams to achieve procedural competency. Additional findings regarding required competency in sexual assault exam completion are included in Table 2. With regard to didactics, the majority of PDs (69%) report their residents receive 1-5 hours of sexual assault education (Figure questions 6-7).

After defining how many sexual assault exams are required of residents for demonstration of competency, PDs were asked how such requirements were established (Table 3). One PD (1%) cited a literature-based recommendation, while the majority of PDs (52%) did not know how their sexual assault exam requirements were established. The remaining respondents cited various other methods, such as consensus decision, or reported that their residency program did not have a set requirement.

Among institutions reporting the availability of SANE programs, PD opinions differed as to whether SANE is felt to have helped or hindered resident education. Of the 56 PDs responding to the question, the majority (45%) felt SANE programs have had no effect on resident sexual assault examination education. Additional findings and associated confidence intervals are presented in Table 4. PDs were asked to further explain their responses to this question, and themes generated from those responses are summarized in Table 5.

DISCUSSION

To our knowledge, this is the first survey addressing sexual assault education across U.S. EM training programs. This study highlights the current state of sexual assault education across EM residencies, associated PD attitudes and attention paid to this area of resident education, and the possible effect of SANE programs on resident training and education.

There is significant variation in sexual assault training across EM residency programs. In our study, 31% of PDs report their EM residency programs do not require procedural competency in the SANE exam, 41% require observation alone, and 38% of programs require fewer than 5 exams. Only 2 programs (3%) reported requiring more than 5 sexual assault exams. This is in stark contrast to the training of SANE providers, who must perform a median of 80 hours of mandated clinical and didactic training to obtain procedural competency.[9] This study highlights the dichotomy in expectations between SANE versus resident competency and is noteworthy given that both groups care for the same patient population. Literature evaluating EM residents' skills in sexual assault exams does support that improvements in sexual assault examination skills can be made by providing tailored SANE-based training, as was done at the University of New Mexico, where a curriculum that included didactics, role play, and skills training was implemented. A study of this program found that resident skills can be on par with that of SANE providers.[10] Broader national support for a training program such as this is worth future consideration.

Second, there are equally varying degrees of awareness paid by EM residency PDs to this component of their residents' overall education, despite the EM Model of Clinical Practice curriculum's inclusion of sexual assault education. More than a quarter (28%) of responding PDs did not know how many resident-performed sexual assault exams are required for demonstration of procedural competency, and more than half of PDs had no insight regarding how their sexual assault guidelines were established. The overall response rate (47%) of this study may also be indicative of decreased attention paid to sexual assault education, though this can only be postulated. While in this study the majority of responding PDs reported they work at institutions with SANE programs (79%), given many physicians will ultimately practice in settings where there is no SANE program, it remains an important component of EM residency training.

Lastly, this study highlights that there is no clear consensus regarding how PDs feel SANE programs have affected resident education in sexual assault. The most commonly held opinion among PD respondents in this study was that SANE programs do not impact residency training, while 27% believed that resident training is improved, and

18% believed training is negatively impacted. There is a paucity of literature regarding the impact of SANE programs on resident competency in treating and examining a sexual assault patient. While SANE programs have been shown to enhance patient care and accuracy of evidence collection, there remains the possibility that the availability of a SANE program may decreases resident exposure to these patients and in turn affects their competency and comfort with the sexual assault exam due to limited exposure.[3,6] Resident training with a SANE nurse can be an excellent opportunity to learn how to proficiently perform exams. However, competency in all procedural components is likely not obtained solely by observation, but also by performing the complete exam and evidentiary collection. If SANE programs continue to thrive, it is possible the EM model of clinical practice may evolve and there may be a shift away from sexual assault examination education for resident physicians. However, many SANE programs have physician advisors; arguably it is important that they be competent in the forensic evaluation of the sexually assaulted patient. Many likely rely on training from residency or an interest in the care of this patient population. In the future EM might consider adopting the Australian curriculum of formal forensic fellowships after EM training as specialty training.[11]

LIMITATIONS

The main limitations of this study are a result of its design as an electronic survey. The response rate was 47%, which is comparable to other web-based surveys, as one review paper reported a mean response rate of 36.8% for email surveys.[12] Our study was subject to response bias given that 79% of respondents have a SANE program at their institution. While we do not know the actual percent of EM residency programs with SANE programs, this is likely biased toward recruitment of PDs who have a SANE program at their institution. The study is inherently limited, given that data is self-reported and sexual assault residency requirements or the basis for them may vary from what is reported. Because of anonymity we were unable to characterize responders versus non-responders.

CONCLUSION

In gathering information from U.S. EM residency PDs, we conclude there is no national consensus as to how an EM resident physician are educated in sexual assault examination and that there are varied attitudes and attention paid to this area of resident education.

Second, there is lack of consensus as to the effect of SANE programs on EM resident education in sexual assault exams. Given the overall success of SANE programs to date, it is anticipated that SANE programs will continue to coexist at residency training sites. In order to better elucidate the effect of SANE programs on resident training, future work should be targeted to residents at programs with SANE versus those without, and if possible target residents at programs before and after the implementation of SANE programs. Projects such as these would more directly assess impact of SANE on resident preparedness in this area of their training.

These results should spur conversation within residency leadership about the status of their own sexual assault educational initiatives, and perhaps serve as the catalyst for groups with interest in this area to convene and assess the need for a national training model in sexual assault education.

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

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Emergency Physicians' Knowledge of Cannabinoid Designer Drugs

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Supervising Section Editor: Eric Snoey, MD
Submission history: Submitted August 24, 2012; Revisions received November 1, 2012; Accepted January 28, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.1.14496

Introduction: The use of synthetic drugs of abuse in the United States has grown in the last few years, with little information available on how much physicians know about these drugs and how they are treating patients using them. The objective of this study was to assess emergency physician (EP) knowledge of synthetic cannabinoids (SC).

Methods: A self-administered internet-based survey of resident and attending EPs at a large urban emergency department (ED) was administered to assess familiarity with the terms Spice or K2 and basic knowledge of SC, and to describe some practice patterns when managing SC intoxication in the ED.

Results: Of the 83 physicians invited to participate, 73 (88%) completed surveys. The terms "Spice" and "K2" for SC were known to 25/73 (34%) and 36/73 (49%) of respondents. Knowledge of SC came most commonly (72%) from non-medical sources, with lay publications and the internet providing most respondents with information. Among those with previous knowledge of synthetic cannabinoids, 25% were not aware that SC are synthetic drugs, and 17% did not know they are chemically most similar to marijuana. Among all participants, 80% felt unprepared caring for a patient in the ED who had used synthetic cannabinoids.

Conclusion: Clinically active EPs are unfamiliar with synthetic cannabinoids. Even those who stated they had heard of synthetic cannabinoids answered poorly on basic knowledge questions. More education is needed among EPs of all ages and levels of training on synthetic cannabinoids. [West J Emerg Med. 2013;14(5):467–470.]

INTRODUCTION

In March 2011, the United States Drug Enforcement Administration (DEA) temporarily placed 5 synthetic cannabinoids (SC) into Schedule 1 of the Controlled Substances Act "to avoid imminent hazard to the public safety."[1] These SC products have received substantial media attention for being sold as "legal highs" that have names such as "Spice" and "K2" and are packaged as "incense." Complications from SC use have resulted in increasing numbers of hospital visits.[2] Currently, additional media and legislative attention is being paid to the difficulty of enforcing such a ban, since producers of SC products have a myriad of additional cannabinoid compounds to use besides the 5 restricted by the DEA.[3]

The initial growth of SC use in the United States (U.S.) was sparked by reports that they had effects similar to marijuana, but with the advantages that they are undetectable on routine urine drug screens and were widely legally available on the internet, in "head shops" and in gas stations. A report by the 2011 "Monitoring the Future" study quantified the popularity of SC, particularly among adolescents, with 11.4% of high school seniors admitting to having used SC

within the previous 12 months.[4] However, reports of such adverse effects as psychosis, seizures, myocardial infarction, dysrhythmias, and metabolic derangements, show that although these substances are cannabinoids with physiologic activity at cannabinoids receptors, their clinical effects are quite different from those caused by smoking marijuana.[5-9] Researchers have voiced further concern about the potential long-term immunologic, neurologic, and psychiatric complications specifically in adolescent patients.[10]

It has been well described that people with drug-related complications often seek care in the emergency department (ED).[11] When the use of new synthetic drugs becomes popular, emergency physicians (EPs) are in a particularly difficult position, often treating patients while having relatively little knowledge of the substance the patient has taken. Using SC as a convenient example of an emerging drug of abuse, we investigated EP knowledge of SC and potential practice patterns for managing patients presenting after ingestion of SC.

METHODS

We performed a self-administered, anonymous, voluntary, internet-based survey in December 2010 of resident and attending EPs at a large academic urban ED with an annual volume of approximately 85,000 visits. The survey was pre-tested among a group of students, was revised for study performance, and then was piloted among a small group of volunteer physicians not participating in the survey study. Given the subject of the survey, the questions were all original. The survey instrument used closed-format questions to assess familiarity with the substances Spice and K2, basic knowledge of SC, and potential practice patterns when managing intoxication with SC in the ED. Responses were categorical, binary, or on a four-point Likert scale. The local institutional review board exempted the project from review.

All statistical calculations were performed using R, version 2.14.0. All percentages are displayed with their associated confidence intervals (CI). Comparisons between groups were performed using chi-square or Fisher's exact test where appropriate. Level of significance was $P<0.05$, and statistical tests were two-sided.

RESULTS

Out of 83 invited participants, 73 EPs completed the survey (88%): 47 were residents and 26 were attending physicians (Table 1). There were no differences in familiarity, knowledge, or management of SC when comparing age of the respondent, level of training (resident or attending), or years of experience. A majority of EPs had never heard of the recreational drugs Spice (48 of 73 [66%; 95% CI, 54%-76%]) or K2 (37 of 73 [51%; 95% CI, 39%-62%]). At the time of the survey, few EPs had ever discussed SC use with a patient (4 of 73 [5.5%; 95% CI, 0.3%-10.7%]), and few had taken care of a patient who used Spice or K2 (3 of 73 [4.1%; 95% CI, -0.4%-8.7%]). Of all respondents, 14% (95% CI, 7%-24%) believed SC were most commonly obtained either from a pharmacy or by physician prescription.

Table 1. Demographics of emergency physician participants in survey about synthetic cannabinoid use.

Demographic Variables	*n* (%)
Age (in years)	
≤25	1 (1.4)
26-29	30 (41.1)
30-39	32 (43.8)
40-49	7 (9.6)
50+	3 (4.1)
Training	
Resident	47 (64.4)
Attending	26 (35.6)
Years practicing emergency medicine (Attendings only, *n*=26)	
≤2	5 (19.2)
3-10	12 (46.2)
11-20	5 (19.2)
>20	4 (15.4)
Year in Residency (*n*=47)	
EM-1	13 (27.7)
EM-2	11 (23.4)
EM-3	11 (23.4)
EM-4	12 (25.5)

Among physicians familiar with SC, 25% (95% CI, 13%-43%) were not aware they are synthetic drugs. While most physicians who were familiar with SC were aware SC are most similar to marijuana, 17% (95% CI, 7%-33%) believed they are more similar to gamma-hydroxybutyrate (GHB), diazepam, or cocaine. When asked about symptoms, 47% (95% CI, 31%-64%) would not expect to see anxiety, sedation, or psychosis in a patient who had used SC. Physicians obtained their information about SC from sources other than medical publications or lectures 72% of the time (95% CI, 55%-85%), citing lay publications, patients, colleagues, and the internet most commonly (Figure).

Those physicians who had never heard of Spice or K2 were more likely to order additional testing, with 65% ordering urine drug screens, as opposed to 39% of those who were familiar with SC ($P < 0.05$). A higher proportion of physicians unfamiliar with SC were more likely to admit an SC user to the hospital (39% vs. 3%, $P < 0.005$). Of all participants, 80% (95% CI, 69%-88%) did not feel "prepared" caring for a patient in the ED who has used SC, and 92% (95% CI, 82%-97%) felt they need more education on such emerging drugs of abuse (Table 2).

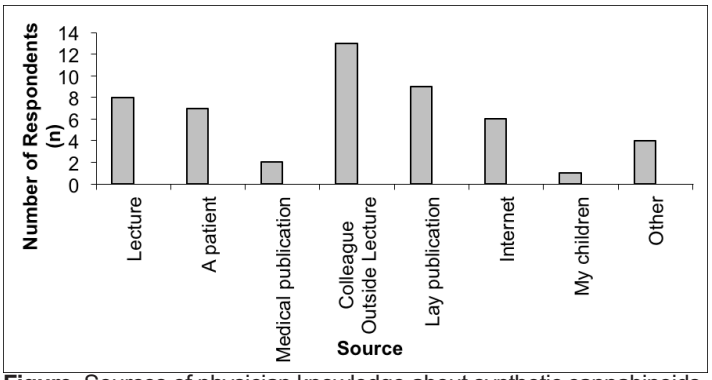

Figure. Sources of physician knowledge about synthetic cannabinoids.

DISCUSSION

This study showed unfamiliarity and inexperience with SC among EPs during a time when their use was growing in popularity. Even among those familiar with SC, there were many misconceptions about SC and their clinical effects, with most physicians obtaining their information from non-medical sources.

This study brings to light the problems physicians face when treating patients who are using new drugs of abuse. Specifically, it became clear that there is an inherent difficulty in treating patients using a new drug of abuse because of a lack of available medical literature on the substance.[12] Further confounding the issue, the medical literature that is available constantly changes with reports of novel side effects and complications.

These facts also made studying physician knowledge of new drugs of abuse particularly challenging. Questions initially included in the survey, including some questions on availability and legality, had to later be excluded because of multiple changes occurring throughout the survey and data analysis period. This ever-changing aspect of "designer drug" investigation is mirrored in the clinical setting with adjustments for rapidly growing medical knowledge.

In the few hospitals with medical toxicologists on staff, it is largely accepted that one of the roles of the medical toxicologist is to educate other healthcare providers on new developments in the field of toxicology. The very large majority of hospitals without a medical toxicologist may instead rely on information provided by their regional poison center. With the seemingly limitless designer drug compounds available for use and with no information on relative toxicity of each compound, this connection to toxicologists, poison centers, or other experts in emerging drugs of abuse will be crucial to EPs dealing with the constantly changing world of designer drugs.

LIMITATIONS

This survey study is limited by having a small sample size and being performed in a single study center. Despite these limitations, this study provides useful information that may help focus the education of emergency physicians during future outbreaks of new drugs of abuse.

CONCLUSION

In the last few years, the use of synthetic drugs of abuse has grown, with little information available on healthcare

Table 2. Clinical practice patterns.[a,b]

Please respond to each of the following statements about patients who present to the emergency department with Spice or K2 intoxication.				
	Strongly agree	Agree	Disagree	Strongly disagree
They need a urine drug screen ordered. (*n* = 70)	15	22	20	13
They require hospitalization. (*n* = 70)	2	13	46	9
They should have substance abuse referral. (*n* = 69)	18	47	4	0
They warrant evaluation for other substances of abuse. (*n*=69)	29	36	4	0
They are at increased risk for traumatic injury (compared to a non-intoxicated patient in the ED). (*n* = 70)	26	42	2	0
I feel prepared to take care of a patient with acute intoxication with Spice or K2. (*n* = 71)	1	13	31	26
Do you feel you need more education on emerging drugs of abuse patterns? (*n* = 71)	Yes 65	No 6		

a. These constitute answers by all respondents, regardless of previous knowledge of synthetic cannabinoids.

b. Each participant in the survey did not complete every question.

provider knowledge about these drugs and how they are treating patients using them.[13] This study focused on synthetic cannabinoids, showing that during this period of growth, EPs were unfamiliar with synthetic cannabinoids and felt they needed more education.

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

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English-based Pediatric Emergency Medicine Software Improves Physician Test Performance on Common Pediatric Emergencies: A Multicenter Study in Vietnam

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Supervising Section Editor: Paul Walsh, MD, MSc
Submission history: Submitted November 14, 2012; Revision received March 21. 2013; Accepted April 2, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.4.15090

Introduction: Global health agencies and the Vietnam Ministry of Health have identified pediatric emergency care and health information technology as high priority goals. Clinical decision support (CDS) software provides physicians with access to current literature to answer clinical queries, but there is limited impact data in developing countries. We hypothesized that Vietnamese physicians will demonstrate improved test performance on common pediatric emergencies using CDS technologies despite being in English.

Methods: This multicenter, prospective, pretest-posttest study was conducted in 11 Vietnamese hospitals enrolled a convenience sample of physicians who attended an 80-minute software training on a pediatric CDS software (PEMSoft). Two multiple-choice exams (A, B) were administered before and after the session. Participants, who received Test A as a pretest, received Test B as a posttest, and vice versa. Participants used the CDS software for the posttest. The primary outcome measure was the mean percentage difference in physician scores between the pretest and posttest, as calculated by a paired, two-tailed t-test.

Results: For the 203 participants, the mean pretest, posttest, and improvement scores were 37% (95% CI: 35-38%), 70% (95% CI: 68-72%), and 33% (95% CI: 30-36%), respectively, with $p<0.0001$. This represents an 89% improvement over baseline. Subgroup analysis of practice setting, clinical experience, and comfort level with written English and computers showed that all subgroups equivalently improved their test scores.

Conclusion: After brief training, Vietnamese physicians can effectively use an English-based CDS software based on improved performance on a written clinical exam. Given this rapid improvement, CDS technologies may serve as a transformative tool in resource-poor environments. [West J Emerg Med. 2013;14(5):471–476.]

INTRODUCTION

The United Nations' Millennium Development Goals campaign is focused on pediatric health care and mortality rates as one of its 8 major goals.[1] This is directly aligned with other global health agencies, such as the World Health Organization, United Nations, and Health Information for All by 2015 (HIFA2015), which have identified the lack of access to current medical information as a significant barrier to effective patient care in the developing world.[2-4]

Health Information Technology (HIT) is a potentially transformational solution towards universal access for healthcare providers in the developing world. It offers under-resourced public health systems and providers with highly scalable, efficient approaches to medical education and training, as well as instant access to evidence-based literature for patient care decision making. More specifically, clinical decision support (CDS) software, a form of HIT, provides information and/or knowledge-based systems, which guide medical decision-making. This might include dosing calculators, management algorithms, computerized order sets, and other tools that help the clinician care for patients in real-time.[5,6] A commonly known CDS software is UpToDate. CDS systems have several unique characteristics that distinguish this type of knowledge system from traditional, hard-copy medical references: immediacy of access to various digital platforms; portability to the point-of-care of the patient; availability of a constantly updated knowledge database; an interactive user interface; and a search engine for rapid navigation to desired information. Some forms of CDS software also offer multimedia tools. PEMSoft (Pediatric Emergency Medicine Software; Brisbane, Australia) is such an English-based CDS software that is designed for the acute and emergent care of children.

In response to urgent requests by the global health community for improved pediatric care in the developing world, KidsCareEverywhere, a nonprofit public charity and non-governmental organization, began a pilot program to train physicians on the use of PEMSoft in Hanoi, Vietnam in 2007. This aligned with the Vietnam Ministry of Health's vision for improved pediatric emergency care in Vietnam,[7] which was emphasized as a national priority at the 2009 Vietnam Pediatric Emergency Medicine Conference. After a highly encouraging 3-year trial, leaders from KidsCareEverywhere and from the Vietnamese National Hospital of Pediatrics in Hanoi sought to evaluate the impact of PEMSoft in improving Vietnamese physician knowledge acquisition on a broader scale throughout Vietnam. Although access to CDS systems has been shown in developed countries to improve knowledge acquisition, processes of care, and patient management decisions,[8-14] this has not been well studied in more resource-poor countries such as Vietnam.[15,16]

We hypothesized that physicians in both urban and rural Vietnam hospitals, after only an 80-minute CDS training session, would improve their scores on a written clinical exam testing common pediatric emergencies. Additionally, we sought to determine whether subgroups showed greater improvement than others to help plan for future software training sessions in other developing countries.

METHODS

Study design

A multicenter, prospective, pretest-posttest study was conducted in 11 geographically diverse Vietnamese hospitals, selected by Hanoi hospital leaders. These included 6 urban (Blood Transfusion Center, Da Nang Central Hospital, Hue Central Hospital, National Hospital of Pediatrics, Ho Chi Minh City Children's Hospital #1 and #2) and 5 rural (Dong Nai Pediatric Hospital, Hoa Binh Provincial Hospital, Nghe An Provincial Hospital, Thai Binh Pediatric Hospital, Tien Giang Provincial Hospital) hospitals. We evaluated the impact of a donated CDS software (PEMSoft) on physician performance on a written clinical examination from November 2010 to April 2011. This study was approved by the National Hospital of Pediatrics.

Selection of participants

The study participants were a convenience sample of volunteer Vietnamese physicians. Hospital leaders from each of the 11 study sites invited volunteer participants from their hospital and local affiliated sites, who had not used PEMSoft before, to attend a PEMSoft software training session. They were told to bring their own laptop and any medical references that they use currently for patient care. After an "open book" pretest using native medical references, each participant installed a free subscription of PEMSoft onto their personal laptop. Participants were excluded from the study if they were medical students or did not submit both their pretest and posttest exams.

Interventions

PEMSoft is a desktop-based, digital reference tool containing approximately 800 different pediatric conditions in its database. A highlighted piece of the software during the training session included the interactive resuscitation module for critical care conditions. For example in this module, the user can type in either the patient's length or age, and the software provides an estimated lean body weight. Subsequently weight-specific drug doses and equipment sizes along with key pearls and pitfalls for various resuscitation algorithms are displayed to guide patient management plans and minimize calculation errors.

Two English-speaking, non-medically trained KidsCareEverywhere interns (TB, AM) dually conducted the 11 training sessions with each lasting 3 hours (Table 1). The actual study intervention lasted only 80 minutes, which consisted of a 20-minute software training video (in Vietnamese) and a 60-minute scripted discussion in the medical

Table 1. Agenda and schedule for each 3-hour training session in clinical decision software for a group of physicians in Vietnam

	Time (minutes)
Registration	10
Pretest	30
Software installation	30
Study intervention:	
- Software training video	20
- Scripted case discussions	60
Posttest	30
Total time	180

management of simulated cases (in English and Vietnamese). A Vietnamese translator was used at all of the sessions.

Methods and measurements

Two 15-question, multiple-choice exams (Tests A and B) were initially created, revised, and translated into Vietnamese. Both exams were mapped similarly to include questions about diagnosis, treatment, equipment sizing, and medication doses for common pediatric advanced life support scenarios, such as sepsis, seizures, and trauma. To access for face validity, these exams were used at pilot training events held at 5 hospitals (Ben Tre Hospital, Hue School of Medicine and Pharmacy, Ho Chi Min City Children's Hospital #1, National Hospital of Pediatrics, and Thai Binh Hospital) in October 2011. The final version of the tests used for this study incorporated participants' test performance and feedback.

A sample question is as follows:

An 8-year-old boy is brought to the hospital after a bee sting to the face. The child is poorly responsive. He has pale skin with hives, rapid breathing, and audible wheezing. The HR is 180/min, BP cannot be obtained, RR 75/min, T 37, SaO2 80%. After opening the airway and giving 100% oxygen, you cannot start an IV. What is the next step?

a. Albuterol by nebulizer
b. Dopamine 30 microgram/kg IM
c. Epinephrine 0.26 mg IM
d. Intubation
e. Normal saline orally

At the beginning of the training session, each participant was assigned a unique, sequential identification number and given a brief survey about demographic and self-reported proficiencies in English and computers. This identification number was used, instead of the participant name, to maintain anonymity, when distributing the pretests and posttests. Participants with an odd-numbered identifier received Test A, while those with an even-numbered identifier received Test B as a pretest. Based on the alternating test assignments, no participant was seated next to another participant with the same test to minimize sharing information.

The pretests were "open-book" such that the participants were allowed to use any written or electronic reference materials to answer the clinical questions. After the 80-minute educational study intervention using a crossed design, participants were then given the other exam as a posttest at the conclusion of the training session. All of the participants navigated PEMSoft on their personal laptop to answer questions in the posttest.

The same two KidsCareEverywhere interns distributed and collected the exams during each 3-hour training event. Training sessions were standardized and scripted for all testing sites to minimize instructor variability. The interns subsequently entered each participant's demographic information, survey data, and exam scores into a private Google Docs database document, which was de-identified and converted into a spreadsheet in Microsoft Excel (Version 14.2.4 for Macintosh, Redmond, WA, USA). We performed analysis natively in Excel and via StatPlus:Mac (AnalystSoft, Inc., Version 2009, Alexandria, VA, USA).

Outcomes

The primary outcome measure was defined a priori as the mean percentage difference in individual physician scores between the pretest and posttest. Secondary outcome measures included the mean percentage change in scores in relation to physician comfort level with written English, spoken English, and computer use.

Analysis

For the primary outcome, we calculated the mean percentage difference and 95% confidence interval in individual physician scores between pretest and posttest using a paired, two-tailed t-test, with an alpha of 0.05 and a power of 80%. We calculated subgroup analyses using the same method to determine if the following predictor variables impacted the participants' change in test scores: participant practice setting, number of years in practice, and 5-point Likert scale comfort levels with written English and proficiency with computers. We considered subjects, who scored 11 or higher (out of a maximum of 15) on the pretest, to meet a satisfactory pretest knowledge threshold and excluded them from posttest improvement analysis.

RESULTS

A total of 234 participants from 11 hospitals were initially enrolled into the study. Three participants were excluded because they were medical students, and 23 were excluded because they did not submit either a pretest or posttest. Five participants met the predetermined pretest knowledge threshold and were also excluded from subsequent analysis, yielding 203 subjects for analysis. Of these, Tests A and B were used as the pretest for 102 and 101 subjects, respectively. Furthermore, 41% of the participants were male and 66% practiced in an urban location. The median age was 33 years (interquartile range 27-42 years) and the median number of years of clinical experience was 5.5 years (interquartile range 2-14 years). The participants' self-reported comfort level with written English, verbal English, and computer proficiency on a 5-point Likert scale were 3.0 (95% CI: 2.8-3.1), 2.6 (95% CI: 2.5-2.7), and 3.5 (95% CI: 3.4-3.7), respectively, where a score of 1 represented "very uncomfortable" and 5 represented "very comfortable."

Figure 1 shows a histogram of absolute change in scores from pretest to posttest. The mean pretest and posttest percentage scores were 37% (95% CI: 35-38%) and 70% (95% CI: 68-72%), respectively, with $p<0.0001$. The mean percentage change in scores from pretest to posttest was 33% (95% CI: 30-36%), which represents an 89% performance improvement over baseline.

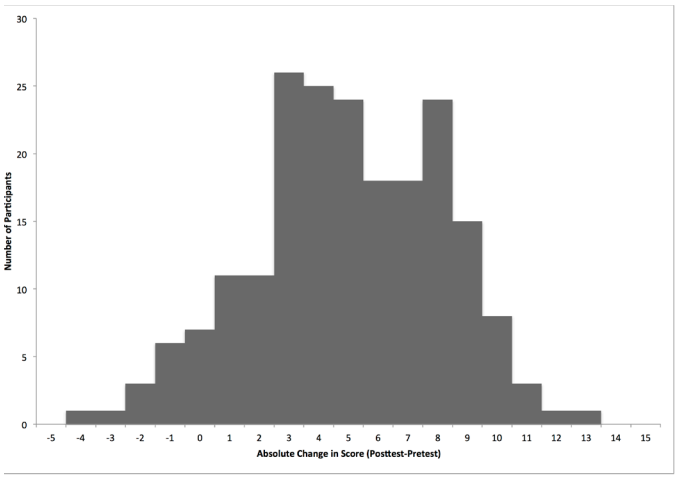

Figure 1. Histogram showing the distribution and number of participants as a function of absolute change in test scores (posttest minus pretest)

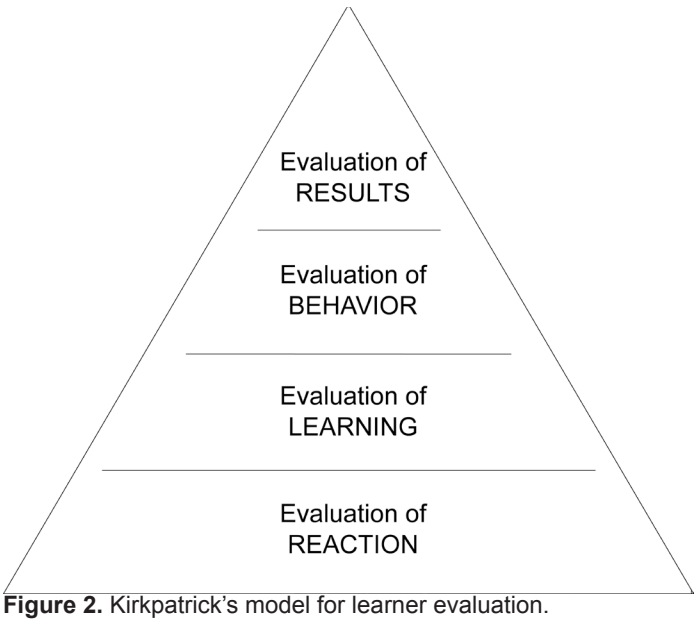

Figure 2. Kirkpatrick's model for learner evaluation.

Subgroup analyses of the mean score percentage changes based on physician practice setting, years of clinical experience, and comfort levels with written English and computer proficiency showed that all subgroups equivalently improved their test scores (data not shown). We noted a trend towards higher pretest and posttest scores for those physicians in urban practices compared to rural practices, although both groups had similar improvements in scores. Also, we noted a trend towards a higher pretest score for physicians who reported that they were "very comfortable" with written English, but their posttest scores were similar to the other physicians, resulting in a lower mean score improvement.

DISCUSSION

To our knowledge, this is the first study demonstrating improved performance on clinical test scores by Vietnamese physicians using an English-based CDS program. The subjects scored significantly higher on their posttest than their pretest across all 11 hospital study sites, despite knowing English only as a second language. Subgroup analyses demonstrated that participants universally performed better on the posttest using the CDS program, regardless of practice setting, years of clinical experience, and self-reported comfort levels with written English and computer proficiency. These encouraging results suggest that CDS technologies, such as PEMSoft, may be broadly impactful in other resource-poor countries, independent of these variables.

We did note, however, that both the pretest and posttest scores for rural physicians were slightly lower than those for urban physicians. We hypothesize that this phenomenon was related to a lesser degree of familiarity with medical English comprehension, based on the observations of the study interns. To reduce such obstacles, key parts of the software could be translated into Vietnamese. Our results may actually significantly underestimate the potential impact of CDS technologies, because the content is written in English.

There were several strengths in our study. First, the study was prospective in design and therefore limited the biases inherent in retrospective studies. Second, the analysis has significant statistical power, because it employed a multicenter approach, yielding a large sample size of 203 physician participants. Third, the test questions were revised and improved for clarity following pilot training sessions at 5 hospitals in the month preceding the study period. Fourth, the pretest-posttest design controlled for bias and possible differences in difficulty between the two tests. Fifth, instructor bias was minimized because each of the software training sessions was standardized, using training videos and scripted lectures, and given by the same paired team of study interns. Last, all written instructional materials – which included the registration, pretest, posttest, and training documents – were presented in both English and Vietnamese. Providing instructions in Vietnamese optimized participant comprehension on how to access and use the English-only software content.

Our encouraging study results show that CDS technologies may be a feasible solution for improved access to current medical knowledge in Vietnam, specifically for acute and emergent pediatric conditions. Future research efforts should focus on validation of the test instrument, assessment of patient outcomes using CDS technologies, and more objective assessment of the impact of English proficiency. If English language proficiency is found to be a major obstacle in knowledge acquisition, priorities might focus on translating PEMSoft into the country's native language.

The ultimate goal, a daunting challenge, will be to assess the impact of CDS on actual patient outcomes in Vietnam. Kirkpatrick's model for learner evaluation suggests a roadmap (Figure 2). The first step in this model requires studying the

learners' reactions to the current training tool. This was initially evaluated in 2010, based on a survey conducted at Danang Hospital, Vietnam, after a pilot software training session by KidsCareEverywhere. Learners universally scored the CDS program highly on all features – including software speed, ease of navigation, medical accuracy, image resolution, value, and quality. The second step includes objective assessment of the learners' ability to improve their medical knowledge, which was accomplished in this study. The third level in the Kirkpatrick pyramid scheme involves evaluation of physician behavior in the use of CDS at the point-of-care. This evaluation could involve assessing whether the learned knowledge translates into measurable behaviors. Indirectly, one could measure frequency of provider usage of the CDS program in the clinical area to assess acceptability, feasibility and sustainability. During the study, the interns noted that desktop computers were available in hospitals, but they were either used for clerical work or located away from the clinical area, such as in libraries. Thus to enhance CDS use, the software might be converted into a web-based or native mobile application for use on smartphone devices, which are widely used by physicians in Vietnam (Dr. Tam Bui, personal communication, August 6, 2012). The fourth Kirkpatrick level would evaluate the impact of CDS on objective patient care indicators.[17,18]

Although multiple studies have already evaluated the advantages of CDS systems in developed countries on each of the first 3 Kirkpatrick tiers, studies assessing the fourth tier of patient outcomes show that actual patient outcomes may or may not be improved by CDS technologies. [13,14] One theory might be that healthcare facilities in developed countries have redundancies and resources in place to maintain a high quality standard of patient care, independent of CDS systems. In resource-poor countries, however, fewer safety nets exist and standards of patient care are often lower. Poor patient outcomes may actually be linked to access to evidence-based health information and practice guidelines. These health systems may benefit significantly from a CDS system. Although early studies using CDS tools in developing countries have demonstrated variable results,[16,19] our results suggest that PEMSoft might play an impactful role not only in Vietnam's goal to improve pediatric emergency care but also in HIFA2015's mission for improved universal health information access in developing countries.

LIMITATIONS

There were several limitations in our study. First, we excluded 26 of the initial 234 study participants, because they were either medical students or did not complete both the pretest and posttest exams. It is possible that these participants may have eliminated themselves because of anticipated poor exam scores; these exclusions, if added into the study pool, may have lowered the mean percentage improvement in the cohort. Declaration of anonymity and nondisclosure were included in the study introductions to minimize this possible confounder. Second, although the research project was conceived and designed by the authors (ML, RD), who are PEMSoft contributors, it is possible that their involvement may have introduced bias. For this reason, only the study interns managed the entire training and data collection processes in Vietnam. Third, because participant enrollment in the CDS training sessions was based on convenience sampling, our findings may not be externally valid for the entire Vietnamese physician population. The study participants may have self-selected themselves because of greater familiarity with computer software and English. And lastly, the current study does not distinguish among different CDS tools. PEMSoft was selected for this project, but the external validity of these results for other products is not known.

CONCLUSION

We demonstrated that Vietnamese physicians could successfully navigate and use a computerized CDS tool written in English, as measured by improved performance on a written clinical exam testing knowledge on pediatric emergencies. These preliminary results suggest that CDS technology can improve pediatric emergency care in Vietnam by bringing current medical literature and reference guides to the bedside. CDS systems may offer a highly scalable, sustainable, and potentially transformative tool in pediatric emergency care in resource-poor environments.

ACKNOWLEDGEMENTS

The authors would like to thank those who helped make this project possible: The Board of Directors of KidsCareEverywhere for their input and encouragement, Dr. Tam Chung for translating training materials and documents into Vietnamese, Dr. Phuc Nguyen for translating training videos into Vietnamese, and PEMSoft for donating its decision-support software. This study was partly funded by the UCSF Vietnam Workgroup Grant, Colorado College's Transitions Fellowship, and KidsCareEverywhere. Special thanks to the Vietnam Minister of Health, Dr. Luong Ngoc Khue, and our gracious hosts and ambassadors at the Vietnamese study hospitals: Dr. Tam Bui (Ho Chi Minh City Children's Hospital 1), Dr. Doan Thi Ngoc Diep (Ho Chi Minh City Children's Hospital 2), Dr. Truong Quy Duong (Hoa Binh Hospital), Dr. Thanh Huynh (My Tho Hospital), Dr. Nghia (Dong Nai Hospital), Dr. Phung The Nguyen (Ho Chi Minh City Children's Hospital 1), Dr. Anh Phuong (Hue School of Medicine and Pharmacy), Dr. Quyn Phuong (Nghe An Hospital), Dr. Chinh Thanh (Thai Binh Hospital), Dr. Dinh Quang Tuan (Hue Central Hospital), and Dr. Xuan (Da Nang Hospital).

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

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Emergency Medicine in Guyana: Lessons from Developing the Country's First Degree-conferring Residency Program

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Supervising Section Editor: Christopher N Mills, MD, MPH
Submission history: Submitted June 1, 2012; Revision received December 10, 2012; Accepted March 25, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.3.12714

Introduction: Academic departments of emergency medicine are becoming increasingly involved in assisting with the development of long-term emergency medicine training programs in low and middle-income countries. This article presents our 10-year experience working with local partners to improve emergency medical care education in Guyana.

Methods: The Vanderbilt Department of Emergency Medicine has collaborated with the Georgetown Public Hospital Corporation on the development of Emergency Medicine skills followed by the implementation of an emergency medicine residency training program. Residency development included a needs assessment, proposed curriculum, internal and external partnerships, University of Guyana and Ministry of Health approval, and funding.

Results: In our experience, we have found that our successful program initiation was due in large part to the pre-existing interest of several local partners and followed by long-term involvement within the country. As a newer specialty without significant local expertise, resident educational needs mandated a locally present full time EM trained attending to serve as the program director. Both external and internal funding was required to achieve this goal. Local educational efforts were best supplemented by robust distance learning. The program was developed to conform to local academic standards and to train the residents to the level of consultant physicians. Despite the best preparations, future challenges remain.

Conclusion: While every program has unique challenges, it is likely many of the issues we have faced are generalizable to other settings and will be useful to other programs considering or currently conducting this type of collaborative project. [West J Emerg Med. 2013;14(5):477–481.]

INTRODUCTION

Guyana's residency program in emergency medicine (EM) began in October 2010. It is one of several EM training programs in low and middle-income (LMI) countries developed in collaboration with an international EM partner.[1-3] The Guyana EM residency stands out as the first postgraduate training program in that country to confer a university-accredited degree, putting EM at the forefront of the development of graduate medical education (GME) in Guyana. In this paper, we will discuss the development of this program, review some of the lessons learned, and anticipate some of the challenges ahead that we believe will benefit the growing number of collaborative EM training programs.

GUYANA

Guyana is a former British colony of 751,000 persons bordered by Venezuela, Brazil and Suriname. Guyana is culturally and economically affiliated with the English-speaking Caribbean countries. The main population center is the coastal capital city of Georgetown. A significant minority of the population lives in small villages scattered across vast tracts of jungle and savannah. Major ethnic groups have

East Asian, African and Amerindian backgrounds. Guyana is among the poorer countries of the Americas and health status indicators lag behind most of the surrounding countries.[4,5] Guyana has fewer than 5 physicians per 10,000 population with the majority not residency trained.[6] The country has seen significant emigration , including a disproportionate number of healthcare providers.[7-9] Georgetown Public Hospital Corporation (GPHC) is the national tertiary care teaching hospital while the Ministry of Health (MOH) runs 26 district and regional hospitals.[6] Many hospitals are located in remote regions and some have significant accessibility limitations.

MEDICAL TRAINING IN GUYANA

Medical training follows the United Kingdom (UK) model with a 5-year undergraduate MBBS degree from the University of Guyana (UG) School of Medicine. This is followed by a rotating internship after which a physician may obtain a license and work as a government medical officer (GMO) or in private practice. Guyana and Cuba also sponsor a program allowing Guyanese students to study in Cuba for medical school and internship.[6,7] These graduates have a 5-year service obligation to the Guyanese government, typically including rotations at GPHC followed by 4 years in a regional assignment.

Emigration of Guyanese healthcare professionals is a significant problem and is related to multiple factors. Relative political instability, a weak economy, and the lack of GME opportunities are among the likely contributors.[7-10] A general surgery diploma program was implemented in 2006 in response to the national shortage of surgeons. This 2.5-year training program was developed in collaboration with the Canadian Association of General Surgeons (CAGS).[7,8] While this and other diploma programs in anesthesia and orthopedics have had relative success, the fact that graduates require further training has led the leaders at GPHC and the MOH to call for the development of university-accredited GME within Guyana.[7]

INITIAL COLLABORATION AND RESIDENCY DEVELOPMENT

Faculty from the Vanderbilt Department of EM began the collaboration with GPHC in 2002 motivated by one of the author's (JPR) personal connections from growing up in Guyana. Based on a need for resuscitation training, as identified by GPHC's leadership, early efforts focused on life support courses for physicians and nurses. Within several years this led to the creation of GPHC's Emergency Cardiac Care program, which operates as a sustainable program under local leadership. Vanderbilt EM and the Institute of Health Science Education (IHSE) at GPHC have worked together to develop other short courses to meet specific training needs, including courses in triage, ultrasound, neonatal resuscitation, intimate partner violence, and wound care.

As this educational collaboration matured, GPHC's leadership began to highlight the emerging priority of a GME program in EM as a step toward improving emergency patient care outcomes. Before the EM training program began, physicians working in the ED at GPHC were not residency trained. During 2009 and 2010 Vanderbilt faculty and fellows, in collaboration with GPHC colleagues, developed the residency curriculum. UG approved the 3-year curriculum leading to a Masters in Medicine degree (M.Med) in June 2010, and the first class of residents entered the program in October 2010. Eleven residents are enrolled in the program as of May 2012.

KEY LESSONS LEARNED

Impetus for Program Development Should Come from Local Leadership

The ultimate success of a program that is intended to introduce a new specialty into a healthcare system depends on the readiness of the system to support GME and accept the new program's graduates. Only the local leadership can adequately determine if the resources exist and the time is right for this type of project. While EM has grown into a worldwide specialty, the appropriate place for EM in the hierarchy of developmental priorities should be a local decision.[11] The Guyana MOH became an early supporter of the program. The Ministry's involvement combined with the support of the IHSE became instrumental in securing the buy-in of the GPHC executive leadership. By the curriculum development stage, UG had come on board as a full partner, ultimately accrediting our program to award the M.Med degree and setting a precedent in Guyana for the development of GME as a shared hospital and university responsibility.[6] That our program was developed in response to a request from the leadership of the national teaching hospital and in collaboration with the national university has optimally positioned it to survive and succeed.

Patience is Vital to Program Implementation

Although the idea of an EM residency was first brought up in early meetings between GPHC and Vanderbilt faculty, it was 8 years before the program was launched. Earlier consideration was given to developing a residency program, but it was felt to be premature for several reasons. The relatively short history of interaction between the partners needed to mature in order to foster mutual trust. In addition, Vanderbilt did not have sufficient internal human resources or funding to devote to the task of residency program development. Nevertheless, Vanderbilt and GPHC continued to develop partnerships around smaller projects, and Vanderbilt accumulated expertise working in Guyana. The Vanderbilt Division of International Health itself matured, increasing its faculty and implementing a fellowship program, strengthening Vanderbilt's ability to engage in Guyana for the long term. The long-standing commitment to working

in Guyana was also recognized in our ability to obtain external funding for the program and played a key role in the willingness of GPHC and the MOH to invest funds in staffing for the EM residency. In retrospect, it is clear that patiently allowing the "pieces of the puzzle" to fall in place, while continuing to work together and build relationships, was key to the successful implementation of this program.

The Staffing Plan Is Key to a Successful Program

United States (U.S.)-based programs supporting international EM residencies use a variety of staffing models. One option is to support local EM faculty by providing curriculum components and augment teaching modules with periodic site visits. This approach depends heavily upon having local faculty to manage day-to-day teaching responsibilities.[11] While this model has been used with success by the CAGS-sponsored surgery residency in Guyana, it was determined that this would not be feasible as there were no trained EM physicians in Guyana to serve as teaching faculty.[8]

Another possible model is to use multiple visiting faculty who spend brief periods of time in the host country, providing a regular though intermittent faculty presence. This can be done with physicians from a single sponsoring department or through a consortium.[12] While this model may allow for flexibility of faculty scheduling, ensuring a continuous supply of teaching faculty can be difficult for supporting institutions. Importantly, this model may make it difficult to maintain effective teaching relationships with trainees and achieve credibility within the local institution to drive change. Additionally, this model did not fit with the vision of the IHSE leadership.

In response to the challenge of staffing the program in Guyana without local physicians with formal EM training, it became a priority to place a fully trained emergency physician on site on a full-time basis to serve as the residency director.[11] Administrative leadership of the ED remained the responsibility of GPHC in order to allow the Vanderbilt physician to focus entirely on resident education. The residency director's continuous presence on site, supplemented at times by other visiting educators, created the consistency that was felt to be desirable for the creation of a maximally effective educational environment. This model's strength of fostering local relationship building and gaining a fully developed understanding of local systems may be outweighed in some contexts by the costs associated with finding salary support for an expatriate faculty member.

The Importance of an Effective Distance-Learning Platform

While internet teleconferencing may be a powerful tool in the exchange of educational products between international partners, the technical challenges associated with managing distance learning applications have been more difficult than anticipated. Even with expert support staff on the Vanderbilt side, we have had limited success with regular webcasts of teaching modules. The primary limitation has been the variable availability of adequate bandwidth to support bidirectional transmission of audio, video, and graphic content. We have found that simple solutions have been the most effective, with Skype video conferencing yielding comparable results to more advanced and expensive modalities.

The Importance of Diversified Funding

With the substantial costs associated with faculty coverage, travel, and educational materials it would not have been feasible to undertake this kind of program without external funding. The usual funding sources for academic activities do not routinely grant funds for international GME development. In addition, government-funding sources that focus on international healthcare development tend to focus on infectious diseases or are limited to specific geographic regions.[13] That our program was able to secure sufficient funding from a private foundation was critical to its successful implementation and created enough confidence in our local partners to allow them to make significant contributions as well. Ultimately, private foundations, GPHC, and the MOH have shared the program costs. As the residency program's graduates become its leaders, ongoing costs will progressively become the responsibility of local stakeholders.

The Importance of Adaptation to the Local System of Medical Education

In addition to working with a local university to accredit our program, it became apparent early in the process that it would be critically important to create a curriculum compatible with local and regional medical education systems.[11] A U.S.-style EM curriculum could not be transplanted and expected to be effective, given the British-based Guyanese medical education system. While we used Vanderbilt's residency curriculum as the foundation for the educational content, it was placed in the framework of Guyanese medical education. For example, following local practice, residents must have completed 1 year of internship and 1 year as a GMO before starting the program. Additionally, instead of program graduation leading to "board certification" as in the U.S., our graduates will receive the M.Med degree from UG. While not a specific guarantee of employment, the granting of the degree will make them eligible to apply for consultant positions within the Guyanese healthcare system. Furthermore, the content of the U.S. core curriculum was adapted to the local context. The core knowledge base was kept but additional emphasis on certain geographically relevant topics, such as tropical diseases and rural health, was provided. Procedural requirements were closely matched to the U.S. training standard. Thus, we strived for careful balance between the U.S. curriculum and adaptation to the local educational needs.

The Importance of a Degree Granting Program

When most physicians in the country have no post-graduate education, explaining the value of residency training may become a challenge. As was found with the surgery diploma program, some potential trainees viewed foreign-backed programs with suspicion.[8] Early applicants had concerns about the sustainability of the program that resulted in doubts the program would exist long enough for them to complete their training. Potential applicants were also concerned that the medical system might not recognize their graduating qualifications and that they might not achieve access to improved salaries or professional advancement. These concerns highlight the importance of going beyond the awarding of a diploma to the conferring of the university-accredited M.Med degree.

FUTURE CHALLENGES

Plan the Transition of Leadership

While the Guyana program is still fairly new, we consider it a priority to transition its primary leadership and teaching responsibility to its graduates.[11] The early graduates will be expected to step into leadership roles, so several program features are intended to improve the chances of a successful transition and ensure the sustainability of the program:

- Graduated responsibility in teaching has been implemented, starting with case presentations, followed by informal didactics and finally full lectures. The goal is a transition to teaching the core curriculum locally and using distance education and visiting faculty for more in-depth topics.
- In parallel with core content curriculum components, we have designed a simultaneous educator development program. This program includes modules in team-based learning,[14] lecture preparation, medical simulation, competency-based assessment, and techniques of effective feedback. This program is reinforced by a 1-month education immersion experience at Vanderbilt for Guyanese residents. Education techniques are modeled and practiced under the supervision of experienced teachers, including 3 faculty who are part of Vanderbilt's Master Clinical Teacher program.
- Early delegation of residency office tasks to the residents, such as scheduling, M&M's, journal club, and attendance of hospital committee meetings.

Continue to Develop Regional Collaboration.

While Vanderbilt's support of the residency has been essential, building regional ties is key to long-term viability. Regional collaboration provides potential regional recognition of Guyana's M.Med program and integration in the soon-to-be-established Caribbean College of Emergency Physicians. Just as South Africa can be considered the driver of EM in Africa,[15] the University of the West Indies (UWI) based EM residencies are the drivers of EM in the Caribbean.[16] Two UWI EM residencies were visited and leaders from the UWI St. Augustine campus have participated as guest faculty in Guyana. As a result, the Guyanese program was invited to participate in the monthly UWI webcast grand rounds and resident rotations at UWI are being planned.

Develop a Doctor of Medicine (DM) Degree in EM

Our program confers the M.Med degree and is the first M.Med conferring program in Guyana. The M.Med fits within the vision of the IHSE of a 3-year generalist degree, while a DM would be required for sub-specialists, such as cardiologists or neurosurgeons, and would involve 5 to 7 years of training. In the UWI system, however, the DM degree is the degree awarded to EM graduates and is arguably the current regional standard. As more GME programs are launched in Guyana and seek to achieve regional recognition, it is expected that most will seek a pathway to a DM. We envision adding a subspecialization in pediatric EM as a next step in that direction.

Retention of Graduates

Retention of graduates within Guyana is paramount to the sustainability of the residency and is probably the ultimate challenge for this program. Guyana suffers from a disproportionate emigration of its medical professionals.[7-9] Lack of specialty training in Guyana has been cited as a driver of physician emigration.[7] Approximately 75% of UG medical school graduates reportedly leave for their internship and do not return, but of the 13 graduates of the surgery diploma program, 10 remain in Guyana. Of the 3 surgery graduates who left Guyana, 2 stayed more than 1 year after the completion of their payback time. This early evidence seems to support the assertion that bona fide in-country GME has the potential to stem the brain drain. The EM residents appear committed to remaining in Guyana and there are contractual measures in place to try to reduce the number who may choose to emigrate. Specifically, each resident's training contract with GPHC includes a requirement for 1 year of service after program completion. Our longer-term goal is that residency training will address some of the push issues that promote migration.[10] Residency training alone is viewed as only part of a meaningful solution. Access to professional advancement and enhanced compensation will also be critically important and new consultant positions for residency graduates will need to be created and adequately funded.[17] Other nascent EM programs in developing countries are grappling with this issue and their progress will be closely followed.[15,16]

DISCUSSION

While the establishment of an EM training program in a LMI country requires a unique approach each time, there are some lessons we have learned that may be generally instructive. The most unique feature of the EM residency in Guyana is that it is the first degree-granting GME training program in that country. As such, it is faced with significant challenges even as it realizes unusual rewards. The program continues

to evolve and a published update will be required as leaders developing EM internationally continue to learn from each other's experiences. The argument in favor of EM training in LMI countries has been well articulated. Indeed, half of the top 10 causes of death and half of the top 10 causes of disability-adjusted life years lost in these countries are diseases for which there is evidence for saving lives with early and appropriate intervention.[18,19] Furthermore, where there is limited access to primary care, chronic diseases are often poorly controlled and tend to present emergently in a decompensated state.[19]

While training emergency physicians is likely to improve outcomes of patients who present to the ED, can such a new specialty thrive as the first training program in a country? While internal medicine, surgery, obstetrics, and pediatrics are often thought of as the core specialties of medicine, EM effectively overlaps with each of these specialties and EM graduates can initiate improved protocols for the treatment of many common ailments from acute asthma exacerbations and acute dehydration to directing the management of myocardial infarction and major trauma.

The argument to develop formal GME programs in LMI countries is compelling and offers the opportunity for improved health outcomes and the advancement of all healthcare workers. Indeed, the goal of the EM residency is to lift the quality of all emergency care personnel, including nurses and rural health workers.[20] Academic centers in LMI countries have an opportunity to be regional leaders of the development of EM, and EM may be a logical starting point for the creation of initial GME programs in some locations. Funding sources should begin to prioritize the support of formal GME programs in developing countries as a model of sustainable health education development.

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

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Electronic Prehospital Records are Often Unavailable for Emergency Department Medical Decision Making

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Supervising Section Editor: William Brady, MD
Submission history: Submitted May 19, 2012; Revision received October 4, 2012; Accepted January 15, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.1.12665

Introduction: To determine emergency physician (EP) opinions of prehospital patient care reports (PCRs) and whether such reports are available at the time of emergency department (ED) medical decision-making.

Methods: Prospective, cross-sectional, electronic web-based survey of EPs regarding preferences and availability of prehospital PCRs at the time of ED medical decision-making.

Results: We sent the survey to 1,932 EPs via 4 American College of Emergency Physicians (ACEP) email lists. As a result, 228 (11.8%) of email list members from 31 states and the District of Columbia completed the survey. Most respondents preferred electronic prehospital PCRs as opposed to handwritten prehospital PCRs (52.2% [95% confidence interval (CI): 49.1, 55.3] vs. 17.1% [95%CI: 11.7, 22.5]). The remaining respondents (30.5% [95%CI: 26.0, 35.0]) had no preference or had seen only one type of PCR. Of the respondents, 45.6% [95%CI: 42.1, 48.7] stated PCRs were "very important" while 43.0% [95% CI: 39.3, 46.7] rated PCRs as "important" in their ED practice. Most respondents (79.6% [95%CI: 76.5, 82.7]) reported electronic prehospital PCRs were available ≤50% of the time for medical decision-making while 20.4% [95%CI: 9.2, 31.6] reported that electronic prehospital PCRs were available > 50% of the time (*P*=0.00). A majority of participants (77.6% [95%CI: 74.5, 80.7]) reported that handwritten prehospital PCRs were available ≥ 50% while 22.4% [95%CI: 11.8, 33.0] of the time for medical decision-making (*P*=0.00).

Conclusion: EPs in this study felt that prehospital PCRs were important to their ED practice and preferred electronic prehospital PCRs over handwritten PCRs. However, most electronic prehospital PCRs were unavailable at the time of ED medical decision-making. Although handwritten prehospital PCRs were more readily available, legibility and accuracy were reported concerns. This study suggest that strategies should be devised to improve the overall accuracy of PCRs and assure that electronic prehospital PCRs are delivered to the receiving ED in time for consideration in ED medical decision-making. [West J Emerg Med. 2013;14(5):482–488.]

INTRODUCTION

The prehospital patient care report (PCR) is an essential tool for communicating pertinent prehospital patient and demographic data to hospital-based healthcare providers. The appearance of the patient prior to hospital arrival, and the prehospital treatment provided, can help speed and guide subsequent emergency department (ED) care.[1-2] Because of this, the accuracy and timeliness of the prehospital PCR is important. In trauma, failure of prehospital personnel to document basic measures of scene physiology has been associated with increased mortality.[3]

The prehospital PCR also plays an important role in research, quality improvement, and protocol development.[4] Recently, there have been attempts to link prehospital and hospital datasets to better study the impact of prehospital care on patient morbidity and mortality.[5-6] The need for standardized datasets, uniform and reliable data transmission, integrated information systems, and provision of feedback to prehospital providers was a recommendation in the *Emergency*

Table 1. Respondents by state.

State	Number	Percentage
Arkansas	1	0.4%
Alabama	1	0.4%
Arizona	74	32.5%
California	4	1.7%
Colorado	4	1.7%
District of Columbia	1	0.4%
Florida	4	1.7%
Georgia	1	0.4%
Illinois	5	2.2%
Indiana	1	0.4%
Massachusetts	6	2.6%
Maryland	3	1.3%
Maine	1	0.4%
Michigan	2	0.9%
Minnesota	3	1.3%
Montana	1	0.4%
North Carolina	1	0.4%
New Hampshire	1	0.4%
New Jersey	7	3.1%
Nevada	26	11.4%
New York	5	2.2%
Ohio	6	2.6%
Oklahoma	1	0.4%
Oregon	1	0.4%
Pennsylvania	10	4.4%
South Carolina	2	0.9%
Texas	5	2.2%
Utah	35	15.4%
Virginia	4	1.7%
Wisconsin	3	1.3%
West Virginia	1	0.4%
Wyoming	1	0.4%
Not available	7	3.1%
Total	228	99.4%

Medical Services Agenda for the Future.[7] With the advent of electronic prehospital PCRs, many of the goals stated in this document are now possible.[8] Electronic prehospital PCRs are now widely available and commonly used in many emergency medical services (EMS) systems. Despite this change, there are still barriers to timely and accurate information delivery.[9] Most modern electronic prehospital PCR systems use an internet-based network and/or telefacsimile (FAX) transmission to deliver the prehospital information to the receiving facility.

A recent transition from handwritten prehospital PCRs to electronic prehospital PCRs was completed in the Las Vegas, Nevada EMS system. Following that change, it was observed that the electronic prehospital PCR was less frequently available for ED medical decision-making when compared to the availability of the older handwritten PCRs. Because of this observation we sought to survey emergency physicians (EP) in regard to their opinion of PCRs and the timeliness of data delivery to other hospital EDs.

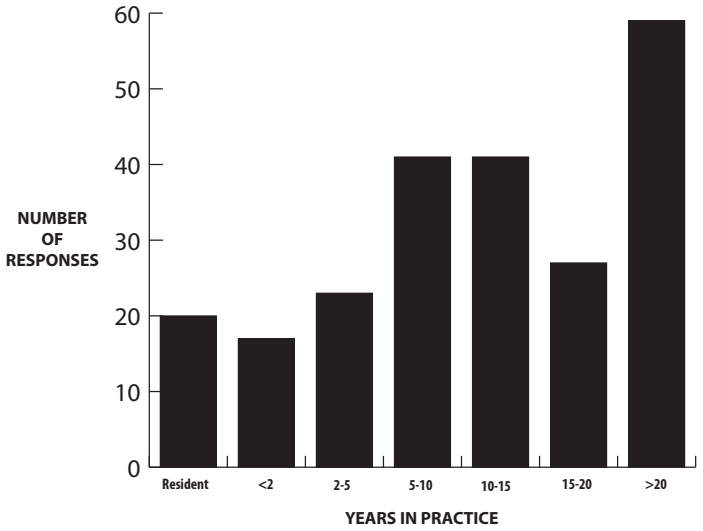

Figure 1. Physician experience by years in practice.

METHODS

We conducted a cross-sectional, prospective, electronic web-based survey (SurveyMonkey; Palo Alto, California) of EPs regarding prehospital PCRs. We established the protocol and developed a 23-question survey instrument. The Institutional Review Board (IRB) of University Medical Center of Southern Nevada in Las Vegas, Nevada reviewed the protocol and granted exempt status.

The survey instrument was developed for EPs and contained 2 sections. The first section (12 questions) surveyed physician opinions regarding both electronic and handwritten PCRs. Of these 12 questions, 4 surveyed physician opinions of perceived benefits and limitations of PCRs based upon experience at our institution (University Medical Center of Southern Nevada; Las Vegas, Nevada). The remaining 11 questions surveyed physician demographics (state of residence, board certification, certifying board, years in practice, age range, practice setting, annual ED volume, gender, computer preference, type of ED recordkeeping). These questions were vetted by the researchers and uploaded to the SurveyMonkey system.

On April 12, 2012, a request to complete the survey was sent to the email lists of 3 state chapters (Arizona, Nevada, and Utah) and the email list of the EMS section of the American College of Emergency Physicians (ACEP). The study was limited to physicians. The email contained a brief overview of the study and a URL link to the survey document. Data

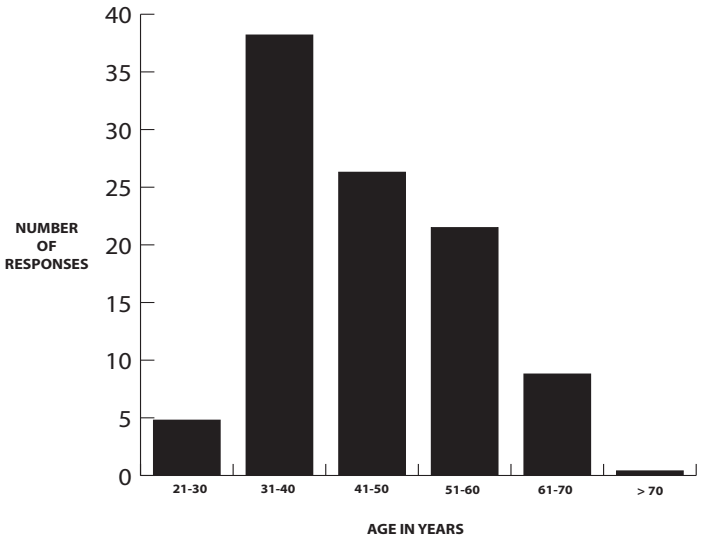

Figure 2. Age range of physicians surveyed.

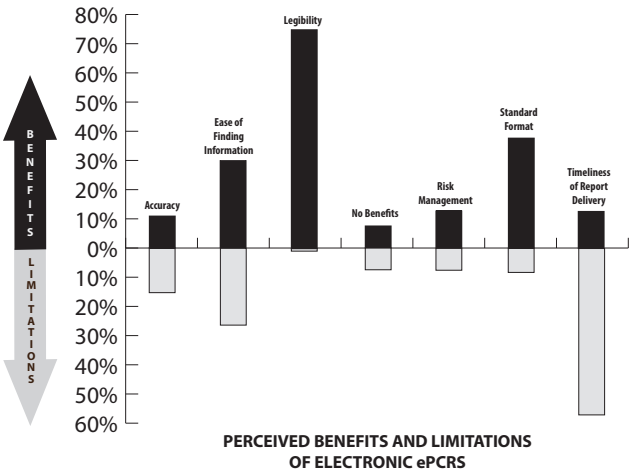

Figure 3. Respondents' report of perceived benefits and limitations of electronic patient care reports.

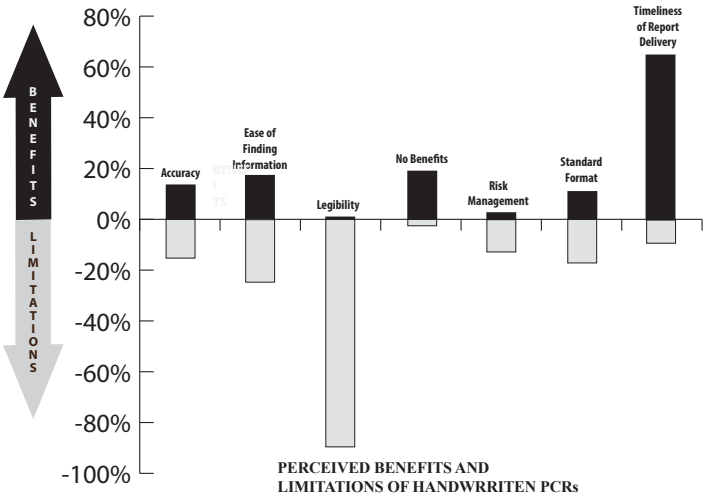

Figure 4. Respondents' report of perceived benefits and limitations of handwritten patient care reports.

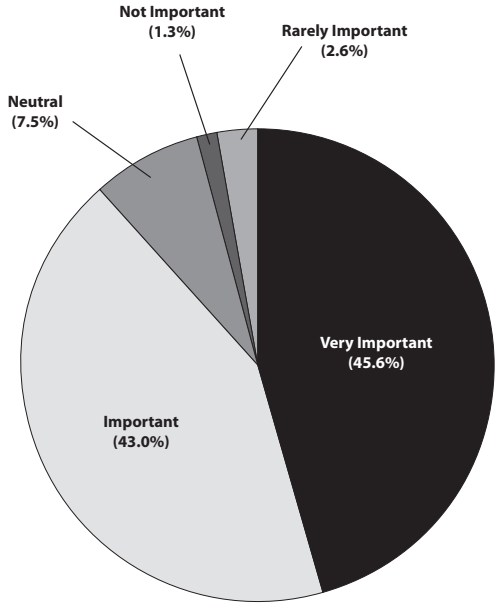

Figure 5. Respondents' opinion of the importance of prehospital patient care reports to their practice.

collection continued for 1 month. Following the study period we gathered and analyzed the data using the worksheet and statistical functions of Microsoft Excel for Mac 2011 (Microsoft Corporation; Redmond, Washington). We determined significance between groups using Fisher's exact test.

RESULTS

We sent the survey to 1,932 EPs via the 4 email lists. Two hundred twenty-eight self-identified EPs responded to the survey. The overall survey return rate, based upon the number of physicians on the 4 email lists, was 11.8%. Every respondent who returned the survey completed all of the core (PCR) questions (although 5 failed to list their state of residence).

Cohort Demographics

Of the 228 respondents, 173 (75.9%) were male and 55 (24.1%) were female. The respondents were from 31 states and the District of Columbia (Table 1). Respondents described their practice location as urban (61.8%), suburban (27.6%), rural (9.6%), or frontier (0.9%). Most of the respondents (88.6%) were board certified with most (97% of those board certified) reporting board certification in emergency medicine. Physician experience (years in practice) is detailed in Figure 1. Physician age range is detailed in Figure 2. Respondents listed their computer preference as Apple/Mac (43.4% [95% confidence interval (CI): 39.7, 47.1]), Windows/PC (38.6%; 95%CI: 34.6, 42.6), or no preference (18% [95% CI: 12.6, 23.4]).

PCR Responses

In this study, 186 (81.6%) respondents reported encountering electronic prehospital PCRs in the course of their practice while 42 (18.4%) respondents had not. Two hundred

Table 2. Survey responses regarding prehospital patient care records

Number	Question	Response rate	Responses	Respondents
1	Do you encounter electronic EMS patient care reports in the course of your emergency medicine practice?	228 (100%)	Yes	186 (81.6%)
			No	42 (18.4%)
2	Do you encounter handwritten EMS patient care reports in the course of your emergency medicine practice?	228 (100%)	Yes	200 (87.7%)
			No	28 (12.3%)
3	Which type of EMS patient care report do you prefer?	228 (100%)	Electronic	119 (52.2%)
			Handwritten	39 (17.1%)
			Only one type encountered	35 (15.4%)
			No Preference	35 (15.4%)
4	What benefits do you derive from electronic EMS patient care reports?	228 (100%)	Accuracy	25 (11.0%)
			Ease of finding information	68 (29.8%)
			I don't see ePCRs	37 (16.2%)
			Legibility	171 (75.0%)
			No benefits	17 (7.5%)
			Risk management	29 (12.7%)
			Standard format	86 (27.7%)
			Timeliness of report delivery	29 (12.7%)
			Other	7 (3.1%)
5	What benefits do you derive from handwritten EMS patient care reports?	228 (100%)	Accuracy	31 (13.6%)
			Ease of finding information	39 (17.1%)
			I don't see hPCRs	15 (6.6%)
			Legibility	2 (0.9%)
			No benefits	43 (18.9%)
			Risk management	6 (2.6%)
			Standard format	25 (11.0%)
			Timeliness of report delivery	148 (64.9%)
			Other	24 (10.5%)
6	What limitations do you see or dislikes do you have in regard to electronic EMS patient care reports?	228 (100%)	Accuracy	35 (15.4%)
			Ease of finding information	60 (26.3%)
			I don't see ePCRs	34 (14.9%)
			Legibility	2 (0.9%)
			No benefits	17 (7.5%)
			Risk management	17 (7.5%)
			Standard format	19 (8.3%)
			Timeliness of report delivery	130 (57.0%)
			Other	49 (21.5%)
7	What limitations do you see or dislikes do you have in regard to handwritten EMS patient care reports?	228 (100%)	Accuracy	35 (15.4%)
			Ease of finding information	56 (24.6%)
			I don't see hPCRs	11 (4.8%)
			Legibility	204 (59.5%)
			No benefits	6 (2.6%)
			Risk management	29 (12.7%)
			Standard format	39 (17.1%)
			Timeliness of report delivery	21 (9.2%)
			Other	12 (5.3%)

EMS, emergency medical services; *ePCR,* electronic patient care report; *hPCR*, handwritten patient care report

Table 2. Continued

Number	Question	Response rate	Responses	Respondents
8	How important is the information in the prehospital patient care report to your practice as an emergency physician in caring for patients transported by EMS?	228 (100%)	Very important	105 (45.6%)
			Important	98 (43.0%)
			Neutral	17 (7.5%)
			Not important	3 (1.3%)
			Rarely important	6 (2.6%)
9	How frequently is the electronic prehospital patient care record available when emergency department (ED) medical decision-making occurs in your practice?	228 (100%)	100% of the time	6 (2.6%)
			75% of the time	34 (14.9%)
			50% of the time	51 (22.4%)
			25% of the time	69 (30.3%)
			0% of the time	36 (15.8%)
			Not applicable	32 (14.0%
10	How frequently is the handwritten prehospital patient care record available when ED medical decision-making occurs in your practice?	228 (100%)	100% of the time	34 (14.9%)
			75% of the time	83 (38.4%)
			50% of the time	42 (18.4%)
			25% of the time	36 (15.8%)
			0% of the time	10 (4.4%)
			Not applicable	23 (10.1%)
11	Do you feel that electronic EMS reports increase your medico-legal risk?	228 (100%)	Yes	50 (21.9%)
			No	83 (40.8%)
			Neutral	85 (37.3%)
12	Do you feel that handwritten EMS reports increase your medico-legal risk?	228 (100%)	Yes	52 (22.8%)
			No	101 (44.3%)
			Neutral	75 (32.9%)

EMS, emergency medical services; *ePCR,* electronic patient care report; *hPCR*, handwritten patient care report

(87.7%) respondents reported encountering handwritten prehospital PCRs in the course of their practice while 28 (12.3%) had not (See Table 2). Respondents preferred electronic prehospital PCRs to handwritten prehospital PCRs (52.2% [95% CI: 49.1, 55.3] vs. 17.1% [95% CI: 11.7, 22.5]). Some respondents (15.4% [95% CI: 9.9, 20.9]) had only encountered one type of prehospital PCR while others (15.4% [95% CI: 9.9, 20.9]) had no preference for electronic or handwritten PCRs.

The respondents were also surveyed in regard to the perceived benefits and limitations of electronic prehospital PCRs (Figure 3). The perceived limitations of handwritten prehospital PCRs are detailed in Figure 4. Of the respondents, 104 (45.6% [95%CI: 42.1, 48.7]) stated prehospital PCRs were "very important," while 98 (43.0% [95% CI: 39.3, 46.7]) respondents stated they were "important" in their practice. Twenty-six (11.4% [95%CI: 6.1, 16.7]) respondents stated prehospital PCRs were "not important," "rarely important," or were "neutral" in regard to the importance of PCRs in their practice (Figure 5). For 156 (79.6% [95%CI: 76.5, 82.7]) respondents, electronic prehospital PCRs were available ≤50% of the time for medical decision-making while 40 (20.4% [95%CI: 9.2, 31.6]) reported that electronic prehospital PCRs were available >50% of the time (P=0.00). A total of 169 (77.6% [95%CI: 74.5, 80.7]) respondents reported handwritten prehospital PCRs were available ≥50% of the time for medical decision-making while 45 (22.4% [95%CI: 11.8, 33.0]) were available <50% of the time (P=0.00) (Figure 4).

DISCUSSION

The demographics of our cohort, while primarily from western states, were similar to those of EPs in general in terms of gender, age, and years in practice.[10] While prehospital PCRs are important to ED practice, problems with both types of PCRs (electronic and handwritten) were commonly reported in this survey. While handwritten prehospital PCRs were more frequently available for medical decision-making, respondents found legibility, accuracy, and ease of finding desired information problematic in this format. Most respondents preferred electronic prehospital PCRs because of legibility, standardized format, and ease of finding desired information. However electronic prehospital PCRs were often unavailable at the time of ED medical decision-making. Accuracy of prehospital data was a perceived problem in both report types.[11]

The communication of patient care data from the prehospital to hospital setting typically occurs in 3 steps:

1. Pre-arrival data (via radio or telephone), 2. Arrival data (handoff) at the time of patient arrival, and 3. Post-arrival delivery of summary medical and demographic data (either electronic or handwritten).[12] Typically, pre-arrival data is limited.[13] Most initial prehospital care information is obtained during the handoff of the patient from the EMS crew to the hospital staff. Studies have shown that much of the data transmitted at this point is not heard or remembered by physicians.[14-16] Thus, when final medical decision-making occurs in the ED, the emergency physician often relies on the final prehospital PCR in addition to pre-arrival and arrival data.

The transition to electronic prehospital PCRs has allowed better integration of prehospital and hospital data.[17-18] However, with this transition, additional technology is necessary to generate a report for the hospital (printers, internet interface, security framework). Presently, these technologies appear to be inadequate in delivering an accurate and legible report to receiving EDs in time for ED medical decision-making. Failure to provide essential prehospital patient care data to the treating ED staff can potentially adversely impact patient care. Strategies need to be devised to assure a more timely, if not contemporaneous, delivery of prehospital PCRs in time for ED medical decision-making. While such strategies are being developed, the present electronic prehospital PCR delivery system falls short of this goal.[19]

LIMITATIONS

There are numerous limitations to this study. First, cross-sectional surveys are subject to both sampling and non-sampling errors. Non-sampling errors include coverage errors, content and reporting errors, and non-reporting errors. There is the possibility of coverage error in this survey as most respondents were from western states (Arizona, Nevada, Utah). In addition, most respondents were from urban areas. Thus, findings from this survey may not have applicability to other geographic areas. The response rate was relatively low based upon the total number of email list members. It was impossible to determine exactly how many list members actually received the survey. There is also the possibility that some non-target subjects (e.g., non-physicians) completed the survey. While steps were taken to avoid this (e.g. questions about board certification and practice type), there is no way to assure that violations did not occur. Finally, the voluntary nature of surveys will result in some non-reporting from those with no interest in the survey topic. Likewise, this format may also foster a bias in those respondents with an interest or strong feelings regarding the nature of the survey questions. Thus, the information gained from this study may or may not be applicable to all EMS systems.

CONCLUSION

In this study, the surveyed EPs felt that PCRs are important to their ED practice and preferred electronic prehospital PCRs over handwritten PCRs. However, most electronic prehospital PCRs were unavailable at the time of ED medical decision-making. Although handwritten prehospital PCRs were more readily available, legibility and accuracy were reported concerns. This investigation suggests that strategies need to be devised to improve the overall accuracy of PCRs and assure that electronic prehospital PCRs are delivered to the receiving ED in time for consideration in ED medical decision-making.

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

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Reducing Ambulance Diversion at Hospital and Regional Levels: Systemic Review of Insights from Simulation Models

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Supervising Section Editor: David E Slattery, MD
Submission history: Submitted June 11, 2012; Revision received December 22, 2012; Accepted March 25, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.3.12788

Introduction: Optimal solutions for reducing diversion without worsening emergency department (ED) crowding are unclear. We performed a systematic review of published simulation studies to identify: 1) the tradeoff between ambulance diversion and ED wait times; 2) the predicted impact of patient flow interventions on reducing diversion; and 3) the optimal regional strategy for reducing diversion.

Methods: Data Sources: Systematic review of articles using MEDLINE, Inspec, Scopus. Additional studies identified through bibliography review, Google Scholar, and scientific conference proceedings. Study Selection: Only simulations modeling ambulance diversion as a result of ED crowding or inpatient capacity problems were included. Data extraction: Independent extraction by two authors using predefined data fields.

Results: We identified 5,116 potentially relevant records; 10 studies met inclusion criteria. In models that quantified the relationship between ED throughput times and diversion, diversion was found to only minimally improve ED waiting room times. Adding holding units for inpatient boarders and ED-based fast tracks, improving lab turnaround times, and smoothing elective surgery caseloads were found to reduce diversion considerably. While two models found a cooperative agreement between hospitals is necessary to prevent defensive diversion behavior by a hospital when a nearby hospital goes on diversion, one model found there may be more optimal solutions for reducing region wide wait times than a regional ban on diversion.

Conclusion: Smoothing elective surgery caseloads, adding ED fast tracks as well as holding units for inpatient boarders, improving ED lab turnaround times, and implementing regional cooperative agreements among hospitals are promising avenues for reducing diversion. [West J Emerg Med. 2013;14(5):489–498.]

INTRODUCTION

When emergency departments (ED) become crowded, incoming ambulances are sometimes diverted to other hospitals in an attempt to mitigate crowding. In 2003 45% of United States EDs reported being "on diversion" at some point within the year.[1] Ambulance diversion has been used since the early 1990s.[2,3] It has been linked to several negative consequences, such as prolonged transport times, delays in care, increased mortality, and lower hospital revenue.[4-12] In response, several efforts have been enacted to reduce ambulation diversion.[12-14] For hospitals, strategies to reduce diversion include implementing ED and hospital patient-flow

improvements aimed at reducing ED crowding,[15] the primary cause of ambulance diversion.[16,17] These improvements include optimizing front end operations, such as patient triage, registration, and tracking.[18] Additional improvement maneuvers include adopting hospital-wide full capacity protocols to expedite the transfer of admitted patients from the ED to inpatient units.[19] At the regional level, strategies include policies to limit the time EDs are allowed to go on diversion[13] and statewide bans on diversion, such as the one implemented in Massachusetts in 2009.[20]

Despite efforts to prevent hospitals from diverting ambulances or preventing crowding altogether, questions remain about how to best reduce diversion without increasing ED crowding and how best to coordinate regional efforts to reduce diversion.[21] Observational data analyses are useful in quantifying the association between ED crowding measures, such as ED patient length of stay or ED occupancy. However, these models are not well equipped to test the impact of multiple strategies to improve ED throughput and increase the ability to receive incoming ambulances.[22] Simulation models, typically employed by industrial engineers and operations researchers, are better suited for testing multiple strategies and understanding the interplay – at least theoretically – in a system with multiple moving parts. In particular, these models can simulate the dynamic and interdependent relationships between hospital inpatient flow, ED flow, and ambulance diversion.[22] A joint report by the Institute of Medicine and National Academy Engineering in 2005 highlighted the knowledge/awareness divide separating healthcare providers from operations researchers. The report states that bridging this gap is key to improving the quality and efficiency of health care.[23] Because simulation models are most often published in engineering journals, the useful knowledge gained may not be reaching the ED medical community.

The goal of this investigation was to perform a systematic review of published simulation model studies that: 1) quantify the tradeoff between ambulance diversion and ED throughput and wait times; 2) identify the predicted impact of patient flow interventions on reducing diversion; and 3) determine the optimal regional strategy for reducing diversion. Our overall goal was to use the results from multiple studies to provide insight in how to optimally reduce ambulance diversion at the hospital and regional level as well as to identify concomitant strategies that reduce the likelihood of increasing ED crowding.

METHODS

We conducted our systematic review and report our methods and results according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[24]

Study Eligibility Criteria

We used an *a priori* defined protocol to search the medical, engineering, and operations research literature for studies using simulation modeling techniques to study ambulance diversion in relation to ED crowding and/or inpatient capacity problems published from 1966-2012. We defined simulation as the development of a mathematical or logical model of a system and the experimental manipulation of the model on a computer, based on the definition of Pritsker.[25] The description of these methods to study ED crowding has been previously described in the literature.[22] In brief, queuing theory is the formal mathematical study of waiting. Discrete event simulation is used to analyze complex queuing systems that cannot be analyzed algebraically. Discrete event simulation assesses the consequences of multiple individual (i.e. discrete) events occurring over time.

We only included simulation models in which ambulance diversion was a consequence, cause, or method of alleviating ED crowding, or models in which ambulance diversion was a result of upstream causes of ED crowding related to patient flow in the hospital. Hospital flow issues could include such cases as decreased inpatient capacity to accept admitted patients form the ED. Finally, we only included models that have been published either in peer-reviewed journals or in peer-reviewed conference proceedings.

Information Sources

We identified studies by searching electronic databases and scanning reference lists of articles. We applied the search to Medline (1966-Present) and adapted for Inspec, accessed via Web of Knowledge, and Scopus. We used Google Scholar to search for any additional studies that have cited, or were similar, to each of the studies identified through our primary database searches. The search was last updated on February 28, 2012. We also searched the table of contents and abstracts of the Winter Simulation Conference, the Institute for Operations Research and Management Sciences (INFORMS) journals and conference proceedings, as these are important venues for the peer-reviewed publication of simulation models. We also searched the table of contents of the conference proceedings of the Society for Academic Emergency Medicine and the American College of Emergency Physicians.

Search

We recognized from the outset that ambulance diversion is one of the many consequences of ED and hospital crowding. Therefore, we devised our search strategy to identify all simulation studies of ED crowding, as well as simulation studies of hospital patient flow that include the ED in order to maximize our chances of identifying studies that investigate ambulance diversion. We present the full search strings for each of the databases (including Medical Subject Headings [MeSH] terms for Medline) in the Appendix.

Study Selection

One author (MKD) performed the database searches, exported the citations into Endnote X5 (Thomson Reuters,

Table 1. Overview of study designs.

Author, Year	Objective	Setting
Chockalingam, 2010	Develop a diversion control policy that optimizes patient care and revenue	Community hospital
Hagtvedt, 2009	Uncover methods by which hospitals in a metro area may cooperate to reduce diversion	Multiple hospitals in a metropolitan area
Kolb, 2008	Explore effect of proposed crowding solutions in isolation and combination on ED triage-to-bed times and ambulance diversion	Suburban, community hospital; 36 bed ED
Kolker, 2008	Identify maximum ED LOS limits that will result in significant reduction in or elimination of diversion; Identify max number of patients in waiting room that should not be exceeded in order to keep ED diversion <3%	Tertiary care hospital with 450 inpatient beds and 30 bed ED
Kolker, 2009	Determine maximum number of elective surgeries scheduled per day (surgical schedule smoothing) to reduce or even eliminate ED ambulance diversion due to a lack of ICU beds.	Tertiary care hospital with 450 inpatient beds and 30 bed ED
Nafarrate, 2010	Development of a simulation model for ED to study the impact of ambulance diversion policies based on (1) number of patients waiting (2) number of patients boarding and (3) number of inpatient beds available	Community hospital with 20 ED beds and 78 inpatient beds
Nafarrate, 2011	For multiple hospitals in an urban area, determine optimum combination of ambulance diversion policies ((1) no diversion; (2) diversion when ED occupancy >100%; (3) optimized diversion based on flexible thresholds and ambulance destination policies (1) nearest hospital; (2) least crowded hospital).	3 medium sized community hospitals in an urban area with average characteristics of U.S. EDs based on NHAMCS
Pines, 2011	Quantify the revenue effect of reducing ED boarding and ambulance diversion via various inpatient bed management policies	Urban, tertiary care hospital with 118,000 ED visits (22% admission rate) and 36,000 non-ED admissions
Ramirez, 2009	Analyze effect of various ambulance diversion thresholds on ED operations and LWBS rates	Community hospital with 40 ED beds
Storrow, 2008	Evaluate effect of decreasing lab turnaround time on ambulance diversion episodes, ED throughput and ED length of stay	Tertiary care hospital with 55,000 ED visits/year

LOS, length of stay; *ICU*, intensive care unit; *LWBS*, left without being seen; *NHAMCS*, National Hospital Ambulatory Medical Care Survey

Table 2. Studies quantifying the tradeoff between ambulance diversion and emergency department (ED) throughput/wait times.

Author, Year	Tradeoff	Implications
Kolker, 2008	Diversion reduced to <3% if: If achieve max ED LOS for both discharged and admitted patients <5 hours: If achieve max ED LOS for discharged patients <5 hours for discharges and <10 hours for admits; If achieve max ED LOS for discharged patients <6 hours for discharges and <6 hours for admits; If waiting room queue kept to <11 patients	Provides flexible throughput targets to reduce need for ambulance diversion.
Nafarrate, 2010	Ambulance diversion policies based on: number of patients in waiting room or number of patients boarding offer best balance of between accessibility of care and waiting time compared with policies based on number of inpatient beds available. For every percentage point increase in diversion status, average waiting time reduced by 2 minutes (based on number of patients in waiting room or patients boarding); If diversion based on number of inpatient beds, for every percentage point increase in diversion status, average waiting time only reduced by 0.5 minutes	Although effect on alleviating ED crowding is very small, the decision to go on diversion should only be made when the ED is at full capacity and there are significant number or patients in the waiting room or patients boarding for inpatient beds
Pines, 2011	1-hour reduction in mean boarding hours: Reduces medical diversion by 1.2 hours/day; trauma diversion by 0.7 hours/day	Provides additional quantitative evidence that the boarding of inpatients in ED leads to ambulance diversion.

LOS, length of stay

Table 3. Studies evaluating effect of emergency department (ED) patient flow interventions on reducing ambulance diversion.

Scenarios tested	Diversion threshold		Predicted effects	Implications
Kolb, 2008	100% ED beds full and number of waiting room patients >50% of ED beds	Baseline scenario: 56 diversion hours per month 1. Add ED holding area for boarding admitted patients 2. Add ED discharge lounge for patients without readily available ride home or who are awaiting ambulance back to skilled nursing facility 3. Add ED observation unit 4. Add ED holding area plus ED discharge lounge 5. Add ED holding area, ED discharge lounge, and ED observation unit	1. Diversion reduced 5-14% 2. Diversion reduced 6-14% 3. Diversion reduced <1% 4. Diversion reduced 18-24% 5. Diversion reduced 24%	Adding ED holding area and ED discharge lounge is expected to be an efficient way to reduce ED ambulance diversion
Ramirez, 2009	Different thresholds tested based on patients in waiting room	Baseline scenario: 30 bed ED (26 regular beds; 4 fast-track beds for low acuity patients). Diversion 7% of time. 1. Expand ED to 40 bed ED (32 regular beds: 8 fast-track beds)	1. Diversion reduced to 4% of time, primarily by increasing throughput of low acuity patients	Expansion of fast-track units can reduce diversion if decision to divert primarily based on number of patients in waiting room
Storrow, 2008	100% ED beds full for 30 mins and >10 patients in the waiting room	Baseline scenario: lab turnaround time 120 mins: Diversion 10.8 hours per day 1. Lab turnaround time 60 minutes 2. Lab turnaround time 20 minutes	1. Diversion 8.5 hours/day 2. Diversion 6.2 hours/day	In an urban, high volume tertiary hospital with high ambulance diversion rates, decreasing lab turnaround time by adopting more point of care testing is expected to reduce probability of ambulance diversion

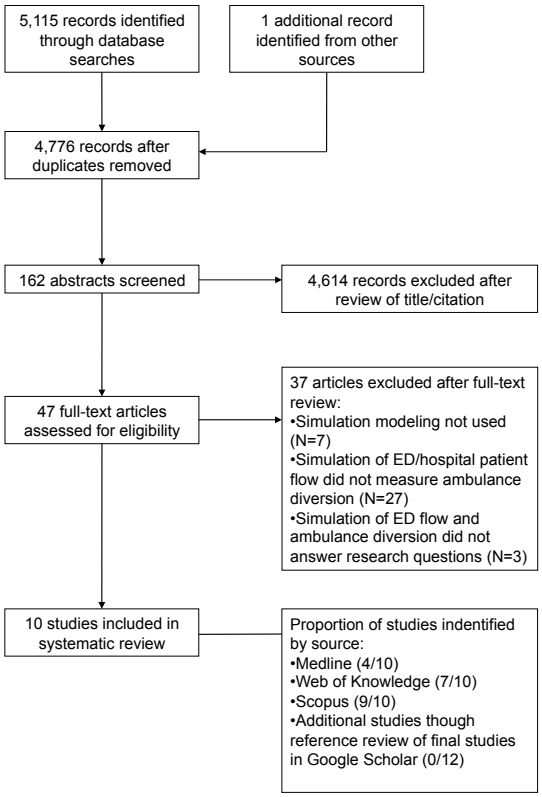

Figure. Flowchart of search.

New York, NY), excluded duplicate records, and excluded records that were clearly not relevant based on title and citation. Two reviewers (MKD, LJM) performed eligibility assessment of the potentially relevant remaining abstracts in an unblinded standardized manner. Disagreements between reviewers were resolved by consensus. If agreement could not be reached, it was planned a third author (GSZ) would decide.

Data Collection Process

We developed a data extraction form and pilot tested it on 5 randomly included studies, and refined it accordingly (See Appendix). One author (MKD) extracted the data items below from included studies and a second author (LJM) checked the extracted data. Disagreements were resolved by discussion, and if no agreement could be reached, a third author would decide.

Data Items

For each study, we summarized the study objective and setting. We then summarized the data from the studies into predefined evidence tables on: 1) the tradeoff between ambulance diversion and ED throughput and wait times; 2) the predicted impact of patient flow interventions on reducing diversion; and 3) optimal regional strategies for reducing diversion.

Table 4: Studies evaluating effect of dynamic bed management interventions on reducing ambulance diversion.

Author, Year	Diversion Threshold	Scenarios Tested	Predicted Effects	Implications
Chockalingam, 2010	ED and ICU at full capacity	*Baseline scenario:* status quo – no dynamic bed management. *New scenario:* Hospital able to predict nearing a divert state in real-time with a simulation model and then able to activate an ED "surge unit" during ED crowding periods.	Hospital profit increased by $50,000 over 1 month period with surge unit strategy; According to model, would need at least 2 extra nurses on call to staff surge unit.	Reducing diversion via an on-call ED surge unit may actually increase hospital profit by accommodating increased patient demand
Kolker, 2009	ICU capacity 2 beds short of full capacity	*Baseline scenario:* mean 3.7 elective surgery cases/day that result in ICU admission (range 0-8). 11% of prehospital ambulance diversion due to "no ICU beds" (49 of 51 ICU beds filled) *New scenarios:* 1. Daily leveling of elective surgeries to not more than 4 elective cases/day requiring ICU admission 2. Daily leveling of elective surgeries to no more than 5 elective cases/day requiring ICU admission AND no cases could be bumped more than 2 weeks 3. Daily leveling of elective surgeries to no more than 5 elective cases/day requiring ICU admission AND no cases could be bumped more than 2 weeks AND elective cases that would require less than 24 hours of ICU care would be admitted to non-ICU beds	1. Ambulance diversion due to "no ICU beds" reduced to 1.5%; but required bumping cases up to 2 months 2. Ambulance diversion due to "no ICU beds" reduced to 8.5% 3. Ambulance diversion due to "no ICU beds" reduced to 1%	Elective surgical schedule smoothing has the potential to reduce probability of ambulance diversion related to a lack of ICU bed availability. More dramatic effects seen when elective cases requiring less than 24 hours of ICU observation can be managed in non-ICU units.
Pines, 2011	Empirically derived from calibration of model to observed data based on number of waiting room patients	*Baseline scenario:* status quo. 85 medical diversion hours per month (lost revenue=$5,388/diversion hour; 66 trauma diversion hours per month (lost revenue=$5,110/diversion hour). *New scenarios:* For every 1-hour reduction in mean boarding hours, under the following hospital revenue projection scenarios: 1. Reduction in boarding hours accommodated without having to cancel elective admissions to meet increased admission demand from ED 2. If the hospital is not always at capacity, only a portion of new ED demand would necessitate reductions of elective admissions (70 different dynamic policies tested). Best policy: when > 560 of the hospital's 565 staffed beds become full (99% occupancy), 2-4 elective admissions would need to be cancelled per day (5% reduction) 3. Each hour of increased ED demand has to be offset with an elimination of a patient-hour of elective admissions.	Medical diversion reduced by 1.2 hours/day; trauma diversion by 0.7 hours/day Hospital revenue projection: 1. Hospital revenue increases by $3.5 million per year 2. Hospital revenue increases by $2.7 million per year; 3. Hospital revenue decreases by $3.1 million per year (from cancelling elective admissions)	With dynamic inpatient bed management policies, hospitals can absorb increased ED inpatient demand from reducing ED boarding associated ambulance diversion without having to cancel elective admissions (except at very high occupancies) or having to add extra inpatient beds.

ED, emergency department; *ICU,* intensive care unit

RESULTS

Study Selection

We identified 10 studies for inclusion in the review (Table 1).[26-34,38] The search of Medline, Inspec (Web of Knowledge), and Scopus produced 5,115 citations (Figure). After removing duplicates, we reviewed 4,776 unique citations. Of these, we discarded 4,614 records for not meeting inclusion criteria based on review of the title and citation, leaving 162 records for full abstract review. After abstract review, 47 citations possibly met criteria for inclusion and went on to full text review, of which we identified 10 meeting inclusion criteria. The most common reason for exclusion after full-text review was that the simulation model of ED flow did not specifically evaluate ambulance diversion (n=27). Three simulation studies of ED flow that examined ambulance diversion were excluded because they did not answer any of our 3 specific research questions.[35-37] We found one additional study meeting inclusion criteria from reviewing the most recent proceedings of the Winter Simulation Conference.[31] We did not find any additional studies after cross-referencing the identified studies in Google Scholar, or by searching the conference proceedings of INFORMS, the Society of Academic Emergency Medicine, or the American College of Emergency Physicians.

Study Characteristics

An overview of the characteristics and design of the studies included for review is presented in Table 1. All but 2 studies simulated patient flow and ambulance diversion in single hospital settings. The other 2 studies evaluated ambulance diversion between 2-3 neighboring hospitals.[27,31]

Studies Quantifying the Tradeoff between Ambulance Diversion and ED Throughput/Wait Times

Three studies quantified the relationship between increases in boarding time in the ED or ED length of stay and increases in ambulance diversion rates (Table 2). One study found that triggering ambulance diversion based on number of patients boarding or number of patients in the waiting room rather than based on inpatient bed availability offered the best balance between accessibility and wait times.[30] However, the projected magnitude of reduced wait times from activating ambulance diversion was relatively small. This study found that for every percentage point increase in diversion status, average waiting room time was reduced by only 2 minutes if the decision to divert was based on number of patients in waiting room or the number of patients boarding. If the decision to go on diversion is instead based on number of available inpatient beds (without regard to ED census), for every percentage point increase in diversion status, average waiting room time was only reduced by 0.5 minutes.[30]

All studies found that reducing boarding time and ED length of stay was expected to reduce ambulance diversion.

Table 5: Studies evaluating effect of regional polices on reducing ambulance diversion.

Author, Year	Scenarios Tested	Results	Comment
Hagtvedt, 2009	*Baseline scenario:* No cooperative agreement between neighboring EDs *Alternative scenarios:* 1. Hospitals allowed to go on partial diversion 2. Cooperative agreement with centralized agent (EMS agency) to route patients	1. Equilibrium would be too fragile to operate in real-life; perverse economic incentives make partial diversion unfeasible 2. Model shows that without binding cooperative scheme, system wide pre-emptive diversion will take place	Queuing model assumes arrivals follow a fixed pattern. Doesn't account for distances between EDs, ED transfers.
Nafarrate, 2011	*Baseline scenario:* No cooperative agreement between neighboring EDs *Alternative scenarios* tested through optimal combination of the two policies: Ambulance diversion polices: 1) Ban diversion; 2) Simple ambulance diversion: ambulance diversion when all beds in the ED are occupied; 3) optimized single factor ambulance diversion: threshold triggered for a particular state that offers best balance between wait times and time on diversion Ambulance destination policies: 1) Patient transported to nearest hospital; 2) Patient transported to least crowded hospital	Optimized ambulance diversion was better than simple ambulance diversion which was better than banning diversion all together in terms of reducing overall non-value added time (transport time, waiting time, and boarding time) among patients treated in 3 hospitals. A policy of taking diverted patients to the least crowded hospital was better than taking patients to the nearest hospital.	Findings apply only to urban areas. No diversion best policy in rural areas (due to longer transport times).

ED, emergency department

For example, one study found that a 1-hour reduction of mean boarding hours in a trauma center was expected to reduce medical ambulance diversion by 1.2 hours/day and trauma diversion by 0.7 hours/day in an urban tertiary care hospital.[32] One study identified various combinations ED throughput benchmarks by whether patients are admitted or discharged that would minimize time on ambulance diversion to less than 3%.[28]

Studies Evaluating Effect of Patient Flow Interventions on Reducing Ambulance Diversion

Two studies examined ED-based patient flow interventions and their predicted effects on ambulance diversion, which would be triggered based on the ED reaching full capacity and the number of waiting room patients reaching a critical threshold (Table 3). Adding a fast track unit for low acuity patients[33] and adding a holding area to remove boarding patients from ED treatment spaces as well as discharge lounge for patient awaiting a ride home or to skilled nursing facilities[38] were predicted to each reducing diversion time by between 4-14%. Adding both a holding area and discharge lounge was expected to reduce diversion time by 18-24%.[38] Adding an ED observation unit was predicted to have little to no effect on reducing diversion time.[38] Finally, one study found that decreasing the average lab turnaround time from 120 minutes to 60 minutes would reduce the time the ED spent on diversion by at least 2 hours per day.[34]

Three different studies evaluated the effect of dynamic bed management interventions on reducing ambulance diversion (Table 4). Two studies found cancellation of some elective admissions would reduce ambulance diversion.[29,32] A simulation study of a tertiary care hospital found that smoothing of the elective surgery schedule to no more than 5 admissions per day expected to result in intensive care unit admission would reduce ambulance diversion.[29] A study of a university trauma center found that adopting a strategy that cancels 2-4 elective admissions as the hospital census reaches 5 beds short of capacity would reduce ambulance diversion and could actually increase hospital revenue by $2.7 million per year.[32] Another study found that using a simulation model to predict when the ED and hospital are soon to be over capacity in order to activate a "surge unit" could reduce diversion and increase hospital profits (by approximately $600,000 per year).[26]

Studies Evaluating Optimal Diversion Policy among Multiple Hospitals

Only 2 studies examined cooperative strategies between hospitals compared with no cooperative agreements to reduce ambulance diversion (Table 5). Both studies found that cooperative strategies among hospitals to reduce diversion were more effective than not having a cooperative strategy. One study provided quantitative evidence that without cooperative diversion strategies, hospitals are likely to go on "pre-emptive" or "defensive" diversion.[27] The other study found that a cooperative strategy that allows some hospitals to go on ambulance diversion based on number of patients in waiting room and that diverted patients to go to the least crowded hospital would optimally reduce "non-value added wait times" more than a simple ban on diversion across hospitals.[31] However, these findings only apply to urban areas where the distance between hospitals is small.

DISCUSSION

In this review of the medical, engineering, and operations research literature, we identified 10 simulation studies that advance the current understanding of the optimal strategies to reduce ambulance diversion. Overall, most simulations involved single EDs, which limits the generalizability of the predicted consequences of various scenarios and the outcome of ambulance diversion. However, there are a number of insights on reducing ambulance diversion that had not been elucidated in previous non-simulation studies on ambulance diversion that could be the starting point for future intervention and policy studies. The insights included: 1) the desired effect of reducing ED waiting room times by diverting ambulances is likely to be very small; 2) if diversion is used, making the decision to divert should be based on number of patients in the waiting room or number of ED boarders instead of just a lack of inpatient beds; 3) adding fast track units and holding units for ED boarders are likely to reduce ambulance diversion; and 4) some dynamic bed management strategies such as smoothing elective surgical admission caseloads could both reduce ambulance diversion and increase hospital revenue. The identified studies also confirm that cooperative strategies among the hospitals may be helpful in preventing "defensive" or "pre-emptive" diversion.[12,39] "Defensive" diversion occurs when a hospital goes on diversion right after a neighboring hospital goes on diversion in order to ward off excessive ED demand from the patients that are being diverted from the neighboring hospital.[39]

This is the first study to systematically review existing literature on simulation models of ambulance diversion with the goal of identifying insights into reducing diversion. One previous study published in the engineering literature examined simulation models on EDs in general.[40] However, this study focused on modeling techniques, data sources and collection methods, and patient classification and flows, and did not summarize the findings of these studies with regards to our focused research questions.[40] Previous reviews of ED crowding and ambulance diversion have been published in the medical literature, but these studies did not capture the contributions of simulation model studies.[6,17]

These studies provide a starting point for testing various strategies at reducing diversion "in-vitro" while allowing for the predicted effect on patient flow and in some cases, hospital revenue. Because of the dynamic and inter-related nature of hospital and ED capacity on patient flow, these

types of predictions cannot readily be made with traditional observational and biomedical research methods.[22] For example, a systematic review of the medical literature on ambulance diversion identified that there is no quantitative evidence that ambulance diversion actually relieves ED crowding or improves ED throughput times.[6] We identified a simulation study of a community hospital ED which found that the effect of diversion on waiting room times is quite small (2 minute reduction for every percentage point increase of time on diversion).[30] If this finding can be confirmed in other simulation and observational studies, it is unlikely that the small decrease in waiting room times from ambulance diversion could outweigh the unintended consequences of prolonged transport times and possibly worse outcomes of diverted patients.[6,7,10]

While it has been known that expanding hospital capacity by adding more inpatient beds could reduce diversion,[41] it may not be easy for many hospitals to add new beds due to space and financial limitations and the hurdles of licensing newly added beds. On the other hand, we identified simulation models that evaluated various strategies to optimize currently available inpatient resources. Two studies found that dynamic management of elective admissions could reduce ambulance diversion,[29,32] and one study found that this could be done in a way that increases hospital revenue.[32]

These models also provide novel experimental insight into alternative methods for networks of hospitals to reduce ambulance diversion. One model found that a coordinated approach that allowed ambulance diversion to be triggered by the number of patients in the waiting room and that re-routed diverted patients to the least crowded ED would lead to the greatest improvement in patient throughput across all EDs.[31] Although this makes intuitive sense, this arrangement would be difficult to implement in practice. It would require all participating EDs to share a common electronic dashboard displaying wait times and ED census. It would also require a central authority available at all times to coordinate the re-routing of ambulances to the least crowded hospitals. Furthermore, implementation of such a program would not put as much pressure on hospital administrators to address root causes of ambulance diversion, such as inpatient throughput and ED boarding, as would implementing a total ban on ambulance diversion. However, this optimized coordinated approach may appeal to regions that have implemented an ambulance diversion ban and are noticing that wait times are increasing despite best efforts to improve inpatient throughput.

LIMITATIONS

Our study has a number of limitations. First, the main limitation with this systematic review, as with any overview, is that study settings, patient populations, scenarios tested, and measurement of the outcome (ambulance diversion) varied across studies. Second, there are no published or validated tools to assess the quality of simulation model studies as compared to the numerous tools available for observational and randomized control studies.[42, 43] Therefore, it is difficult to assess the quality of the studies included for our analysis. Third, one reviewer, as opposed to two or more, did the initial database search and exclusions. However, given the clear primary exclusion criteria, there is little reason to believe that this may have led to bias in the selection of studies. Fourth, 6 out of 10 studies included in our analysis were published in peer reviewed conference proceedings and not in the peer review literature.[26, 27, 30, 31, 33, 38] However, the *Proceedings of the Winter Simulation Conference* is considered a top-tier publication venue in the field, and studies published in the proceedings are usually not submitted to peer review journals. We felt that excluding these studies would exclude a significant body of work related to this topic. Future publication of simulation models in the medical literature would likely increase the perceived reliability of these results among the ED medical community. Finally, the studies included in this review are all simulation studies. The results of these simulation models need to be confirmed in real world settings.

CONCLUSION

In summary, smoothing elective surgery caseloads, adding ED fast tracks as well as holding units for inpatient boarders, improving ED lab turnaround times, and implementing regional cooperative agreements among hospitals are promising avenues for reducing diversion. Using ambulance diversion to alleviate ED crowding is expected to only have a minimal effect on reducing ED wait times. However, if diversion is used to try to temporarily alleviate ED crowding, this decision should be based on the number of patients in the waiting room or number of admitted patients boarding rather than a lack of available inpatients beds alone. More simulation research is especially needed to project the effects of implementing ambulance diversion bans on ED throughput times and hospital revenues.

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

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In-flight Medical Emergencies

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Supervising Section Editor: Christopher Kang, MD
Submission history: Submitted January 29, 2013; Revision received April 9, 2013; Accepted April 19, 2013.
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.4.16052

Introduction: Research and data regarding in-flight medical emergencies during commercial air travel are lacking. Although volunteer medical professionals are often called upon to assist, there are no guidelines or best practices to guide their actions. This paper reviews the literature quantifying and categorizing in-flight medical incidents, discusses the unique challenges posed by the in-flight environment, evaluates the legal aspects of volunteering to provide care, and suggests an approach to managing specific conditions at 30,000 feet.

Methods: We conducted a MEDLINE search using search terms relevant to aviation medical emergencies and flight physiology. The reference lists of selected articles were reviewed to identify additional studies.

Results: While incidence studies were limited by data availability, syncope, gastrointestinal upset, and respiratory complaints were among the most common medical events reported. Chest pain and cardiovascular events were commonly associated with flight diversion.

Conclusion: When in-flight medical emergencies occur, volunteer physicians should have knowledge about the most common in-flight medical incidents, know what is available in on-board emergency medical kits, coordinate their therapy with the flight crew and remote resources, and provide care within their scope of practice. [West J Emerg Med. 2013;14(5):499–504.]

INTRODUCTION

In-flight medical incidents during commercial air travel are common yet poorly understood and studied phenomena. The cramped quarters of an aircraft cabin environment and limited available resources make responding to such events fraught with challenging clinical decisions.

Despite the expansion of commercial air travel over recent decades, there are currently no guidelines for managing ill passengers during commercial flights from the standpoint of volunteer medical professionals. The incidence of these cases is hard to estimate given the paucity of available data. While commercial airlines often collect information on medical events during flight, they do not do so in a standardized format, so it is difficult to compare data across regions.

Equipment stocked in "emergency medical kits" is not mandated by any international aviation body, although the International Air Transport Association (IATA), the Aerospace Medical Association (AsMA), and the International Civil Aviation Organization (ICAO) have agreed upon standardized recommendations. Given the difficulties pertaining to epidemiological data described above, their contents are guided by anecdotal evidence and experts' opinions.

This paper discusses the unique characteristics of the flight environment, reviews the literature describing aviation medical incidents, and suggests an approach to managing these patients.

Flight Physiology

Air travel is associated with an assortment of potential stressors on the physical and psychological well being of travelers. Altitude changes and resultant fluctuations in cabin pressure in particular can affect susceptible airline passengers. A commercial jet's cruising altitude typically ranges between 29,000 and 39,000 feet. The Federal Aviation Administration (FAA) requires airlines to maintain cabin pressure below 8,000 feet, and a commercial plane traveling at 39,000 feet will usually maintain a cabin pressure at or below 7,874 feet.[1] When compared to the altitude of Aspen, Colorado, which is approximately 7,800 feet above sea level, it is not surprising

Table 1. Study characteristics and incidence of in-flight medical emergencies.

Authors	Journal	Dates	Study Design	Total # of Cases reported	Incidence	Diversion	Cardiac Arrest/Death
Hung et al	*Arch Int Med 2010*	01/2003-01/2008	Retrospective Cohort, Single Airline-Hong Kong	4068/5 years	Appx. 11.63 per billion revenue passenger killometers	46 (1.1%)	30 (0.7%)
Sand et al	*Crit Care 2009*	01/2002-12/2007	Retrospective 2 Airlines-Europe	10,189/ 5 years	Appx. 14 (+2.3) per billion revenue passenger kilometers	279 (2.7%)	52 (0.5%)
Baltsezack, S	*J Travel Med. 2008*	01/2006-01/2007	Retrospective Single Airline-Asia	191/1 Year	Not Analyzed	Not Analyzed	1 (0.5%)
Qureshi et al	*E Med Journal 2005*	06/2002-12/2002	Retrospective Single Airline- Edinburgh	507/6 months	Not Analyzed	Not Analyzed	Not Analyzed
Delaune et al	*Aviat Space Environ Med 2003*	07/1999-06/2000	Retrospective single airline.	2965/1 year	22.6 per million passengers	181 (7.9%)	7 (0.1 per million passengers).
Dowdall, Nigel	*BMJ 2000*	03/1998-03/1999-	Retrospective Single Airline-British Airways	3386/1 year	Appx. 1 per 11,000 passengers	Not Analyzed	Not Analyzed
Szmajer et al	*Resuscitation*	01/1989-12/1999	Retrospective Single Airline-Air France	380/10 years	1/20,000 passengers (during the last 2 years under review)	37 (9.7%)	3 (0.8%)
Cummins et al	*JAMA 1989*	09/1986-08/1987	Prospective Single airport	754/1 year	52.4 per million passengers.	7 (4%)	1 (1%)

that some passengers experience symptoms of altitude changes when flying.

According to Dalton's law, the total pressure of a system is equal to the sum of the partial pressures of its components. While the partial pressure of oxygen remains 21% throughout the atmosphere, atmospheric pressure drops at higher altitude resulting in a lower partial pressure of oxygen. At sea level, the partial pressure of oxygen is 160 mmHg, while at 8,000 feet it is 118 mmHg. The partial pressure of oxygen is further reduced when air is inspired into the lungs, which contains high concentrations of water vapor and carbon dioxide. The lower level of inspired oxygen results in less oxygen available for gas exchange and can lead to hypoxia.

The average person is usually able to ascend to a height of 7,800 feet without difficulty. People with cardiopulmonary co-morbidities, however, are more susceptible to changes in altitude. Patients with chronic obstructive pulmonary disease (COPD), interstitial pulmonary disease, or pulmonary hypertension are at an appreciably higher risk of developing symptoms of symptomatic hypoxia. Clinically, patients may appear to have dyspnea at rest, cough, weakness or drowsiness, anxiety or agitation, cyanosis, tachycardia, tachypnea or rales.[2-6] Other medical conditions may also be exacerbated by high altitude, including congenital and valvular heart diseases, symptomatic coronary artery disease, decompensated heart failure, sickle cell disease and obstructive sleep apnea.[2-6] While there are no studies on pre-flight medical screening of passengers, many sources advise primary care providers to screen patients for these disorders and provide advice prior to commercial air travel.[7,8] Patients with relative hypoxia at rest or with minimal exertion at ground level elevation should be advised to avoid air travel or travel with supplemental oxygen.

Incidence studies

We conducted a MEDLINE search in March 2010 using search terms relevant to aviation medical emergencies and extracted incidence studies and high quality topic summaries published between 1980 and 2010. Reference lists of selected articles were reviewed to identify additional relevant publications.

The incidence of medical incidents during commercial air travel is unknown. MedAire, a medical assistance company that provides remote assistance to several commercial airlines in the United States, responds to an average of 17,000 cases per year. Given the absence of a national (or international) registry of incidents, reported numbers of cases from individual airlines and telemedicine providers cannot be generalized to an overall estimation of incidence.

Table 1 demonstrates the wide range of estimates generated by analyzing data from single airports or carriers.[9-16] Most are retrospective cohort studies. Qureshi, et al,[13] in a study published in 2005, retrospectively studied data from a single international carrier and characterized 507 medical incidents reported over a 6-month period in 2002. Dowdal, et al,[9] also performed a retrospective study using a single airline over 1 year and found the incidence of medical incidents to be 1 per 11,000 passengers.

Multiple airline studies include the study by Sand et al,[11] which was a retrospective study of incidents from 2 European airlines over the course of 5 years, demonstrating an incidence of 14 incidents per billion passenger kilometers. This is comparable to the study by Hung et al,[10] a 5-year retrospective

Table 2. In-flight emergencies by diagnosis.

	Journal	Syncope	GI	CV	Neuro: Seizures, CVA, Dizziness, Headache	MS, Trauma	Resp	Alleric Rxn	Ob/ Gyn	Psych/ Intox	Other/ Unknown	Total
Hung et al	*Arch Int Med 2010*	---	---	0.239	0.391	--	--	--	0.13	---	0.24	4068
Sand et al	*Crit Care 2009*	5307 (52.1%)	1286 (12.6%)	675 (6.6%)	250 (2.5%)	359 (3.5%)	231 (2.3%)	222 (2.2%)	62 (0.6%)	616 (6.0%)	1,181 (11.6%)	10189
Baltsezack, S	*J Travel Med. 2008*	28 (14.6%)	68 (35.6%)	18 (9.4%)	9 (4.7%)	16 (8.4%)	13 (6.8%)	7 (3.7%)	3 (1.6%)	6 (3.1%)	168 (12.0%)	191
Qureshi et al	*E Med Journal 2005*	128 (25.2%)	40 (7.8%)	46 (9.1%)	1 (0.2%)	37 (7.3%)	69 (13.6%)	---	1 (0.2%)	3 (0.6%)	182 (35.9%)	507
Delaune et al	*Aviation Space, Environmental Med*	348 (15%)	271 (12%)	258 (11%)	254 (11%)	279 (12%)	251 (11%)	63 (2.8%)	31 (1.4%)	68 (3%)	66 (2.9%)	1889
Szmajer et al	*Resuscitation 2001* (Air France)	62 (16.3%)	59 (15.5%)	45 (11.8%)	35 (9.2%)	20 (5.3%)	14 (3.7%)	9 (2.4%)	15 (3.9%)	35 (9.2%)	86 (22.6%)	380
Cummins et al	*JAMA 1989* (1 year prospective from one airport)	7 (3.7%)	28 (14.7%)	37 (19.4%)	16 (8.4%)	26 (13.7%)	15 (7.9%)	---	4 (2.1%)	2 (1.1%)	55 (28.9%)	190

GI, gastrointestinal; *CV,* cardiovascular*; CVA,* cerebrovascular accident*; MS,* musculoskeletal*; Resp,* respiratory

cohort study that demonstrated an incidence of 11.6 cases per billion passenger kilometers.The variation of incidence, flight diversion, and cardiac arrest data underscores the need for standardized, system-wide reporting and data tracking.

Common In-Flight Medical Events

Table 2 provides a breakdown of the types of in-flight medical incidents reported.[9-16] Once again, the lack of standardized data sources and the overlapping categorizations become evident through the wide-ranging results. The table nevertheless highlights common complaints and alludes to the predominant organ systems affected by the in-flight environment. Syncope, gastrointestinal upset, and respiratory symptoms were among the common medical complaints reported. Chest pain and cardiovascular events were also noted, and these cases were often associated with diversion.[7,9]

The data presented by Sand et al[11] indicated that syncope was the most common type of in-flight medical emergency. Baltsezack et al[12] noted that gastrointestinal complaints were the most common. Qureshi et al,[13] demonstrated that the exacerbation of pre-existing diseases (usually respiratory) was the most common cause of an in-flight medical emergency, and syncope and respiratory conditions were the most common complaints. A study focused only on pediatric medical consultations requested from a single airline noted a high incidence of infectious disease complaints in addition to respiratory and neurologic symptoms.[17] Each incident described was likely the product of a combination of contributing factors, including patient co-morbidities, the flight environment, and alcohol and drug use or withdrawal.

What's Available in Flight?

The FAA requires all American commercial airlines weighing 7,500 pounds or more and serviced by at least one flight attendant to carry an automatic external defibrillator (AED) and an enhanced emergency medical kit. AED use during the commercial flight environment has been validated as safe and effective.[18] Flight attendants must be CPR and AED certified every 2 years.

The standard emergency medical kit on American commercial airlines, which is based on recommendations by the Aerospace Medical Association's (AsMA) Air Transport Medicine Committee, includes a stethoscope, bag valve masks, syringes and intravenous catheters in a range of sizes, and commonly used medications listed in Table 3.[19] Several medications are listed as drug types, including "bronchodilator," "antihistamine," and "analgesic," so the specific medication included may vary from one kit to another. Flight attendants are trained to be familiar with the contents of the kit, and its seal is examined during every pre-flight check and restocked after it is used. According to FAA regulations, a flight may not take off if it is missing the medical kit or AED. Flight attendants may only use the equipment and medications under the direction of a licensed medical provider. For minor medical complaints, flight attendants may use a "first aid" kit that is stocked separately. Physicians requiring additional equipment or medications (e.g. a glucometer) can ask flight attendants to make an overhead announcement requesting the items from other passengers.

All United States (U.S.) airlines are required to carry the standard kit and many supplement its contents with additional equipment and medications. There are, however, no international regulations requiring a complete kit to be available overseas. The International Air Transport Association (IATA) does not regulate the contents of emergency medical kits of international airlines, although it

Table 3. The emergency medical kit.

Medications
Epinephrine 1:1,000
Epinephrine 1:10,000
Antihistamine, inj.
Dextrose 50%, inj. 50 ml (or equivalent)
Nitroglycerin tablets or spray
Major analgesic, inj. or oral
Sedative anticonvulsant, inj.
Antiemetic, inj.
Bronchial dilator inhaler
Atropine, inj.
Adrenocorticoid steroid, inj.
Diuretic, inj.
Medication for postpartum bleeding
Normal Saline
Acetyl salicylic acid for oral use
Oral beta blocker
Equipment
Stethoscope
Sphygmomanometer
Airways, oropharyngeal
Self-inflating manual resuscitation device with pediatric, small adult, and large adult mask
CPR masks (pediatric, small adult, large adult sizes)
Syringes
Needles
Intravenous catheters & tubing
Antiseptic wipes
Gloves
Sharps disposal box
Urinary catheter
Venous tourniquet
Sponge gauze
Tape adhesive
Surgical mask
Flashlight and batteries
Thermometer (non-mercury)
Basic instructions for the use of medications in the kit

does endorse the AsMA's recommendations. An international study evaluating the medical kits stocked by 32 European airlines revealed a high degree of variability, with several kits evaluated to be inadequate to administer emergency care.[20]

A growing number of airlines use the services of remote emergency response centers. "MedAire," "The First Call," and the University of Pittsburgh Medical Center's "StatMD," for example, offer 24-hour consultations via call centers staffed by physicians. If medically trained passengers volunteer their assistance they should coordinate with cabin crew and a response center physician. If a call center physician is not available, the volunteer physician must work with cabin crew and can suggest treatment or diversion options.

Table 4. General approach to managing in-flight medical incidents.

Approach
Identify yourself and your training/expertise
Treat in the seat whenever possible; use of the aisle blocks mobility of flight crew
Document your findings and treatments administered
Communicate and coordinate with flight crew and ground resources
Do not attempt to practice beyond your expertise
Request access to the emergency medical kit
Use a translator if necessary

Medico-legal Issues

Federal legislation contained in the Aviation Medical Assistance Act of 1998 has provided limited protection and guidance for physicians and other medical professionals who volunteer their services during flight. Volunteers must be "medically qualified" and receive no monetary compensation in order to receive protection.[21]

The legislation states that "an individual shall not be liable for damages in any action brought in federal or state court arising out of the acts or omissions of the individual in providing or attempting to provide assistance in the case of an in-flight medical emergency unless the individual, while rendering such assistance, is guilty of gross negligence or willful misconduct." To date there are no documented cases of a physician being sued for providing assistance during an in-flight incident.[7,22,23]

While physicians have no obligation under U.S. law to volunteer, one can argue that they have an ethical obligation to do so, especially if they are specifically trained to respond to undifferentiated medical emergencies.

Volunteer physicians should document their assessment and interventions administered using a standard airline medical incident form if available, or on a blank sheet of paper if a form is not available. If possible, the volunteer physician should request a copy of the medical document or form for their personal records. If a patient requires ongoing monitoring and therapy, the volunteer may need to stay by their side for the duration of the flight. Once the plane lands, the volunteer can hand over care to on-the-ground medical staff who can transfer the patient to an appropriate facility.

Approach to patient and guidelines

A 2002 article published in the *New England Journal of Medicine* by Gendreau et al,[22] offers recommendations for volunteer physicians faced with an in-flight medical incident. The authors' key points and others are outlined in Table 4. Table 5 outlines evaluation and management considerations

for specific in-flight medical incidents.

If the patient's condition is unstable and requires immediate formal medical attention, the physician may recommend diversion of the flight to the nearest airport capable of landing the aircraft and with access to appropriate medical facilities. The act of diverting a full aircraft to the nearest city is expensive, estimated to range between $3,000 and $100,000 depending on the size of the plane and costs of additional fuel and passenger re-routing, and has far-reaching consequences.[22] Diversion is usually made in consultation with ground-based medical expertise and should account for regional medical resources along the flight path. The final decision to make an emergency landing rests with the pilot in command. An article published by Ruskin et al[23] advised diversion for unremitting chest pain, shortness of breath, or severe abdominal pain. Grendreau et al[22] add stroke, persistent unresponsiveness, refractory seizures, and severe agitation to this list. A 2010 study reviewing 4 years of flight diversion data from Air Canada revealed that the majority of diversions occurred following cardiac complaints.[7] Regardless of the presenting symptom, in-flight or ground-based providers must assess a patient's stability and perceived medical condition based on the limited clinical information available and then make a risk-based recommendation. Factors affecting this decision include the differential diagnosis of the patient's condition, available in-flight resources, the patient's response to initial treatments, and ground resources along the flight path. International flights that traverse oceans or large tracts of sparsely populated land may have a lower threshold for diversion before crossing these spaces given the paucity of resources once they are entered.[7]

In the case of multiple volunteers or a severe incident requiring a team approach, health providers should introduce themselves, their level of training, and their specialty in order to determine who should take the lead role. In some cases, a sub-specialist physician (e.g. a neonatologist) should defer to other personnel (e.g. an ED nurse or advanced paramedic) when responding to incidents beyond the scope of their training and experience.

DISCUSSION

An aircraft in mid-flight is a unique environment in which to provide medical care. Any setting, be it a wilderness location, a ship, or at the scene of an accident, is associated with clear challenges and resource constraints that warrant academic study and guideline development. The specialty of emergency medicine focuses on the management, evaluation, and diagnosis of medical emergencies in a variety of environments including resource-limited settings. It is the only recognized medical specialty that takes a health systems approach to emergency care by incorporating the principles of triage, screening for life-threatening conditions, and pre-hospital emergency medical services. The specialty must therefore take a leadership role in the field of aviation medical emergencies.

Recent decades have witnessed an increase in the ease and accessibility of air travel, with a resultant rise in the number and diversity of aircraft passengers. Patients with chronic medical conditions should be screened by their primary care providers prior to air travel to determine their ability to endure the flight environment. Patients with significant pulmonary or cardiovascular disease should be counseled to avoid air travel when possible. When in-flight medical incidents occur, emergency physicians are ideally suited to respond given the breadth of their training, improvisational skills, and team leadership experience. Volunteer physicians should request access to the on-board emergency medical kit, coordinate their

Table 5. Approach to common in-flight medical incidents.

Syncope	Assess vital signs, cardiovascular exam, and neurological exam. Recommend diversion for hypotension, arrhythmia, or suspected stroke.
Altered Mental Status	Assess for toxidromes. Administer oxygen, establish intravenous access and administer normal saline and dextrose 50%.
Seizure	Clear space around passenger. Administer sedative/anticonvulsant (benziodiazepine if available). Provide supportive care during post-ictal period. Recommend diversion for status epilepticus.
Chest Pain	Assess vital signs. Perform cardiovascular and respiratory exam. Administer oxygen, nitroglycerin, and aspirin. Recommend diversion for arrhythmia, abnormal vital signs, or concern for myocardial infarction.
Respiratory	
a) Asthma Exacerbation	a) Administer inhaled bronchodilator and oxygen. Consider intravenous steroid for moderate to severe symptoms. Consider intramuscular epinephrine (0.3 to 0.5 ml of 1:1000 solution) for severe symptoms.
b) Suspected Pneumothorax	b) Perform needle thoracostomy for suspected tension pneumothorax (unequal breath sounds, chest pain, dyspnea). Recommend diversion.
c) Suspected Congestive Heart Failure	c) Administer oxygen, assess vital signs and establish intravenous access. Administer oral nitroglycerin and intravenous diuretic. Recommend diversion.
Allergic Reaction	For mild allergic reaction, administer intravenous antihistamine and corticosteroids. For severe allergic reaction/ anaphylaxis, administer intramuscular epinephrine (0.3 to 0.5 ml of 1:1000 solution).
Gastrointestinal	
a) Nausea/Vomiting	a) Administer antiemetic. Establish intravenous access and administer normal saline.
b) Diarrhea	b) Establish intravenous access and administer normal saline.
Pregnancy Complications	Assess vital signs and establish intravenous access. Recommend diversion for abdominal pain or vaginal bleeding.

therapy with the flight crew and remote resources, and provide care within their scope of practice.

Existing data on both the incidence and classification of in-flight medical events are limited by the lack of a central registry with standardized data collection. Such a data collection tool has been advocated for by several international aviation organizations and could inform the development of emergency medical kits, flight crew medical training, and passenger screening protocols.

ACKNOWLEDGEMENTS

The authors would like to thank Dr. Claude Thibeault, Dr. Paulo Alves, and Dr. Stephen Brawley for their assistance in the preparation of this manuscript.

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

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Ultrasound-guided Intraarticular Hip Injection for Osteoarthritis Pain in the Emergency Department

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Supervising Section Editor: Rick McPheeters, DO
Submission history: Submitted October 8, 2012; Revisions received December 18, 2012; Accepted February 15, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.2.13966

Ultrasound-guided intraarticular hip corticosteroid injections may be useful for emergency care providers treating patients with painful exacerbations of osteoarthritis of the hip. Corticosteroid injection is widely recommended as a first-line treatment for painful osteoarthritis of the hip. Bedside ultrasound is readily available in most emergency departments; however, using ultrasound to guide therapeutic hip injections has not yet been described in emergency practice. Herein, we present the first description of a successful emergency physician-performed ultrasound-guided hip injection of local anesthetic and corticosteroid for pain control in a patient with an acute exacerbation of osteoarthritis. [West J Emerg Med. 2013;14(5):505–508.]

INTRODUCTION

Hip osteoarthritis (OA) is a common painful condition in the emergency department (ED). It is estimated that one in four people will develop painful hip OA in their lifetime.[1] Acute exacerbations of painful hip OA can be severe and disabling, often presenting a clinical challenge for emergency physicians (EP). Intraarticular corticosteroid hip injection is a well-established and effective treatment used extensively by rheumatologists, orthopedists, and pain physicians.[2] Landmark-based techniques of intraarticular injections are technically difficult with a relatively high failure rate and are associated with inadvertent neurovascular injury.[3] Over the past decade, ultrasound-guided intraarticular hip injection has emerged as a safe and efficacious alternative to landmark techniques.[4-6,8] Despite the evidence for the efficacy and excellent safety profile of ultrasound-guided hip corticosteroid injections as a first-line treatment for acute OA pain, this technique has never been described in emergency medicine practice.

Entering the hip joint space can be technically challenging due to its depth and proximity to the femoral neurovascular bundle. Fluoroscopy, which has been shown to be relatively safe and accurate, requires significant resource allocation and introduces the risk associated with exposure to ionizing radiation. Also, fluoroscopy does not visualize soft tissue or neurovascular structures.[2,3] As a result, the ultrasound-guided technique for hip joint injections has been widely accepted as a safe and effective alternative by interventional radiologists, pain physicians, and orthopedists.[4-12]

Within emergency medicine, diagnostic ultrasound-guided hip arthrocentesis for cases of suspected septic joint has been recently described.[13-15] Herein we present the first description of EP-performed ultrasound-guided native hip injections for pain control.

METHODS

Ultrasound-guided technique

Preparation

An ultrasound system (Sonosite M-Turbo Bothell, Washington) is positioned contralateral to the affected hip with the screen in the line of sight of the operator. The skin overlying the hip should be cleaned in a sterile manner.

Survey Scan

A low-frequency curvilinear probe (5-2 MHz), covered with an adhesive sterile dressing, is placed in a transverse plane parallel to the inguinal ligament and used to identify the femoral artery and vein above the hyperechoic femoral head. The probe is then moved laterally to just above the hyperechoic femoral head and rotated to an oblique sagittal position so that the probe marker is aimed towards the umbilicus. The femoral head, femoral neck, anterior capsular recess, and ileofemoral ligament should be visualized.

Table 1. Ultrasound-guided intraarticular hip injection in the emergency department.

Emergency care indications	Pain from osteoarthritis and other degenerative disease of the hip.
Ultrasound-guided techinique	Low frequency curvilinear transducer is used to visualize hip joint and target the anterior synovial recess for injection.
Positioning	Supine with hip slightly abducted and internally rotated.
Needle approach	In-plane approach with a 20-22 gauge 3.5 inch standard cutting spinal needle.
Important anatomy	Inguinal crease, femoral neurovascular bundle, and the anterior synovial recess.
Potential complications	Significant complications are rare. Flare of chronic pain and an increased risk of post-operative infection is possible if total hip arthroplasty is done within 3-4 months of injection.[12] Local irritation, and puncture of the femoral artery or vein are possible but have not been reported with ultrasound guidance.

*Needle insertion and injection***.** A superficial wheal of local anesthetic is placed at the point of planned needle entry. A 6ml mixture of 5ml of bupivicaine 0.5% and 1ml of 40mg/ml of triamcinolone is placed in a 10cc syringe. A 20-gauge 3.5 inch standard cutting spinal needle is guided in-plane under real-time ultrasound guidance to the anterior capsular recess (Figure). When the needle tip is clearly visualized in the joint space, 1-2 mL aliquots of the solution is slowly injected under low pressure. Successful targeting of the joint space is confirmed by spread of anechoic fluid under the ileofemoral ligament within the anterior capsular recess.

Disposition

Only a short period of observation is necessary as the volume of local anesthetic is quite small. It is, however, possible that inadvertent partial femoral nerve blockade could result and all patients should demonstrate full muscle strength before discharge.

CASE PRESENTATION

A 47-year-old male presented to the ED with an acute flare of his chronic severe left hip due to osteoarthritis. He was being followed as an outpatient by the orthopedic service and was scheduled for an upcoming fluoroscopy-guided therapeutic hip injection. He complained of 8/10 pain in the left hip that was significantly limiting his daily functioning. In conjunction with orthopedics consultation and after informed consent, the left hip was injected according to the previously stated technique. At follow up 1 week later, the patient reported significant improvement in his pain and increased daily activity without evidence of infection.

DISCUSSION

We present the first description of an ultrasound-guided injection for pain relief from osteoarthritis of the hip by an EP. In the ED there are few options for treating patient's pain from osteoarthritis and other forms of degenerative hip disease. The American College of Rheumatologists has no recommendations for control of pain in the acute care setting. They do, however, recommend oral pain medications and intraarticular cortisone injections as initial treatment in outpatient practice.[16] Not only is osteoarthritis of the hip common, patients with pain from osteoarthritis are more likely to visit EDs than patients without pain from hip osteoarthritis.[1,17] The economic costs of disability from osteoarthritis are staggering – patients with pain have higher healthcare costs and higher economic costs from missed work and disability compared to patients without pain from osteoarthritis.[17] With such a common, painful and costly problem presenting frequently to EDs, an approach to pain control with only oral pain medications may be limited. Oral medications such as NSAIDs and opiates are often inadequate and not without complications.[18,19]

Hip injections with corticosteroids are not without potential complications. In a review of the literature by Kruse in *Current Reviews in Musculoskeletal Medicine* in 2008, there were 3 main clinically significant complications of intraarrticular corticosteroid injection of the hip: septic arthritis, osteonecrosis, and infection of total hip replacement following pre-operative joint injection.[12] Of the 4 randomized controlled trials of imaging guided hip injections with corticosteroids involving 265 patients, no clinically significant adverse events were reported.[12] There were some minor side effects noted, such as flushing, flare of pain in the days following injection, and hyperglycemia.

The incidence of septic arthritis after hip injection has not been well studied, and only 2 case reports were found in the literature. One case details septic arthritis after a single injection, while in the second case it occurred after repeated injections of sodium hyaluronate and a single injection of triamcinolone.[20,21] There is 1 case report of osteonecrosis after 1 injection of methylprednisolone, although it is unclear if this was due to disease progression or the steroid injection.[22]

The injection of corticosteroids for pain control of hip osteoarthritis in the ED has not been studied or commented on in emergency medicine literature to our knowledge. The idea is not without potential concerns. Patients may present to EDs on a regular basis requesting injections for pain control,

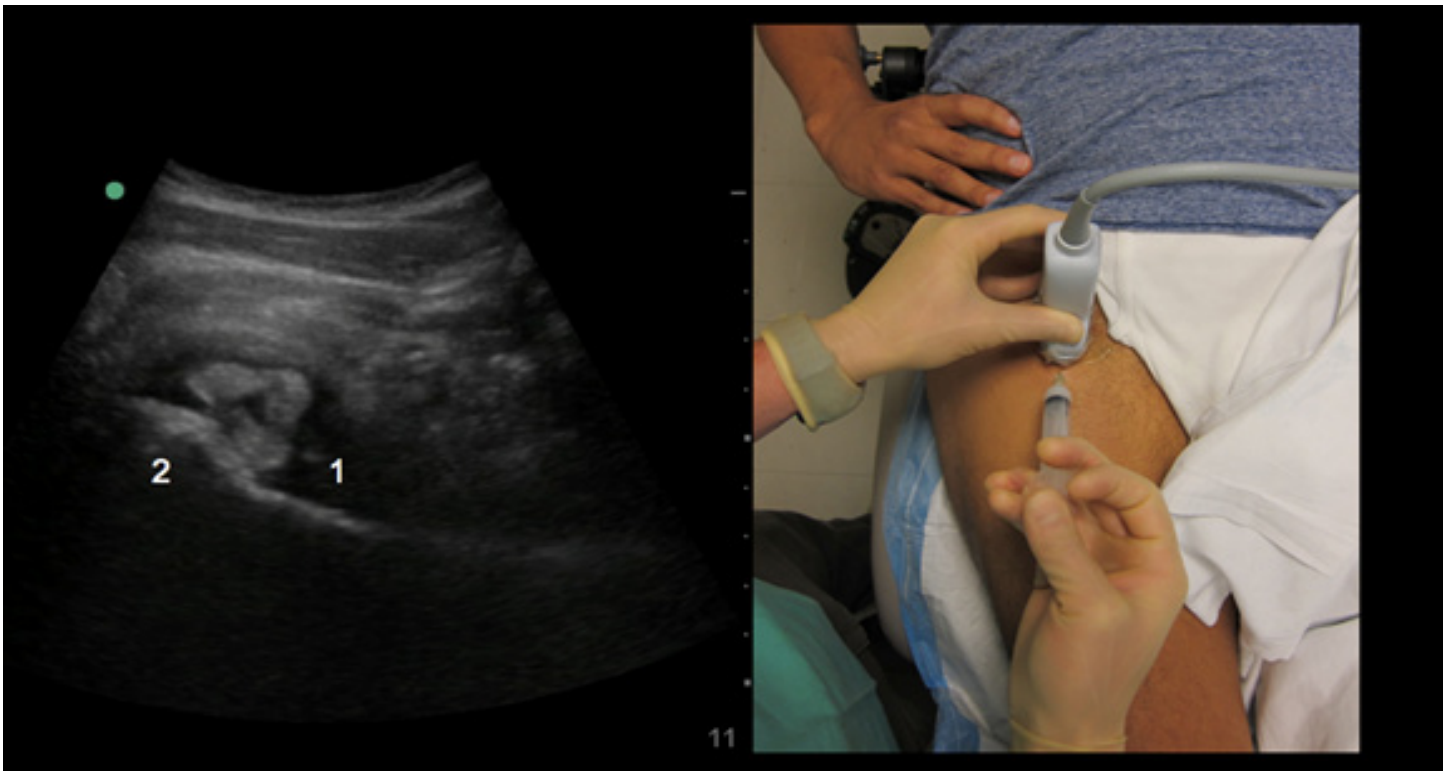

Figure. The needle tip (1) is noted under the illeofemoral ligament in the anterior synovial recess, with the femoral neck (2) in view. Injectate is deposited with a resultant spread of anechoic fluid.

and without the follow up and consultation of an orthopedist, this would be outside the standard of care for managing hip osteoarthritis. A patient presenting to the ED with hip pain has many more diagnostic and therapeutic considerations than a patient presenting with chronic hip pain to a subspecialty outpatient clinic.

Ultrasound-guided hip injections are commonly performed in the outpatient clinic and could easily be transferred to the ED for pain control in the properly selected patient.[5-8] Emergency providers familiar with point-of-care ultrasound can become proficient in this procedure, which has proven to be safe in office-based settings.[7-8] We present a case of an alternative technique for pain reduction in patients with clinical signs and symptoms of chronic OA of the hip. In conjunction with consultative services, this novel technique may be a potentially useful method to reduce pain from OA in the ED setting.

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

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Prognostic Value of Emergency Physician Performed Echocardiography in Patients with Acute Pulmonary Thromboembolism

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Supervising Section Editor: Michael Burg, MD
Submission history: Submitted May 26, 2012; Revision received March 4, 2013; Accepted April 5, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.4.12690

Introduction: Pulmonary embolism (PE) is a life-threatening illness with high morbidity and mortality. Echocardiography (ECG) plays an important role in the early identification of right ventricular (RV) dysfunction, making it a helpful tool in identifying hemodynamically stable patients affected by PE with a higher mortality risk. The purpose of this study was to evaluate if one or more ECG indexes could predict a short-term evolution towards RV dysfunction.

Methods: We selected all patients consecutively admitted to the Careggi Hospital Emergency Department with the clinical suspicion of PE, confirmed by computed tomography angiography prior to enrollment. Subsequently, properly trained emergency physicians acquired a complete ECG to measure RV morphological and functional indices. For each patient, we recorded if he or she received a fibrinolytic treatment, a surgical embolectomy or heparin therapy during the emergency department (ED) stay. Then, every patient was re-evaluated with ECG, by the same physician, after 1 week in our intensive observation unit and 1 month as outpatient in our ED regional referral center for PE.

Results: From 2002 to 2007, 120 consecutive patients affected by PE were evaluated by echocardiography at the Careggi Hospital ED. Nine patients (8%) were treated with thrombolytic therapy. Six died within 1 week and 4 abandoned the study, while the remaining 110 survived and were re-evaluated by ECG after 1 week and 1 month. The majority of the echocardiographic RV indexes improve mostly in the first 7 days: Acceleration Time (AT) from 78±14 ms to 117±14 ms ($p<0.001$), Diameter of Inferior Vena Cava (DIVC) from 25±6 mm to 19±5 mm ($p<0.001$), Tricuspid Annular Plane Systolic Excursion (TAPSE) from 16±6 mm to 20±6 mm ($p<0.001$). Pulmonary Artery Systolic Pressure (PASP) showed a remarkable decrease from 59±26 mmHg to 37±9 mmHg, ($p<0.001$). The measurements of the transverse diameters of both ventricles and the respective ratio showed a progressive normalization with a reduction of RV diameter, an increase of Left Ventricular (LV) diameter and a decrease of RV/LV ratio over time. To evaluate the RV function, the study population was divided into 3 groups based on the TAPSE and PASP mean values at the admission: Group 1 (68 patients) (TAPSE+/PASP-), Group 2 (12 patients) (TAPSE-/PASP-), and Group 3 (30 patients) (TAPSE-/PASP+). Greater values of AT, minor RV diameter, greater LV diameter and a lesser RV/LV ratio were associated with a short-term improvement of TAPSE in the Group 2. Instead, in Group 3 the only parameter associated with short-term improvement of TAPSE and PASP was the treatment with thrombolytic therapy ($p<0.0001$).

Conclusion: Greater values of AT, minor RV diameter, greater LV diameter and a lesser RV/LV ratio were associated with a short-term improvement of TAPSE-/PASP- values. Patients with evidence of RV dysfunction (TAPSE-/PASP+), may benefit from thrombolytic therapy to improve a short- term RV function. After 1 month, also a decreased DIVC predicted improved RV function. [West J Emerg Med. 2013;14(5):509–517.]

INTRODUCTION

Acute pulmonary embolism (PE) is defined as a partial or complete occlusion of the pulmonary artery branches; together with deep vein thrombosis it is a possible manifestation of the same disease: venous thromboembolism.[1] Clinical features of PE can range from a totally silent presentation to sudden dyspnea and tachypnea, associated with tachycardia, chest pain, hemoptysis or syncope. Those signs are neither specific nor sensitive, because of a wide spectrum of possible differential diagnoses, including coronary artery disease, pneumonia, congestive heart failure, pericarditis, pleurisy and primary pulmonary hypertension.[1,2]

PE is associated with high morbidity and mortality, especially when associated with signs of right ventricular (RV) dysfunction. [2-4] Patients can be prognostically stratified into 3 risk classes: high-risk PE with a short-term mortality >15% including hemodynamically unstable patients, intermediate-risk PE according to the identification of either RV dysfunction or blood markers of myocardial injury, and low-risk PE. Echocardiography (ECG) represents a very important source of prognostic information in PE, as it can recognize many signs of RV dysfunction and is therefore helpful to assign the patient to low- or intermediate-risk classes.[2]

Many studies have analyzed 1 or more ECG indices of RV dysfunction in relation to short-or long-term patient survival,[3,5-16] but none assess whether 1 or more of these ECG indices could predict short-term changes of RV dysfunction or pulmonary hypertension in patients with PE. Thus, the aim of our study was to identify 1 or more ECG indices of RV anatomy and function predictors of short-term RV dysfunction in patients with PE.

METHODS

The study, which is consistent with the principles of the Declaration of Helsinki on clinical research involving human subjects, was approved by an Institutional Review Board.

We enrolled all patients consecutively admitted to the Careggi Hospital Emergency Department (ED) with current and past history, clinical symptoms, and pretest probability suggestive of PE confirmed by computed tomography angiography in this study.

Subsequently, each patient underwent an ECG to measure several morphological and functional RV indices.

Age, heart rate (HR), respiratory rate (RR), systolic blood pressure (SBP) and diastolic blood pressure (DBP) of all patients were obtained on admission to the ED; if a patient had a shock index (defined as heart rate divided by systolic blood pressure),[17] >1 he or she was considered affected by high-risk PE.

All patients had a transthoracic ECG performed using standard views (parasternal long-axis view, parasternal short-axis view, apical four-chamber view and subcostal long-axis view) with M-Mode, B-Mode, Continuous-Wave Doppler, Pulsed-Wave Doppler and Color-Doppler techniques.

We acquired the images with an Acuson Sequoia 512 system (Siemens AG, Erlangen, Germany) equipped with a sectorial transducer with frequencies between 2,5 and 3,5 MHz. Each ECG was executed and interpreted by emergency physicians (EP). All EPs attended an initial training during an introductory course of 24 hours covering the core applications with practical hands-on sessions, and subsequent detailed courses covering single applications (vascular, cardiac and chest ultrasonography lasting 8 hours for each area). Then they performed, under a tutor's supervision, 250 ultrasonographic exams of each kind before being certified to perform ultrasonography.

We measured right and left ventricular dimensions following the American Society of Echocardiography guidelines.[18-20] M-mode ECG was used to evaluate the RV systolic function from long and short axis views. We detected RV long axis function by measuring the tricuspid annular plane systolic excursion (TAPSE), placing the M-mode cursor in the apical four-chamber view at the junction of the RV free wall and tricuspid annular plane and recording the longitudinal displacement of the annulus towards the apex from end-diastole to end-systole. The larger the excursion, the better was the RV systolic function, and values less than 16 mm were considered indicative of RV dysfunction.[21] We evaluated RV short axis function from the parasternal short-axis view at the level of the aortic root. With the M-mode technique, we recorded the right ventricular outflow tract fractional shortening (RVOTFS). The dimensions were measured at end-diastole and end-systole using endocardial leading edge methodology. We calculated RV fractional shortening as the percentage fall in right ventricular outflow tract diameter in systole with respect to that in diastole.[13,19]

We recorded the diameter of the inferior vena cava (DIVC) and its variation with inspiration expressed in percentage (%DIVC) from the subcostal long-axis view.[19,22] The mid-cavity diameters of the right and left ventricles in end-diastole were measured from the standard parasternal long-axis, subcostal long-axis and apical four-chamber views. From these measurements, for each view we calculated the right ventricle to left ventricle ratio (RV/LV).[19,21,23] This measure is considered an important ECG index, because a RV enlargement resulting in a RV/LV >1, can be indicative of a hemodynamically significant PE. Using the Continuous-wave Doppler technique from the parasternal short-axis view, we estimated the RV to right atrial pressure gradient, and calculated the pulmonary artery systolic pressure (PASP) with the information about the diameter and the respiratory collapse of the inferior vena cava (IVC).[19]

Using the Pulsed-wave Doppler technique with the sample volume positioned at the tricuspid valve in apical four-chamber view, we recorded the diastolic flow, visualizing the E and A waves of the tricuspid flow and calculating the E to A ratio (E/A) and the deceleration time of the E wave (DTE).[19] Using the same technique the acceleration time of the RV (AT) was measured in the parasternal short-axis view, positioning

Table 1. Echocardiographic indices upon presentation to emergency department.

		Range	Normal values	*p*-value
Acceleration time of RV (ms)	77 ± 15	52-97	>120	<0.001
Diameter of the inferior vena cava (mm)	26 ± 6	17-39	<21	<0.001
RV outflow tract fractional shortening (%)	36 ± 18	5-54	>48*	<0.001
Deceleration time of the E wave (ms)	123 ± 17	92-144	<120	0.039
E to A wave ratio	0.64 ± 0.29	0.02-0.99	0.8-2.1	<0.001
Pulmonary artery systolic pressure (mmHg)	62 ± 28	36-118	<35	<0.001
Tricuspidal annular plane systolic excursion (mm)	15 ± 7	5-24	>16	NS
RV				
Apical 4-chamber view (mm)	36 ± 11	24-57	<35	NS
Parasternal long-axis view (mm)	33 ± 11	22-56	<27	<0.001
Subcostal long-axis view (mm)	35 ± 11	22-57	-	-
LV				
Apical 4-chamber view (mm)	49 ± 5	41-65	-	-
Parasternal long-axis view (mm)	49 ± 5	40-64	42-59 Male§ 39-53 Female§	<0.001
Subcostal long-axis view (mm)	49 ± 5	37-66	-	-
RV/LV				
Apical 4-chamber view	0.75 ± 0.29	0.44-1.36	<0.6ç	<0.001
Parasternal long-axis view	0.70 ± 0.29	0.42-1.40	-	-
Subcostal long-axis view	0.73 ± 0.29	0.42-1.36	-	-

RV, right ventricle; *LV,* left ventricle; *RV/LV,* right ventricle to left ventricle ratio
*Normal values of right ventricular outflow tract fractional shortening were obtained from the work by Lindqvist et al[13,19] but these have not currently been validated by other studies.
§ Normal values from 25.
ç Normal values from 26.

the sample volume at the pulmonary valve.[5,19]

Furthermore, we evaluated the presence of 2 ECG signs of RV dyskinesia: the McConnell's sign (a distinct regional pattern of right ventricular dysfunction, with akinesia of the mid free wall but normal motion at the apex) and the D-shaped LV (systolic movement of the interventricular septum toward the LV).[6]

For each patient, a record was made if he or she received a fibrinolytic treatment, a surgical embolectomy or heparin therapy during the ED stay. Then every patient was re-evaluated with ECG, by the same EP, after 1 week in our Intensive Observation Unit and 1 month as outpatient in our ED regional referral center for pulmonary embolism.

Statistical analysis

Data are presented as mean ± standard deviation for continuous variables, and numbers or percentage for categorical variables. We tested differences by Student's t test or χ square test or Fisher's exact test, as appropriate. Analysis of variances and Sheffé's post-hoc test assessed differences for multiple comparisons of continuous variables. Univariate logistic regression analysis assessed the association between every ECG parameter and the 7-day survival, eventually followed by a multivariate logistic regression analysis.

To characterize RV functionality in terms of contractility and pressure developed, TAPSE and PASP were exploited. It was possible to identify 3 groups of patients using the mean values of these 2 parameters: Group 1 with TAPSE over the mean value and PASP under the mean value (TAPSE+/PASP-), Group 2 with TAPSE and PASP below the mean value (TAPSE-/PASP-), and Group 3 with TAPSE under the mean value and PASP elevated over the mean value (TAPSE-/PASP+).

A 2-tailed p value <0.05 was considered statistically significant in all calculations. We did all computations using SPSS statistical package (SPSS version 17 Inc. Chicago, IL, USA).

RESULTS

We enrolled 120 patients (44% male) who had been diagnosed with pulmonary embolism in the ED by computed tomography (CT) angiography from January 2002 to December 2007. Mean age was 73±14 years, and at the time of presentation 12 patients (10%) were in shock. The remaining 108 patients (90%) had a mean HR of 101±25 beats per minute, a RR of 23±9 breaths per minute, a SBP of 130±25 mmHg and a DBP of 77±13 mmHg.

One-hundred eleven of the 120 patients (92%) never

Table 2. Result of the comparison between the echocardiographic indices registered upon admission to the emergency department, after 1 week and after 1 month.

	1 week	1 month	ANOVA
Acceleration time of RV (ms)	117 ± 14*	119 ± 21	p<0.001
Diameter of the inferior vena cava (mm)	19 ± 5*	17 ± 3	p<0.001
RV outflow tract fractional shortening (%)	49 ± 14*	53 ± 13	p<0.001
Deceleration time of the E wave (ms)	145 ± 19*§	158 ± 16§	p<0.001
E to A wave ratio	0.93 ± 0.28*§	1.13 ± 0.28§	p<0.001
Pulmonary artery systolic pressure (mmHg)	37 ± 9*ç	30 ± 8ç	p<0.001
Tricuspidal annular plane systolic excursion (mm)	20 ± 6*	22 ± 6	p<0.001
RV			
Apical 4-chamber view (mm)	29 ± 7*	27 ± 6	p<0.001
Parasternal long-axis view (mm)	26 ± 6*	25 ± 4	p<0.001
Subcostal long-axis view (mm)	28 ± 6*	26 ± 5	p<0.001
LV			
Apical 4-chamber view (mm)	51 ± 4*	52 ± 4	p<0.001
Parasternal long-axis view (mm)	51 ± 4*	52 ± 3	p<0.001
Subcostal long-axis view (mm)	51 ± 5*	52 ± 4	p<0.001
RV/LV			
Apical 4-chamber view	0.59 ± 0.18*	0.53 ± 0.13	p<0.001
Parasternal long-axis view	0.52 ± 0.14*	0.49 ± 0.10	p<0.001
Subcostal long-axis view	0.57 ± 0.16*	0.51 ± 0.11	p<0.001

RV, right ventricle; *LV,* left ventricle; *RV/LV,* right ventricle to left ventricle ratio
* p<0.001 compared with the values at the admission with the Sheffé's post-hoc test.
§ p<0.001 compared with the Sheffé's post-hoc test.
ç p=0.025 compared with the Sheffé's post-hoc test.

had a history of PE, while 9 (8%) had a recurrence of venous thromboembolism. Nine of the 120 patients (8%) were treated with thrombolytic therapy.

In 9 patients (8%) the ECG exam was incomplete due to inadequate visualization of the heart. Therefore, it was not possible to record the dimensions of the RV in 1 patient in parasternal long-axis view (1%) and in 9 patients (8%) in subcostal long-axis view, and the LV was impossible to evaluate in 8 patients (7%) in subcostal long-axis view.

Six patients (5%) died within a week, and all belonged to group 3 (TAPSE-/PASP+). One of these was treated with thrombolytic therapy. Two patients (2%) received a surgical embolectomy because of absolute contraindications to fibrinolysis, 1 (1%) was transferred to another hospital and 1 (1%) refused admission to the hospital; the remaining 110 patients (92%) were hospitalized and followed up with ECG after 1 week and 1 month.

The mean values of the ECG indices we evaluated were altered at ED presentation, compared to normal values presented in other studies, except for TAPSE and the mid-cavity diameter of the RV in the apical four-chamber view (Table 1).

Analyzing the development of the various ECG indices obtained from the 110 patients that were re-evaluated after

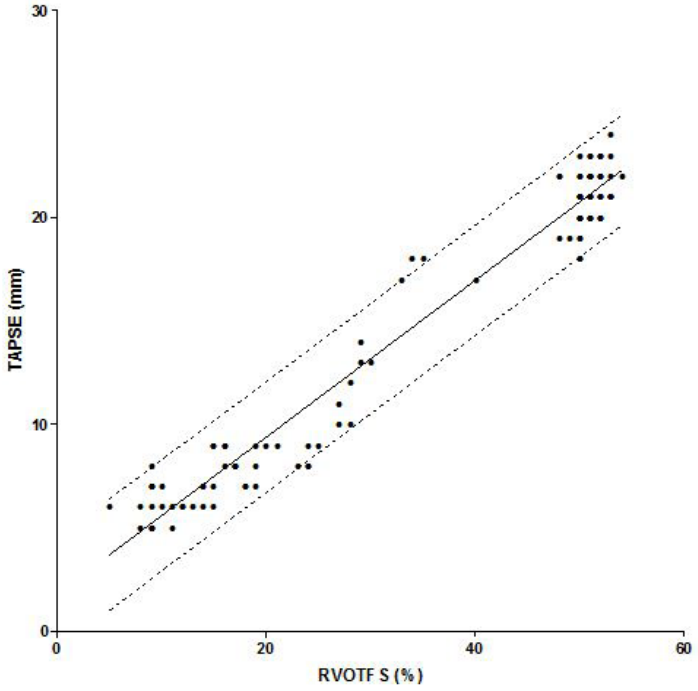

Figure 1. Correlation between right ventricular outflow tract fractional shortening (RVOTFS) and tricuspid annular plane systolic excursion (TAPSE) values of the right ventricle registered at the admission. The central continuous line indicates the regression line. The dashed lines indicates the standard error of estimates.

Table 3. Echocardiographic indices: age and vital signs in deceased and 30-day survivor subgroups.

	Dead	Survivors	*p*-value
Acceleration time of RV (ms)	55 ± 1	78 ± 14	<0.001
Diameter of the inferior vena cava (mm)	36 ± 2	25 ± 6	<0.001
RV outflow tract fractional shortening (%)	9 ± 2	38 ± 16	<0.001
Deceleration time of the E wave (ms)	100 ± 3	125 ± 16	<0.001
E to A wave ratio	0.25 ± 0.05	0.67 ± 0.27	<0.001
Pulmonary artery systolic pressure (mmHg)	110 ± 6	59 ± 26	<0.001
Tricuspidal annular plane systolic excursion (mm)	5 ± 1	16 ± 6	<0.001
RV			
Apical 4-chamber view (mm)	29 ± 7	27 ± 6	<0.001
Parasternal long-axis view (mm)	26 ± 6	25 ± 4	<0.001
Subcostal long-axis view (mm)	28 ± 6	26 ± 5	<0.001
LV			
Apical 4-chamber view (mm)	51 ± 4	52 ± 4	<0.001
Parasternal long-axis view (mm)	51 ± 4	52 ± 3	<0.001
Subcostal long-axis view (mm)	51 ± 5	52 ± 4	<0.001
RV/LV			
Apical 4-chamber view	0.59 ± 0.18	0.53 ± 0.13	<0.001
Parasternal long-axis view	0.52 ± 0.14	0.49 ± 0.10	<0.001
Subcostal long-axis view	0.57 ± 0.16	0.51 ± 0.11	<0.001
Age (years)	82 ± 14	73 ± 13	NS
Systolic arterial blood pressure (mmHg)	138 ± 17	129 ± 25	NS
Diastolic arterial blood pressure (mmHg)	83 ± 15	76 ± 13	NS
Heart rate (beats/min)	130 ± 12	100 ± 26	NS
Respiratory rate (breaths/min)	36 ± 7	23 ± 9	NS

RV, right ventricle; *LV,* left ventricle; *RV/LV,* right ventricle to left ventricle ratio

1 week and 1 month, we found that the majority improved primarily in the first 7 days, with further, but not statistically significant, improvements within 1 month (Table 2).

In detail, the AT improved from a mean value of 78 ± 14 ms, recorded at the first ECG done in the ED, to 117 ± 14 ms after 1 week (p<0.001); after a month the improvement was minimally better (119±21 ms) but not statistically significant (versus 1 week).

The dimension of the inferior vena cava associated with its collapsibility during inspiration is a very reliable parameter to estimate right atrial pressure (RAP), and accordingly central venous pressure. DIVC showed a progressive and significant decrease, starting from mean values of 25 ± 6 mm at presentation to 19 ± 5 mm after one week (p<0.001), decreasing further to a mean value of 17 ± 3 mm after 1 month (p=NS versus 1 week).

The RVOTFS was described by Lindqvist et al[13] at least as reliable as TAPSE for the evaluation of RV function: according to our analysis, RVOTFS was correlated with TAPSE showing a progressive increase of the average value (38 ± 16% at presentation, 49 ± 14% after 1 week, p<0.001, and 53±13% after 1 month, p=NS versus 1 week), comparable to that of TAPSE (16 ± 6 mm at presentation, 20 ± 6 mm after 1 week, p<0.001, and 22±6 mm after 1 month, p=NS versus 1 week).

The 2 parameters showed a highly significant linear correlation (r=0.980; p<0.001) and the standard error in the estimate of TAPSE using the RVOTFS values was ±1.34 mm. The range of TAPSE observed in our study is 5-24 mm, and using the RVOTFS to assess TAPSE, there would be a mean error of approximately ±9% (Figure 1).

The DTE and the E/A of the trans-tricuspid flow measured with Doppler technique are ECG indices of diastolic function of the right heart; these parameters significantly improved in our patients, showing an increase of the mean value of DTE from 125 ± 16 ms at the admission to 145 ± 19 ms after 1 week (p<0.001), to 158 ± 16 ms after 1 month (p=NS versus one week), while E/A mean value started from 0.67 ± 0.27 at the admission and increased after 7 days to 0.93 ± 0.28 (p<0.001) and then to 1.13 ± 0.28 after 1 month (p=NS versus 1 week).

The estimate of PASP showed a remarkable and

Table 4. Correlation according to the logistic univariate regression model of echocardiographic indices compared with the 7-day mortality, with relative *p*-value, odds ratio and confidence interval.

	p-value	Odds ratio	95% confidence interval
Acceleration time of RV (ms)	NS		
Diameter of the inferior vena cava (mm)	0.015	1.469	1.076-2.006
RV outflow tract fractional shortening (%)	NS		
Deceleration time of the E wave (ms)	0.018	0.860	0.758-0.974
E to A wave ratio	0.027	3x10-6	4x10-11-0.228
Pulmonary artery systolic pressure (mmHg)	NS		
Tricuspidal annular plane systolic excursion (mm)	NS		
RV			
Apical 4-chamber view (mm)	NS		
Parasternal long-axis view (mm)	0.023	3.593	1.189-10.859
Subcostal long-axis view (mm)	NS		
LV			
Apical 4-chamber view (mm)	0.014	0.230	0.071-0.742
Parasternal long-axis view (mm)	0.009	0.492	0.289-0.839
Subcostal long-axis view (mm)	0.012	0.685	0.509-0.921
RV/LV			
Apical 4-chamber view	NS		
Parasternal long-axis view	NS		
Subcostal long-axis view	NS		

RV, right ventricle; *LV,* left ventricle; *RV/LV,* right ventricle to left ventricle ratio; *NS,* not statistically significant

progressive decrease in our series: starting from a mean value of 59 ± 26 mmHg upon admission. After 7 days we saw a marked and statistically significant decrease in pressure (37 ± 9 mmHg, p<0.001) that continued even after 1 month (30 ± 8 mmHg, p=NS versus 1 week).

The measurements of the transverse diameters of both ventricles and the respective ratio in the apical 4-chamber, parasternal long-axis and subcostal long axis views all showed a progressive normalization of the mean values, which is a reduction of RV dimension, an increase of LV dimension and a RV/LV ratio that decreased over time (Table 2).

Comparing survivors with non-survivors at 1 month, we saw that all the ECG indices we studied showed differences between the 2 groups (p<0.001), but age and vital signs registered on admission to the ED did not show statistically significant differences (Table 3).

In the univariate logistic regression analysis the parameters that showed an association with increased mortality within 7 days were as follows: an increased DIVC, an augmented DTE, a decreased E/A, an increased RV diameter in parasternal long-axis view and a diminished LV diameter in all 3 ECG views we performed (Table 4); but when those parameters were included in a multivariate logistic regression model, none of them proved to be an independent

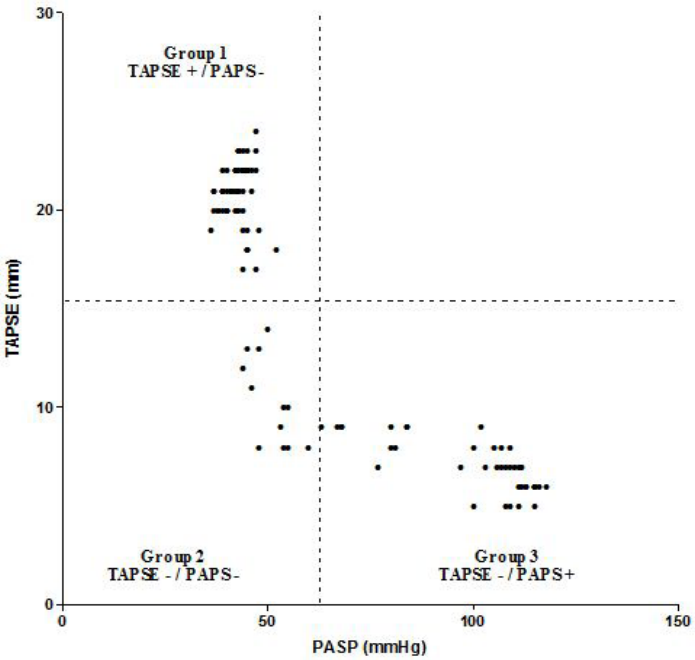

Figure 2. Distribution of patients according to tricuspid annular plane systolic excursion (TAPSE) and pulmonary artery systolic pressure (PASP) values at the admission. Dotted lines represent the mean values of TAPSE and PASP and divide the population in 3 Groups.

predictor of 7-day mortality (p=NS).

McConnell's sign was found in 45 patients (39%) upon admission. Six of them died within 1 week. The 75 patients without McConnell's sign survived 1 month (p=0.003).

All survivors with positive McConnell's sign (39) were still positive for this sign after 1 week (p=NS), but after 1 month McConnell's sign was detected in 21 patients (p=0.047).

The presence of a D-shaped LV was detectable in 55 patients (47%) upon admission and was present in 6 of the patients who died within 7 days, unlike the group of the 55 patients that did not have a D-shaped LV, who all survived one month (p=0.01).

Of the 49 patients with D-shaped LV that survived, 26 had this finding after 1 week (p=0.0051), with only 1 patient still positive after 1 month (p<0.001).

Of the 42 patients (36%) whose IVC was not collapsible, 6 died within 7 days, while all those whose IVC was collapsible with inspiration survived (p=0.002).

Of the 36 survivors with non-collapsible IVC, only 1 patient had this sign (p<0.001) after 1week and 1 month, while the others reverted to normal (p=NS).

Therefore, the presence of McConnell's sign, a D-shaped LV, or evidence of a non-collapsible IVC with inspiration showed a correlation with a higher mortality. However, performing further regression curve analysis, this relationship was not statistically significant (p=NS).

To evaluate right heart function, we divided the population of our study into 3 groups based on the TAPSE and PASP values: at the admission in the ED, 68 patients formed Group 1 (TAPSE+/PASP-), 12 patients formed Group 2 (TAPSE-/PASP-) and the remaining 30 patients formed Group 3 (TAPSE-/PASP+) (Figure 2). All patients in Group 1 remained in this group after 1 week and 1 month, not showing a deterioration in right heart function. After 1 week, 10 of 12 patients (83%) in Group 2 showed an improvement of right ventricular contractility (TAPSE+) moving to Group 1. The remaining 2 patients (17%) showed no improvement even after 1 month, remaining in the initial group. In Group 3, the majority (22 out of 30, 73%) moved to Group 2 due to a reduction of pulmonary hypertension (PASP-) not associated with a significant improvement of the systolic function of the RV, while the remaining 8 patients (27%) moved directly to Group 1 due to both an improvement of RV systolic function and reduction of pulmonary hypertension (TAPSE+/PASP-). After 1 month, 5 out of 22 patients that moved from Group 3 to Group 2 showed a further improvement, shifting to Group 1. The following findings were all associated with a short-term improvement of TAPSE and PASP in this subgroup of patients: greater values of AT, a smaller RV diameter, a greater LV diameter in parasternal and subcostal-long axis views and a lower RV/LV ratio in apical four-chamber and subcostal long-axis views.

In Group 3 the only parameter related to 7-days improvement of RV function was the receipt of thrombolytic therapy. Indeed among this group of 30 patients, 22 (73%) did not receive thrombolytics, and improved to Group 2 status due to reduction of pulmonary hypertension (PASP-) but not a significant improvement in systolic function of the RV. The remaining 8 (27%) patients who were treated with thrombolysis, improved to a greater degree and moved directly to Group 1 due to both improvement of RV systolic function (TAPSE+) and reduction of pulmonary hypertension (PASP-). This difference in degree of improvement between the 22 patients without thrombolytics and the 6 with, was statistically significant (p<0.0001) (Fisher's Exact Test). Furthermore, we note that 6 of the 8 patients thrombolysed, had intermediate-risk PE, while 2 were in shock, indicating that thrombolytic therapy may be of benefit not only for patients in extremis. Finally in Group 3 a decreased DIVC after 1 month was predictive of an improvement in RV function.

DISCUSSION

Our study investigated whether 1 or more ECG indexes could predict a short-term evolution towards RV dysfunction in patients affected by PE. Accordingly, the study was not aimed at evaluating the diagnostic ECG indices suggestive of pulmonary thromboembolism that were already extensively evidenced in the medical literature. Being able to predict short-term evolution towards RV dysfunction is important for the EP, to tailor therapy in the first hours after diagnosis according to the hemodynamic profile. We examined a consecutive group of 120 patients with PE on CT angiography, without regard to severity determined purely on clinical presentation.

Mortality rate in our population (5%) was similar to that of other studies.[3,4,24] In those who survived (and excluding those not re-evaluable by ECG) the evolution after 1 week and 1 month of every ECG index was recorded. Every index showed a more or less rapid back-to-normal trend, but in some patients this trend was much slower than in others.

We used 2 ECG parameters studied extensively TAPSE and PASP to identify patients with a worse right heart dysfunction among those with the same clinical severity.

This way, we managed to verify an improvement or not of the right heart dysfunction after 1 week and 1 month, and so a favorable outcome or not, as reported in literature.[16]

As a matter of fact, in the group in which TAPSE and PASP were under the mean values, a higher AT, lower diameters of the RV, greater diameters of the LV, and a lower RV/LV ratio were all related to the improvement of the RV dysfunction after only 1 week from the episode of PE.

In the group 3, TAPSE-/PASP+, we were able to predict considerable improvement of RV dysfunction after 7 days, only if the patients had been treated with thrombolysis compared to those treated only with heparin. Furthermore, since the majority of patients who received

thrombolytic therapy (6 out of 8) belonged to the category at intermediate prognostic risk of pulmonary embolism, we can reasonably state that not only patients with high-risk PE (hemodynamically unstable patients) (2 out of 8) but also patients with an intermediate-risk PE showing an impairment of the RV function (reduced TAPSE and elevated PAPS) may benefit from thrombolytic therapy [2], after the exclusion of bleeding risk factors. This is very important for the ED physician approach to PE. These results therefore allow for the chance to improve the clinical status of a patient with PE based solely on ECG parameters recorded at the time of presentation in the ED.

Regarding DIVC, our study showed that this index remained higher than normal after 1 month, documenting the persistence of right heart dysfunction.

Moreover, we investigated the association between TAPSE and RVOTS, as described by Lindqvist et al.[13] In those authors' opinion, RVOTS is strictly related to TAPSE and in patients with PE it is highly indicative of RV dysfunction.

In our study, we confirmed the existence of a direct correlation between those 2 parameters, but TAPSE has a standard error of estimates of about ±1.34 mm for constant values of RVOTS. This means that for every value of RVOTS, TAPSE would have a CI of ±2.6 mm in a population in which TAPSE ranges from 5 to 24. This information, along with the absence in the literature of a reference value for normal population, suggests that further study is needed for a better definition of the relationship between TAPSE and RVOTS.

This study is the first analysis on the prognostic indices for PE detected by ECG in the emergency medicine literature.

LIMITATIONS

The most important limitation of our study is that we analyzed a highly select population in which the diagnosis of PE was already done, although the first ECG was performed in the ED soon after the CT angiogram.

CONCLUSION

ECG represents an invaluable instrument for the definition of prognosis of patients with PE. Even though an index or ECG sign that is more specific than another does not exist, each one supports the classification as an "intermediate-risk patient," and only the absence of any sign of RV dysfunction predicts a good short-term prognosis.

In intermediate-risk patients AT, RV diameter in all views, LV diameter in parasternal long-axis and subcostal long-axis views, and the RV/LV ratio in apical 4-chamber and subcostal long-axis views could also be investigated to obtain information about diagnosis and rate of improvement in right heart dysfunction.

Moreover, although it is also recognized that massive acute pulmonary embolism causing a hemodynamic instability is the clearest indication for thrombolytic agents, thrombolysis is probably useful in some patients with hemodynamic stability. This study attempts to identify how many and which patients are the best candidates. We found that those patients with low bleeding risk affected by intermediate-risk PE in which TAPSE is depressed and PASP is elevated could benefit from a thrombolytic therapy. This would result in a short-term improvement in RV function compared to those patients treated with heparin alone. Finally, patients in whom DIVC remains elevated after 1 month will maintain the RV dysfunction, with the long-term risks related to this condition. Further investigations, with a larger sample size will be needed to confirm these data.

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

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Emergency Department Crowding and Time to Antibiotic Administration in Febrile Infants

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Supervising Section Editor: Judith R. Klein MD
Submission history: Submitted April 13, 2012; Revision received November 5, 2012; Accepted January 21, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.1.14693

Introduction: Early antibiotic administration is recommended in newborns presenting with febrile illness to emergency departments (ED) to avert the sequelae of serious bacterial infection. Although ED crowding has been associated with delays in antibiotic administration in a dedicated pediatric ED, the majority of children that receive emergency medical care in the United States present to EDs that treat both adult and pediatric emergencies. The purpose of this study was to examine the relationship between time to antibiotic administration in febrile newborns and crowding in a general ED serving both an adult and pediatric population.

Methods: We conducted a retrospective chart review of 159 newborns presenting to a general ED between 2005 and 2011 and analyzed the association between time to antibiotic administration and ED occupancy rate at the time of, prior to, and following infant presentation to the ED.

Results: We observed delayed and variable time to antibiotic administration and found no association between time to antibiotic administration and occupancy rate prior to, at the time of, or following infant presentation ($p>0.05$). ED time to antibiotic administration was not associated with hospital length of stay, and there was no inpatient mortality.

Conclusion: Delayed and highly variable time to antibiotic treatment in febrile newborns was common but unrelated to ED crowding in the general ED study site. Guidelines for time to antibiotic administration in this population may reduce variability in ED practice patterns. [West J Emerg Med. 2013;14(5):518–524.]

INTRODUCTION

Emergency department (ED) crowding has become a prominent public health concern, compromising patient safety and the delivery of emergency medical care.[1-11] Children are at particular risk for poor outcomes because not all EDs have the requisite skills, staffing, and equipment necessary to comprehensively treat pediatric emergencies.[1,12] The majority of children in the U.S. are treated in general, community EDs with a minority cared for in a dedicated pediatric ED.[12-14] It has been suggested that children may be vulnerable to delays in treatment in the crowded general ED if time-sensitive quality performance indicators for adults take precedence over the treatment of children.[13] Although less likely, concerns have also been raised that pediatric patients may suffer delays in emergency medical care due to the need for age- and weight-specific medication administration by providers unfamiliar with pediatric dosing

regimens.[13] Despite concern over the potential effect of ED crowding on children, few studies have addressed the impact of crowding on pediatric outcomes specifically.[13,15,16]

The febrile infant ≤ 28 days of age represents a clinical challenge due to the immaturity of the newborn's immune system and the potential for serious infection without clinical signs of illness.[17] Despite a normal examination, approximately 10% of these children may have a serious bacterial infection, including up to 3% with meningitis or bacteremia.[18-20] Thus, these infants may be at increased risk for adverse outcomes if delays in treatment occur due to ED crowding. Although specific guidelines for timing of antibiotic administration in this population do not exist, it is well established that early antibiotic administration reduces morbidity and mortality in patients with sepsis, especially in immune compromised children with fever.[21-25] One single-site study suggested that febrile infants ≤ 28 days of age be given antibiotics within 120 minutes of ED triage to prevent morbidity associated with serious bacterial infection.[26] Although delays in antibiotic administration have been reported in this population,[16,26] the relationship between crowding in the general ED, where the majority of children receive emergency care, and time to antibiotic administration has not been examined.[16] The purpose of this study was to test the hypothesis that crowding in a general ED is associated with prolonged time to antibiotic administration in febrile newborns.

METHODS

Study Design and Setting

Researchers performed a retrospective review of the electronic medical record (EMR) of all infants ≤ 28 days of age who were admitted to the hospital from the ED with a chief complaint of fever, respiratory or gastrointestinal symptoms or a final ED or hospital diagnosis of fever, pneumonia, urinary tract infection, pyelonephritis, meningitis, peritonitis, cellulitis, sepsis, severe sepsis, septic shock, bacteremia, other infections specific to the perinatal period, congenital pneumonia or omphalitis of the newborn from October 1, 2005 to July 1, 2011.

The study site is a tertiary-care, university hospital and Level I Trauma Center located in the Southeastern United States. The hospital contained 740 beds in 2005 and 850 beds in 2011. The study site is located in a moderately-sized urban community with a county-wide population of approximately 250,000. The ED annual patient census was 43,000 in 2005, increasing to 80,000 visits in 2011. The ED serves a mostly White (62%) population with a range of payer sources (40% public, 36% private and 24% uninsured), and children comprised 20% of the general ED patient population from 2005-2011. During the study period, the ED provided treatment to pediatric and adult emergencies.

Sample Size Determination

Based on a pediatric ED study in which hourly boarding was associated with significantly delayed antibiotic administration (adjusted R^2 of a multiple regression model = 0.153),[16] a sample size of 80 infants was required to detect an $R^2 = 0.15$ or higher for a multiple regression model with 5 predictors between time to antibiotic administration and ED crowding with a power of 80% and significance set at 0.05.

Selection of Participants

Inclusion Criteria

Infants ≤ 28 days of age admitted through the ED with the previously defined ED chief complaints or final ED or hospital diagnoses were eligible for study inclusion.

Exclusion Criteria

Newborns who did not receive parenteral antibiotics in the ED or whose time to antibiotic administration was not recorded in the EMR were excluded from analysis.

Study Protocol

Data collection was performed by 4 trained abstractors. At least 2 abstractors reviewed each infant chart, and discrepancies were resolved by consensus. For each infant ED visit, the following time-related data elements were extracted from the EMR through the hospital's information system or by abstractor review: (1) date and time of arrival; (2) date and time of triage; (3) date and time seen by a physician; (4) date and time antibiotic ordered; and (5) date and time antibiotic administered. Demographic and clinical data collected from the EMR included age (in days), gender, race, payer category (Medicaid, private or uninsured), initial temperature, triage severity score, chief complaint, ED and hospital discharge diagnosis, hospital length of stay and inpatient mortality. Crowding measures for the 6 hours prior to, the hour of, and 4 hours following infant arrival were obtained from the ED's information system designed for operational monitoring.

Measures

Predictor Variables

We determined ED occupancy rate by dividing the ED hourly census, regardless of patient location, by the total number of licensed ED treatment bays (which exclude hallways).[27] Occupancy rates were calculated at the top of the nearest hour, based on time of infant arrival. ED occupancy rate is a simple, reproducible and validated measure of ED crowding that has been identified as a preferred method for comparing crowding across treatment sites.[27]

A limitation of prior studies that link crowding to patient outcomes is that most studies report crowding as a static measure at a single point in time.[16,28] In fact, ED crowding is a dynamic measure that may vary substantially prior to or during a patient's ED encounter, thereby affecting quality of care and outcomes.[28] To determine the effect of changes in crowding on time to antibiotic administration, our study assessed occupancy rate at the top of each hour for the 6 hours prior to, the hour of, and 4 hours following infant presentation.

Outcome Variables

Consistent with previous reports, the primary outcome is defined as time from infant arrival to antibiotic administration.[16] Additional timeliness-of-care measures were recorded so that if delays in care were observed, it would be possible to assess at what stage(s) in the care process delays occurred and to target quality improvement initiatives accordingly. Timeliness-of-care measures were (1) time from arrival to triage, (2) time from triage to physician assessment, (3) time from physician assessment to antibiotic order, (4) time from antibiotic order to drug administration and (5) time from triage to antibiotic administration.[16,26]

Secondary Outcome Measures

To examine the potential effect of delays in processes of care on time to ED drug treatment, we determined the association of each of the timeliness-of-care measures on time to antibiotic administration. To examine the effect of time to ED treatment on patient outcome, the association of time to antibiotic administration with hospital length of stay and inpatient mortality was determined.

Analysis

We calculated frequency distributions for categorical variables and medians and ranges for continuous variables. Bivariate analysis using Spearman correlation coefficients were calculated to test the association between ED occupancy rate prior to, at the time of, and after infant arrival with time to antibiotic administration and the timeliness of care measures. We developed multiple linear regression models for time to antibiotic administration and timeliness of care measures to control for patient age, triage severity score, and time of infant arrival (day, afternoon or night) as previously described.[16] We also conducted bivariate analysis to test the association between time to antibiotic administration and the timeliness-of-care measures, as well as length of hospital stay. Occupancy rate and time to antibiotic administration were positively skewed and therefore, the analysis was focused on the median rather than the mean rates and times. We considered a p-value < 0.05 statistically significant. The statistical software JMP v9.2 (SAS Institute, Cary, North Carolina) was used for the analyses. The institutional review board of the study site approved the study in advance.

RESULTS

Characterization of Study Subjects

One hundred ninety newborns admitted through the ED during the study period met the chief complaint or discharge diagnosis eligibility criteria. Of these, 31 were excluded due to: (1) failure to receive antibiotics during the ED encounter (22 infants); (2) the time of antibiotic administration was not recorded in the EMR (2 patients); or (3) age > 28 days at the time of ED presentation (7 infants). Baseline characteristics of the study population (159 infants) are outlined in Table 1.

Table 1. Patient characteristics and presenting complaints.

Sample size	159
Age in days (mean ±SD)	15.4±8
Gender (number of males, %)	89 (55%)
Race (n, %)	
White	105 (66%)
Black	30 (18%)
Other	24 (16%)
Payer status (n, %)	
Medicaid	71 (45%)
Private	26 (16%)
Uninsured	62 (38%)
Chief complaint	
Fever	103 (65%)
Respiratory complaint	18 (11%)
Gastrointestinal complaint	9 (6%)
Other	29 (18%)

SD: Standard Deviation

Main Results

Effect of Occupancy Rate on Time to Antibiotic Administration

Table 2 summarizes the results of the bivariate analyses examining the association between occupancy rate and time to antibiotic administration. Median occupancy rate on infant arrival was 75.4% (range 25.5-161.3%). Median time from infant arrival to antibiotic administration was 216 minutes (range 43-848 minutes) and was not significantly associated with occupancy rate at the time of infant presentation (p>0.05) (Table 2) or to occupancy rate in any of the 6 hours prior to or 4 hours following patient arrival (all p>0.05). When adjusted for patient characteristics, only triage severity on infant arrival had a significant positive association with overall time to antibiotic administration (R^2 0.07, p<0.02).

Table 2 also summarizes the results of bivariate analyses examining the association between occupancy rate and other timeliness-of-care measures. There was marked variation in all timeliness-of -care measures. Time from infant arrival to triage ranged from 0-102 minutes and time from physician assessment to antibiotic order ranged from 3-494 minutes. With the exception of time from triage to physician assessment, occupancy rate prior to, at the time of, or following infant presentation was not significantly associated with timeliness-of-care measures in bivariate tests (all p>0.05). There was a positive and significant association between time from triage to physician assessment and occupancy rate at the time of (r=0.2, p =0.005) and for the 4 hours after infant arrival (Table 2). Timeliness-of-care measures did not have a statistically significant relationship with occupancy rate in models adjusted for patient age, triage severity, or time of arrival (all p>0.05) (data not shown).

Table 2. Correlation of timeliness-of-care measures with overall time to antibiotic administration and emergency department (ED) occupancy rate. Time to antibiotic administration is defined as the time in minutes from infant arrival to antibiotic administration. Non-significant (NS) at p>0.05. T-6 represents hour 6 prior to infant presentation; T0 represents time of infant arrival and T+4 represents hour 4 following infant arrival.

Timeliness-of-care Time in minutes (range)	Correlation with time to antibiotic administration r (significance)	Correlation with ED occupancy rate before, at the time of, and following infant arrival r (significance)	
Infant arrival to triage 21 (0-102)	r=0.1 (ns)	T-6 T 0 T+4	r=0.0 (ns) r=0.1 (ns) r=0.1 (ns)
Triage to physician assessment 8 (-78-208)	r=0.5 (p<0.0001)	T-6 T 0 T+4	r=0.1 (ns) r=0.2 (p=0.005) r=0.2 (p=0.0027)
Physician assessment to antibiotic order 85 (3-494)	r=0.8 (p<0.0001)	T-6 T 0 T+4	r=0.0 (ns) r=0.0 (ns) r=0.0 (ns)
Antibiotic order to administration 64 (48-333)	r=0.4 (p<0.0001)	T-6 T 0 T+4	r=0.0 (ns) r=0.0 (ns) r=0.0 (ns)
Triage to antibiotic administration 187 (25-817)	r=0.9 (p<0.0001)	T-6 T 0 T+4	r=0.0 (ns) r=0.0 (ns) r=0.0 (ns)
Time to antibiotic administration 216 (43-848)		T-6 T 0 T+4	r=0.0 (ns) r=0.1 (ns) r=0.0 (ns)

Effect of Timeliness of Care Measures on Time to Antibiotic Administration

With the exception of time of arrival to infant triage, there was a significant association between each of the timeliness-of-care measures and overall time to antibiotic administration (all p<0.0001) (Table 2). Time from physician assessment to antibiotic order accounted for the greatest variability in time to ED antibiotic administration ($R^2 = 0.58$, p<0.0001) (Table 2).

Effect of Time to Antibiotic Administration on Patient Outcome

There was no association between time to antibiotic administration and overall length of hospital stay (median 2 days; range 1-45 days) (r = 0.0; p>0.05) and there were no inpatient deaths in the study population.

DISCUSSION

Dramatic increases in ED crowding have occurred over the past 2 decades associated with patient and provider dissatisfaction, treatment delays, and patient mortality.[1-11,29] Although the Institute of Medicine identified the impact of ED crowding on children as a priority research area, few studies have examined the relationship between ED crowding and pediatric specific outcomes.[12-16] We undertook this investigation to examine the relationship between time to antibiotic administration in febrile newborns and crowding in a general ED. The results of this study demonstrate that delays in antibiotic administration are common in febrile neonates presenting to the general ED, but these delays do not appear to be related to ED crowding. To evaluate the robustness of this finding, we tested occupancy rate measured at different points before, during, and after infant presentation. We were unable to detect a significant correlation between occupancy rate and the primary outcome measure of time from infant arrival to antibiotic administration. The results of this study address a significant gap in the literature by examining the dynamic effect of ED crowding on time to antibiotic administration in febrile newborns. Further, the majority of children in the U.S. receive emergency care in facilities treating both adult and pediatric populations.[12-14] Our results are relevant to the emergency care received by most children in that we report the effect of ED crowding on time to antibiotic administration in an ED treating both adults and children.

Although we documented prolonged and variable time to antibiotic administration in this study, we did not detect an association between delayed antibiotic administration and length of hospital stay in these children. Further, there was no inpatient mortality in this cohort. This finding is consistent with the decreasing trend in mortality of all infants presenting with febrile illness and sepsis in the U.S. Other, more sensitive, determinants of patient outcome may be necessary to fully examine the potential effect of delays in ED treatment on the outcome of neonatal sepsis.

Although it is important to evaluate the impact of ED crowding on pediatric outcomes, these evaluations need to be considered in the context of initiatives that improve the quality of ED care delivered to children. For example, although Sills et al[15] found an inverse relationship between crowding and good quality care, they also reported an adjusted relative risk of receipt of

good quality fracture care that was less than 20% during the least crowded conditions.Thus, focus on lower quality care during periods of greatest crowding may obscure the more significant issue that most children did not receive good quality fracture care, even when the pediatric ED was least crowded.[15]

The delayed and variable time to antibiotic administration reported in this and other investigations may speak to the need for improvement in ED quality-of-care processes for children, regardless of crowding conditions.[16,26] In this context, it is noteworthy that with the exception of time from infant arrival to triage, each of the process-of-care measures was positively and significantly associated with time to antibiotic administration. Importantly, time from physician assessment to placement of antibiotic order accounted for the greatest variability in overall time to antibiotic treatment. Ensuring emergency physicians recognize neonatal sepsis and are aware of treatment recommendations in newborns with fever or other presenting complaints may impact time to treatment. In addition, in regression models adjusted for patient characteristics, time to antibiotic administration was significantly associated with triage severity score at infant presentation. These results suggest that ensuring febrile newborns are assigned an emergent triage classification may reduce time to antibiotic administration.

The prolonged time to antibiotics observed in very young febrile infants suggests there may be a need for clear guidelines for timing of antibiotic administration in these children.[16,26] Although infants > 28 days and older children with low risk of serious bacterial infection can be successfully identified through careful screening procedures,[30-32] these screening protocols are not sufficiently sensitive in infants ≤ 28 days of age to detect serious bacterial infection.[19,33] Although controversy exists regarding routine use and timing of antibiotic administration,[34] investigators have demonstrated adverse outcomes in children with serious infection secondary to delayed antibiotic administration.[23] Taken together, the existing evidence suggests that the risk of serious bacterial infection in very young infants may be present without clinical signs of illness and that adverse outcomes may be associated with delays in appropriate antibiotic therapy. Although current recommendations suggest that infants 28 days of age and younger with fever require *immediate* empirical antibiotic administration, clearly defined time-to-treatment guidelines do not exist. [17-20,25,26]

Physician adherence to clinical practice guidelines in the ED is historically poor.[35] This may be in part a consequence of the perception that guidelines are cumbersome and time-consuming.[35] However clinical practice guidelines are designed to communicate the best available evidence to busy clinicians and if used effectively, reduce variations in healthcare practice. Examples of successful quality improvement initiatives in emergency care have been published. For example, clinical guidelines have been used in a pediatric ED to improve the efficient treatment of acute exacerbations of childhood asthma.[35] Further evidence of the benefit of treatment guidelines is provided by findings from a pilot quality improvement project in which investigators reported decreased time to antibiotic administration and an increased proportion of children receiving antibiotics in response to newly established quality guidelines.[36] Of particular relevance to the present study, an ED quality improvement process reduced time to antibiotic administration by 25% in febrile infants less than 3 months of age.[26] Thus, clinical guidelines may improve timeliness of care and may also remove observed variation in processes of care.

LIMITATIONS

A limitation of this investigation is the fact that long-term patient follow up was not possible because many children had inconsistent or no subsequent care at the study institution. Further, time to antibiotic administration was determined in one ED treating adult and pediatric emergencies and therefore, the results may not be generalizable to all general and community EDs, particularly those with protocols to initiate pediatric consultation immediately after ED physician evaluation. However, the prolonged and variable time to antibiotics reported here is similar to a recent study in a pediatric ED[16] and suggests that delayed and variable time to antibiotic administration may be a pervasive problem in this population. Importantly, although time from physician assessment to placement of antibiotic order accounted for much of the variation in time to ED treatment in this study, the reasons for the observed variations in practice patterns are not clear. Our models explained only some of the observed variation in time to antibiotic administration, suggesting that undefined confounding variables influence this measure. Some have reported that differences in provider experience and confidence in recognizing serious bacterial infection[37] and variations in clinical presentation and illness severity of the child may account for variations in clinical practice.[38]

CONCLUSION

The results of this investigation demonstrate that prolonged and highly variable time to antibiotic administration was common in very young infants with fever presenting to a general ED. Time to antibiotic administration was not significantly associated with ED crowding before, during, or after infant presentation. Importantly, time to ED antibiotic administration in febrile newborns was significantly associated with several processes-of-care measures and patient characteristics, including time from physician assessment to placement of drug order and infant Emergency Severity Index (ESI). Efforts to raise awareness of the emergent nature of neonatal fever and guidelines on time to ED antibiotic treatment in this population merit consideration.

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

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Need for Intervention in Families Presenting to the Emergency Department with Multiple Children as Patients

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Supervising Section Editor: Jeremey Hess, MD, MPH
Submission history: Submitted March 30, 2012; Revision received May 22, 2012; Accepted January 21, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.1.12059

Introduction: To assess if families presenting to a pediatric emergency department (PED) with multiple children as patients require interventions at the same rate as families presenting with a single child.

Methods: This is a retrospective chart review looking at PED encounters for families presenting with single children versus multiple children as patients. Patients presenting with siblings were retrospectively selected from the electronic tracking board, and we randomly selected age/gender matched single-patient controls from a comparable time period. The primary outcome was a comparison of visit acuity between families presenting with single versus multiple children, with the hypothesis that families presenting with multiple children as patients would require less utilization of services (as a surrogate for acuity). Admission, intravenous fluid administration (IVF), planned observation, subspecialty consultation, performance of procedures, laboratories and radiographs, administration of prescription medications, and prescription medications for home were all recorded and compared via chi-squared comparison. We considered 5 interventions (admission, subspecialty consultation, performance of procedures, IVF administration, and observation > 6 hours) "critical interventions" and compared them separately.

Results: In our sample of 83 patients from 41 families registering multiple children and 248 singleton controls, we found a significant difference in the percentage of patients requiring critical interventions (4.8% versus 32.5%, $P < 0.0001$).

Conclusion: Families presenting with multiple children concurrently to an ED require critical interventions at a much lower rate than children presenting as single patients. Many of these families could be well-served at an urgent care or primary care provider. [West J Emerg Med. 2013;14(5):525–528.]

INTRODUCTION

It is not uncommon for families to bring multiple children for evaluation in the pediatric emergency department (PED) at a single visit. From our personal experience in an urban PED, these children often require less emergency department (ED) resources than patients presenting individually. Such non-acute visits can pose an obstacle to throughput and optimal use of the ED. A recent study by Kannikeswaran, et al[1] investigated the epidemiology of such visits to an inner city ED and concluded that these patients have lower triage acuity and low hospital admission rates when compared with the general patient population of individual pediatric ED patients. To our knowledge, no other studies have been published on families presenting to the ED with multiple children as patients.

Defining which patients require ED care is a challenge. Studies looking at the use of EDs by "non-urgent" patients

typically define these patients by triage acuity, need for procedural intervention, physician time, or by physician judgment of the need for evaluation or care within 24 hours.[2-5] The American College of Emergency Physicians (ACEP) defines an emergency as "any medical condition of recent onset and severity, including but not limited to severe pain, that would lead a prudent layperson, possessing an average knowledge of medicine and health, to believe that his or her condition, sickness, or injury is of a nature that failure to obtain immediate medical care could result in placing the patient's health in serious jeopardy, serious impairment of bodily function, or serious dysfunction of bodily organ or part."[6] When the "prudent layperson" is asked to rate symptoms as emergent, only 29% of symptoms are consistently rated emergent, and common symptoms, such as nausea, vomiting, coughing, fever, and abdominal pain, are not rated emergent.[7] When this is extrapolated to pediatrics, parents tend to slightly overestimate the acuity of non-urgent scenarios. When confronted with non-urgent scenarios and asked to rank them on a Likert scale where 5 represents least urgent, the "prudent layperson" mean score was 3.7 out of 5.[8] Clearly, patients attend EDs because of overestimation of illness severity, convenience, lack of insurance or primary care, transportation issues, and need for reassurance. These factors are important, but do not modify the actual acuity of a patient's illness.

In this study, we sought to look at the actual need for urgent intervention in children of families registering multiple patients at once versus those registered alone. We hypothesized that a low proportion of such multiple patient visits would warrant a critical ED intervention when compared with singleton patient encounters.

METHODS

Study Setting and Population

This study was performed at an urban ED with a dedicated PED from April to July 2011. Consecutive families registering more than 1 child simultaneously for ED care were selected from the electronic patient tracking system retrospectively within 4 days of their registration (the duration for which the tracking board is stored). Once these patients were identified, controls were chosen by retrospectively selecting day(s) during the study period and consecutively enrolling age- and gender-matched patients from the electronic tracking board.

Study Design

This is a retrospective analysis. A notation is made on the tracking board if a family registers multiple children, and this information is stored for 96 hours. Once patients were selected from the tracking board by the primary investigator, ED records were obtained for each patient and evaluated by the 2 co-authors. Blinding was inconsistent, as most charts for the families registering multiple children indicated the presence of a sibling. Each patient was treated as an independent data point. In families presenting with multiple children, no "index patient" was selected because the retrospective nature of the study did not allow the investigators to determine which child the parent had indicated a greater level of concern for. Investigators completed a data sheet to record demographic information, disposition, and interventions. We eliminated patients with incomplete data (charts not scanned into the computer for analysis). Laboratory and radiology records were reviewed as well to insure thoroughness of data collection. The local Internal Review Board approved this study.

Outcome Measures/ Definition

Our primary outcome measure was the need for any "critical intervention" in the ED, which was defined as a hospital admission, planned observation of 6 hours or greater (documented by the provider), any subspecialty consultation, administration of intravenous fluids, performance of a procedure (e.g. suturing, urinary catheterization, splinting). The literature is silent on which interventions are commonly performed in the offices of primary care providers who care for children. Thus, this list was developed based on calls to and website assessment of local providers. Since most providers do provide medication, laboratory services, and radiographs, need for these interventions was collected, but analyzed separately. We chose to assess interventions rendered as the outcome measure for several reasons. As a retrospective study, these parameters are collectable with relative objectivity. Assigned triage acuity is similarly objective, but with 41% underestimation of acuity and variable inter-provider correlation.[9-10] As our triage system, the Emergency Severity Index is based on need for intervention; we elected to make the eventual need for a critical intervention our outcome measure.

Data Analysis

We performed a sample size calculation to identify a 20% difference between groups, assuming that 40% of patients presenting to the PED would require an intervention. This indicated that 82 patients would be required per group. For the final analysis of interventions, we elected to collect 3 control patients per study patient, or 246 single patients, to minimize the chance of an alpha error. We used chi-squared testing to compare the proportion of patients ultimately requiring intervention in Group Multiple or GM (families with multiple children registering simultaneously) with that of Group Single or GS (single patients).

RESULTS

We identified 83 patients for GM, all of whom had adequate data sets. This represented 41 families, 3 of which presented with 3 children as patients and the rest presenting with 2 children as patients. Initially 248 were identified for GS, of whom 18 were eliminated for missing data, leaving 230

Table 1. Demographic information of sibling pediatric patients presenting to the emergency department.

	Group Multiple	Group Single
Female/ male (%)	48/52	49/51
Age in years (mean)	5.5	5.4
Latino/other (%)	94	93
Presentation from 7AM-3PM/ 3PM-11PM/11PM-7AM (%)	47/42/11*	29/44/27*
Insurance (% state sponsored/ no insurance/ private)	84.3/15.7/0	83.4/13/3.6
ESI triage category (%1/2/3/4/5)	0/3.6*/28.9*/63.9*/3.6	0/19.2*/51.8*/27.7*/1.2

* significance of < 0.05

patients in that group. Patient demographics are detailed in Table 1. Breakdown of category of chief complaints is detailed in Table 2.

Four of the GM patients (4.8%) required any of the "critical" variables (admission, IVF, performance of a procedure, urgent subspecialty consult, and planned observation period > 6 hours), with 1 requiring an admission, 1 requiring a splint, 1 requiring a 6-hour period of observation, and 1 requiring a burn service consultation. Two of the children requiring a critical intervention were from the same family. Therefore, only 3 of the 41 families (7.3%) had any child requiring a critical intervention. In the GS group, 32.5% patients required a critical intervention ($P < 0.0001$), with 19% requiring an admission. The difference between the groups was significant for each of the critical variables except > 6 hours observation ($P = 0.464$). Percentages of each group requiring each intervention are shown in Figure 1.

When any intervention (including laboratories, radiographs, medication administration, or medication prescription for home as well as the critical interventions) was considered, 62% of patients in GM and 71% of the patients in GS required an intervention. This result was not significant with a *P*-value of 0.103. The most commonly required interventions in both groups were use of imaging, laboratories, and prescription medications.

LIMITATIONS

Being a retrospective study, our sample is limited by provider documentation. We attempted to use objective measures and access multiple data sources (patient records, lab data, etc.) to minimize this concern. This study was inspired by a sense that families presenting with multiple children as patients represent a less-ill sample than children registering independently, and this perception may have altered physician behavior. While all physician behavior is subjective to some degree, it seems unlikely that patient admission or performance of a procedure would have been altered due to such bias. Additionally, there are inherent limitations to any surrogate marker of the acuity of a patient's presentation. The need for critical procedures was our marker, as it seemed the most objective; however, this system will clearly miss certain patients whom any "prudent layperson" would consider emergent. For example, the febrile seizure patient may receive none of these interventions, though most laypeople, and perhaps many medical professionals, would appropriately seek emergency care for such a complaint. It is also notable that the groups differed in terms of their time of presentation. This could be due to a myriad of different factors from parental perception of degree of illness to availability of transportation and is an observation that merits further investigation, but is beyond the scope of this study. Finally, there are several threats to generalizability. We included an overwhelmingly underinsured Latino population during a 4-month period in the late spring and summer. It is possible, with the seasonal nature of illness, that the make-up of patients would be different at another point in the year or in a different practice setting.

CONCLUSION

In families presenting to the ED with multiple children as patients, only 4.8% of patients required a critical ED intervention, a significantly lower proportion than found in patients registering without siblings. When all interventions were considered, there was no significant difference between the groups. Therefore, while it is likely that the majority of children required medical care, over 95% of the GM could have been seen in a primary care setting.

The concept of the ED as primary care has been well substantiated in the literature, particularly in an underinsured population. Just over half of parents presenting to a PED assess their child's complaints as "minor" or "somewhat urgent." Over half of parents who have a primary care provider (PCP) for their child do not attempt to contact them prior to presentation to an ED.[11] In those patients who visit the ED after attempting to call the PCP, only 6% were able to make contact, and the majority were directed to the PED.[12] Patients in the PED with non-urgent complaints tend to have high expectations and can potentially require provider time disproportionate to their level of acuity.[13]

The ED is used for non-emergent illnesses for a number of reasons, including lack of cost awareness, organizational problems in primary care, better convenience and availability, illness perception, and confidence in ED services.[14] In a systematic review, the preponderance of data indicated a decrease in ED usage with increase in primary care centers and broadening of hours. Telephone triage and education interventions targeting patients had no lasting impact.

Table 2. Information regarding nature of chief compliants.

Chief complaint category	Group multiple	Group single
Trauma	10%	19.6%
Upper respiratory tract infection	20.5%	8.4%
Other ENT compaints	10.8%	8.4%
Abdominal pain	1.2%	10%
Other GI tract complaints	8.4%	7.3%
Exacerbation of chronic disease	0%	2.4%
Other respiratory/cardiac symptoms	1.2%	2.4%
Fever	21.6%	20.5%
Other	25.4%	20.5%

ENT, otolaryngology; *GI*, gastrointestinal

Insurance with cost-sharing of the ED visit by the patient is associated with less ED use than coverage with no patient cost-sharing.[15] Oregon's experience with tightening of Medicaid restrictions, including institution of a $50 co-pay for ED visits (versus $5 for primary care), showed a 6% decrease in ED use by Medicaid recipients, but did not report on potential adverse consequences of those abandoned ED visits.[16]

In our study sample, families presenting with multiple children as patients mainly fell into this non-urgent category in terms of need for ED resource use. The majority of these patients' complaints could likely be addressed by a PCP visit. Every effort should be made to improve systems that allow families to use primary care in this setting.

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

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Racial Disparity in Duration of Patient Visits to the Emergency Department: Teaching Versus Non-teaching Hospitals

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Supervising Section Editor: Trevor Mills, MD, MPH
Submission history: Submitted May 21, 2012; Revision received November 30, 2012; Accepted March 25, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.3.12671

Introduction: The sources of racial disparity in duration of patients' visits to emergency departments (EDs) have not been documented well enough for policymakers to distinguish patient-related factors from hospital- or area-related factors. This study explores the racial disparity in duration of routine visits to EDs at teaching and non-teaching hospitals.

Methods: We performed retrospective data analyses and multivariate regression analyses to investigate the racial disparity in duration of routine ED visits at teaching and non-teaching hospitals. The Healthcare Cost and Utilization Project (HCUP) State Emergency Department Databases (SEDD) were used in the analyses. The data include 4.3 million routine ED visits encountered in Arizona, Massachusetts, and Utah during 2008. We computed duration for each visit by taking the difference between admission and discharge times.

Results: The mean duration for a routine ED visit was 238 minutes at teaching hospitals and 175 minutes at non-teaching hospitals. There were significant variations in duration of routine ED visits across race groups at teaching and non-teaching hospitals. The risk-adjusted results show that the mean duration of routine ED visits for Black/African American and Asian patients when compared to visits for white patients was shorter by 10.0 and 3.4%, respectively, at teaching hospitals; and longer by 3.6 and 13.8%, respectively, at non-teaching hospitals. Hispanic patients, on average, experienced 8.7% longer ED stays when compared to white patients at non-teaching hospitals.

Conclusion: There is significant racial disparity in the duration of routine ED visits, especially in non-teaching hospitals where non-White patients experience longer ED stays compared to white patients. The variation in duration of routine ED visits at teaching hospitals when compared to non-teaching hospitals was smaller across race groups. [West J Emerg Med. 2013;14(5):529–541.]

INTRODUCTION

A number of studies have addressed racial disparities across healthcare settings.[1-10] The literature documents that Blacks/African Americans experience reduced access to regular health care due to lower rates of health insurance coverage, poorer access to primary care, and more frequent use of emergency departments (EDs).[4] And once they have entered the healthcare system, the quality of care for Blacks has been found to be lower than for Whites.[11-12] Several studies concluded that poorer health outcomes could be due to lower-quality hospital care and a lower likelihood of receiving specific indicated interventions.[13-17] The sources of racial disparity in EDs have not been documented well enough for policymakers to distinguish patient-related factors from hospital- or area-related factors.

The hospital ED is a primary portal of entry into the healthcare system for many Americans. Length of stay (LOS) is generally perceived as an important indicator of quality of care in EDs.[18] Increased LOS at EDs may contribute to systematic problems in the delivery of efficient and high quality medical care in the U.S. Increased LOS may also mean patients wait longer to see ED physicians and to obtain

critical treatments and test results.[19,20] Several studies have documented that extended LOS is usually due to evaluation time by a physician for critical testing, treatment, and bed placement.[21] Variation in ED LOS provides a good opportunity to study racial disparity because it is affected by a number of complex public health and healthcare facility-related issues. One study showed that disparities in waiting times exist in emergency care and that black patients wait longer to see emergency physicians than white patients.[22] A few studies used the National Hospital Ambulatory Medical Care Survey to document racial disparity in ED LOS for admitted patients.[23-26] Several studies in the literature found no evidence of racial or ethnic disparity in use of emergency care or in ED LOS.[27-29]

The objective of this study was to determine whether racial disparities in duration of ED visits exist at teaching and non-teaching hospitals. ED visits for this study are limited to routine visits in which the patients are discharged for home or self care. This study contributes to the existing literature in the following important ways: First, existing studies examining racial disparity in ED LOS and general resource use employ data drawn from a sample of ED visits obtained from a survey or tracked as part of a before-and-after intervention study.[30] One of the largest of these data files is a nationally representative sample of 138,569 ED visits over a 5-year period.[20] In contrast, our data file includes 4.3 million ED visits in a single year. Healthcare policies designed to provide solutions to increased ED LOS, ED crowding, and related issues may produce better outcomes when they are based on these large data sets. Such large databases may also shed light on the wide variations in use patterns of ED services and the significant differences in patient-related and area-specific factors.[31] Second, our findings may inform public and private policymakers on a broad range of issues, including, but not limited to, the variation in duration of routine ED visits by patient race group, age, gender, insurance coverage, and disease category; by hospital bed size, location, system membership, trauma center classification, and ownership status; and by geographic income distribution. Third, our study is also the first, to our knowledge, addressing racial disparity in ED LOS by hospital type. We compare the duration of routine ED visits across race groups in teaching and non-teaching hospitals, as the former generally treat more severe or clinically complex patients compared to the latter. Finally, this study further contributes to the existing literature by addressing several important factors affecting ED LOS,[32-41] i.e., hospital ED visit volume and ED admission day of the week.

METHODS

Study Design and Population

We performed retrospective data analyses and multivariate regression analyses to investigate the racial disparity in the duration of routine ED visits that were discharged for home or self care using the Healthcare Cost and Utilization Project (HCUP)[1] State Emergency Department Databases (SEDD) for 2008. HCUP is maintained by the Agency for Healthcare Research and Quality (AHRQ). The SEDD employed in this study include data on 4.3 million routine ED visits in 3 states: Arizona, Massachusetts, and Utah. In general, the SEDD provide detailed diagnoses, procedures, total charges, and patient demographics. Demographics include gender, age, race, and insurance coverage (i.e., Medicare, Medicaid, private insurance, other insurance, and uninsured). However, the SEDD from these 3 states also provide admission and discharge time for each visit, from which duration[2] may be calculated.

We obtained information about hospital characteristics (i.e., urban versus rural, ownership status, teaching status, bed size, and system membership) from the 2008 American Hospital Association Annual Survey Database and linked that data to SEDD files using hospital identifiers. In addition, we obtained information about the trauma level of the hospital using the Trauma Information Exchange Program database, collected by the American Trauma Society and the Johns Hopkins Center for Injury Research and Policy. Finally, we used the 2008 Area Resource File[3] to obtain county-level income information.

A value for ED LOS is not readily available in our data. We computed the duration for each visit by taking the difference between admission and discharge times, which is the time patients waited in ED rooms plus their treatment time (the time spent with doctors).[32] Our measure of duration does not include boarding time because our ED data file includes information for only treat-and-release patients, not admitted ones. Therefore, we do not believe that the lack of separable ED LOS measures (i.e., waiting room time and treatment time) compromises our results because we use the same measures of ED LOS for all race groups within each hospital. More specifically, we assume that ED treatment time for patients with the same clinical conditions, age, and gender are similar regardless of their race groups. However, there might be some variation in ED waiting room time within and across hospitals. Our analytic approach addresses this issue. Hence, if we document that there is racial disparity in duration of ED visits as defined above, we can attribute that disparity mostly to ED waiting room time because our multivariate analysis of ED duration, explained in detail below, controls for the severity of clinical cases and other socio-economic

1. Further details about HCUP databases are available at http://hcup-us.ahrq.gov/.
2. Some data elements, such as admission times and discharge times, are considered too sensitive by HCUP data organizations for general release to public. However, we received special permission to have access to these more sensitive data for analysis. In this study, the Arizona Department of Health Services, the Massachusetts Division of Health Care Finance and Policy, and the Utah Department of Health granted permission for the admission hour and discharge hour data elements.
3. The Area Resource File (ARF) provides county-level data. Further details are available at http://arf.hrsa.gov/.

characteristics which are typically responsible for any significant variation in actual treatment times.

Statistical Analyses

We started with extensive secondary data analyses by patient, hospital, and area characteristics to explore racial disparity in the duration of routine ED visits at teaching and non-teaching hospitals separately. ED duration is expressed in minutes, measured as the difference between admission time and discharge time.[4] The mean (median) duration for a specific admission hour was measured as the mean (median) value of the durations of all routine ED visits at that specific hour during 2008. We applied a similar approach when reporting the mean duration of ED visits across patient demographics and hospital characteristics. For example, the mean duration of ED visits for female patients was measured as the total duration of routine ED visits by all female patients divided by the total number of routine ED visits by female patients during 2008. We analyzed data with SAS 9.02 and Stata 12.

Severity of illness is an important factor that can affect the mean duration of ED visits. To further explore the potential relationship between the mean duration of visits and various disease groups, we grouped ED visits into major disease categories based on Clinical Classification Software—a diagnosis and procedure categorization scheme based on the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM). While the HCUP SEDD provide all diagnosis codes for every visit, they do not always clearly differentiate between the primary diagnosis codes and other diagnosis codes. Therefore, we used all diagnosis codes reported for each visit when developing our major disease categories.

Next, we developed a flexible functional linear model that controls for patient demographics and hospital and area characteristics to assess racial disparity in duration of routine ED visits at teaching and non-teaching hospitals. More specifically, we estimated several regression models using the natural log value of the duration[5] as the dependent variable to examine factors associated with the duration of patients' routine ED visits. We estimated a linear regression model that controls for: 1) patient characteristics including race group, age, gender, insurance coverage, and major disease categories; 2) hospital characteristics including bed size, location, membership in a large hospital system, trauma center classification, and ownership status; 3) geographic income distribution measured by median household income in patient's residence ZIP code; and 4) admission day of the week and average volume at the ED 1 hour before the admission hour.

We tested our flexible linear models for the undesirable presence of multicollinearity (i.e., a linear relationship among predictor variables) and heteroskedasticity (i.e., variance of the error terms correlated with 1 or more explanatory variables). We saw no evidence of multicollinearity in the correlation coefficients of the predictor variables, and we corrected the heteroskedasticity we identified using Huber-White sandwich estimators to obtain robust standard errors and variance estimates.[42] We further estimated our linear model using robust regression methods to assess the validity of our results based on the linear model.[43-46] More specifically, we ran robust regressions using iteratively reweighted least squares, that is, we assigned a weight to each observation, with higher weights given to better-behaved observations.

RESULTS

Descriptive Results

Patient Characteristics.

We began our analysis with a descriptive comparison of duration of routine ED visits across race groups to profile the differences by age, gender, insurance coverage, and disease category. We analyzed patient demographics to explore potential explanations for the racial disparity we observed. Table 1 displays the total number of routine ED visits and mean and median duration of visits for various patient characteristics at both teaching and non-teaching hospitals. As shown in Table 1, the mean duration of visits[6] ranged from 223 to 245 minutes at teaching hospitals, and 173 to 189 minutes at non-teaching hospitals across race groups. The mean duration increased with the age of the patient regardless of the teaching status of the hospitals. We also observed longer mean duration of routine ED visits for female patients when compared to male patients across race groups within each hospital setting.

Next, we analyzed the mean duration of routine ED visits by insurance coverage for each race group at both teaching and non-teaching hospitals. We found that Medicare patients' visits had the longest mean duration (278 minutes at teaching hospitals and 213 minutes at non-teaching hospitals), which could be due to higher severity of illness and presence of multiple diseases among these patients. Table 1 shows that the mean duration of routine ED visits by white, black/African American, Hispanic, and Asian Medicare patients visiting teaching hospitals (non-teaching hospitals) was 280, 268, 280, and 300 (209, 241, 242, and 255) minutes, respectively. Table 1 also shows that the mean duration of routine ED visits by white, black/African American, Hispanic, and Asian patients with Medicaid coverage, at teaching hospitals (non-teaching hospitals) was 228, 201, 214, and 205 (159, 170, 164, and 185) minutes, respectively. For those without insurance coverage, the mean duration of routine ED visits by white, Black/African American, Hispanic, and Asian patients at

4. Ideally, ED waiting time would be deconstructed into waiting room, treatment, and boarding times experienced by ED patients. However, in our data, we can only observe the total length of stay in the ED for each visit.
5. Because the distribution of duration of ED visits was skewed, the natural logarithm of ED duration was used as the dependent variables for the analysis.
6. We focus mainly on the mean value of duration in our analysis. However, we have provided both mean and median values for each measure separately throughout all tables and figures to set the stage for further research and to provide additional detail to key policymakers and interested researchers.

Table 1. Mean and median duration* of routine visits to hospital emergency departments by patient characteristics.

	Teaching Hospitals					Non-Teaching Hospitals				
	All Visits	White	Black	Hispanic	Asian	All Visits	White	Black	Hispanic	Asian
Total Visits (N) (% of Total)	1,285,700	712,284 (55.4%)	174,294 (13.6%)	317,609 (24.7%)	23,805 (1.9%)	3,040,928	2,221,015 (75.3%)	138,385 (4.6%)	488,849 (16.1%)	42,375 (1.4%)
Mean (Median) Duration	238 (180)	245 (180)	223 (166)	234 (180)	235 (180)	175 (120)	173 (120)	187 (122)	186 (120)	189 (125)
Age										
Under 15	175 (124)	182 (128)	154 (120)	176 (121)	181 (129)	132 (104)	126 (96)	142 (120)	144 (119)	143 (118)
15–24	229 (177)	230 (178)	208 (156)	235 (180)	231 (177)	165 (120)	159 (120)	179 (120)	186 (120)	179 (120)
25–44	242 (180)	242 (180)	230 (167)	252 (180)	239 (180)	180 (120)	174 (120)	193 (128)	199 (131)	196 (141)
45–64	266 (183)	265 (184)	258 (180)	282 (193)	264 (189)	197 (130)	191 (125)	216 (166)	225 (180)	227 (174)
65–74	285 (218)	286 (215)	272 (195)	296 (240)	274 (209)	207 (167)	201 (160)	250 (180)	258 (180)	250 (180)
Over 74	281 (236)	279 (235)	296 (233)	292 (240)	317 (240)	219 (180)	216 (180)	253 (188)	259 (180)	254 (185)
Gender										
Male	226 (172)	235 (179)	207 (149)	218 (167)	224 (173)	167 (120)	174 (120)	176 (120)	174 (120)	179 (120)
Female	249 (180)	254 (180)	237 (175)	249 (180)	245 (180)	183 (120)	180 (120)	196 (137)	195 (126)	197 (140)
Insurance Coverage										
Medicare	278 (217)	280 (221)	268 (191)	280 (226)	300 (234)	213 (176)	209 (173)	241 (180)	242 (180)	255 (180)
Medicaid	217 (168)	228 (173)	201 (148)	214 (172)	205 (166)	162 (120)	159 (120)	170 (120)	164 (120)	185 (120)
Private	244 (180)	244 (180)	247 (170)	250 (180)	245 (180)	175 (120)	170 (120)	194 (134)	207 (140)	181 (124)
Other	233 (179)	225 (174)	213 (165)	228 (180)	230 (180)	149 (120)	142 (114)	167 (120)	161 (120)	161 (120)
Uninsured	239 (180)	241 (180)	213 (164)	251 (180)	243 (180)	171 (120)	163 (120)	187 (120)	187 (120)	191 (120)
Disease Category**										
Infectious and parasitic diseases	226 (173)	230 (179)	220 (152)	224 (174)	227 (174)	166 (120)	163 (120)	177 (120)	172 (120)	171 (120)
Neoplasms	368 (280)	369 (263)	396 (300)	349 (300)	395 (300)	250 (180)	244 (180)	294 (240)	288 (240)	314 (240)
Endocrine, nutritional, and metabolic diseases and immunity disorders	316 (240)	311 (240)	315 (238)	332 (240)	325 (240)	251 (180)	243 (180)	286 (193)	277 (188)	275 (207)
Diseases of the blood and blood-forming organs	359 (290)	359 (293)	370 (263)	355 (300)	323 (290)	318 (240)	313 (235)	332 (240)	335 (240)	351 (240)
Mental illness	311 (240)	308 (240)	315 (228)	315 (240)	295 (240)	234 (176)	227 (169)	268 (180)	260 (180)	285 (180)
Diseases of the circulatory system	303 (239)	300 (240)	303 (221)	315 (240)	306 (240)	236 (180)	229 (180)	263 (180)	267 (180)	269 (181)
Diseases of the respiratory system	230 (180)	245 (180)	211 (154)	216 (174)	229 (180)	171 (120)	170 (120)	179 (120)	173 (120)	183 (120)
Diseases of the digestive system	276 (216)	289 (236)	240 (180)	265 (193)	290 (239)	216 (178)	215 (176)	214 (173)	221 (180)	235 (180)
Diseases of the genitourinary system	297 (240)	302 (240)	277 (218)	300 (240)	290 (232)	225 (180)	220 (180)	240 (180)	239 (180)	233 (180)

Table 1 continued.

	Teaching Hospitals					Non-Teaching Hospitals				
	All Visits	White	Black	Hispanic	Asian	All Visits	White	Black	Hispanic	Asian
Diseases of the skin and subcutaneous tissue	196 (130)	201 (137)	188 (122)	193 (123)	183 (122)	147 (112)	145 (111)	148 (120)	155 (119)	161 (117)
Diseases of the musculoskeletal system and connective tissue	238 (180)	240 (180)	241 (170)	236 (180)	246 (180)	178 (120)	174 (120)	189 (124)	193 (124)	191 (137)
Congenital anomalies	308 (240)	323 (240)	325 (238)	262 (180)	320 (248)	199 (126)	199 (124)	220 (180)	199 (140)	188 (122)
Certain conditions originating in the perinatal period	177 (121)	189 (135)	156 (120)	170 (120)	203 (142)	132 (67)	129 (65)	141 (115)	136 (60)	134 (120)
Injury and poisoning	208 (146)	211 (153)	197 (133)	201 (139)	200 (147)	143 (116)	140 (114)	152 (120)	157 (120)	151 (120)
Other conditions	276 (223)	285 (237)	251 (182)	270 (204)	267 (201)	208 (177)	207 (176)	223 (180)	211 (175)	213 (178)

Note: Data include all hospital emergency department routine visits that are discharged for home or self care during 2008 in Arizona, Massachusetts, and Utah. Statistics are not reported when there are fewer than 10 observations in a particular cell. Median durations are in parentheses. We only present the descriptive results for major race groups here.

* Duration is measured in minutes as the difference between admission and discharge time for each visit.

** Disease categories are based on Clinical Classification Software, which is a diagnosis and procedure categorization scheme based on the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM).The HCUP SEDD do not differentiate between the primary diagnosis codes and other diagnosis codes. Therefore, we used all diagnosis codes reported for each visit when creating broader CCS disease categories. Further details about CCS disease codes are available at: http://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp#info.

teaching hospitals (non-teaching hospitals) was 241, 213, 251, and 243 (163, 187, 187, and 191) minutes, respectively. These results suggest that there is no sizable difference in mean duration of ED visits between patients with any insurance coverage and uninsured patients.

Severity of illness is an important factor that can affect the mean duration of ED visits. To further explore the potential relationship between the mean duration of visits and various disease categories, we grouped ED visits into major disease categories based on Clinical Classification Software. We used all diagnosis codes reported for each visit when developing our major disease categories. As presented in Table 1, routine ED visits for neoplasm; endocrine, nutritional, and metabolic diseases and immunity disorders, diseases of blood and blood forming organs, and mental disorders are associated with longer mean duration across all race groups regardless of hospital teaching status; routine ED visits for diseases of the skin and subcutaneous tissue, certain conditions originating in the perinatal period, and injury and poisoning were generally associated with shorter duration of ED visits at both teaching and non-teaching hospitals.

Hospital and Area Characteristics.

Next, we analyzed hospital and area characteristics to explore other potential factors associated with longer ED visits for each race group. Figure 1 shows that mean duration of ED visits at teaching hospitals is consistently longer when compared to non-teaching hospitals. Table 2 further shows that hospitals with large bed size[7] were associated with the longest duration of visits (279 minutes at teaching and 191 minutes at non-teaching hospitals) when compared to hospitals with small bed size (207 minutes at teaching and 161 minutes at non-teaching hospitals) or medium bed size (173 minutes at teaching and 161 minutes at non-teaching hospitals). White patients had longer ED stays when compared to black/African American, Hispanic, and Asian patients at teaching hospitals regardless of hospital bed size. In contrast to the pattern at teaching hospitals, white patients generally experienced shorter ED stays at non-teaching hospitals regardless of bed size. Table 2 also shows that the mean duration of routine ED visits at urban teaching hospitals was 67 minutes longer than at their urban non-teaching counterparts. The mean duration of routine ED visits encountered by white patients was longer by 22, 10, and 10 minutes (shorter by 13,14, and 16 minutes), respectively, when compared to the mean duration of routine ED visits encountered by black/African American, Hispanic, and Asian patients at urban teaching hospitals (urban non-teaching hospitals). We found that non-teaching hospitals generally serve rural areas and the mean ED duration of all routine visits at these hospitals

7. Further details about hospital bed sizes are available at: http://www.hcup-us.ahrq.gov/db/vars/hosp_bedsize/nisnote.jsp.

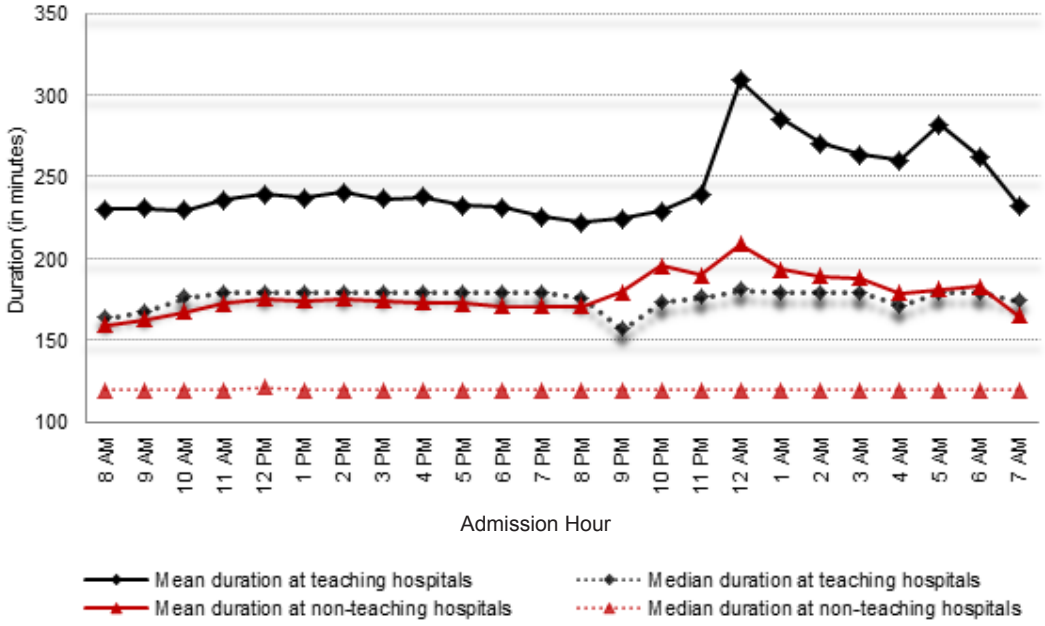

Figure 1. Mean and median duration of routine visits to the hospital emergency departments. Data include all hospital emergency department routine visits that are discharged for home or self care during 2008 in Arizona, Massachusetts, and Utah. Duration is measured in minutes as the difference between admission time and discharge time for each visit.

was 164 minutes, with some variation across race groups. Recognizing the differences in income levels across geographic regions, we compared the mean duration based on income distribution. In general, we did not find significant differences in mean duration of routine ED visits between relatively richer or poorer counties. Akin to previous results, white patients generally had longer ED stays at teaching hospitals and had slightly shorter ED stays at non-teaching hospitals when compared to other race groups regardless of geographic income distribution. We also observed that the mean duration of routine ED visits at teaching hospitals (non-teaching hospitals) that were members of a hospital system was 40 (25) minutes longer when compared to non-system-member teaching hospitals (non-teaching hospitals). Similarly, the mean duration of visits at Level 1 trauma centers was 269 minutes and substantially longer than those at Level 2 or Level 3 trauma centers, or at non-trauma centers at teaching hospitals. We also found that the mean duration of routine ED visits at Level 1 trauma centers when compared to Level 2 and Level 3 trauma centers or to non-trauma centers at non-teaching hospitals was longer by 81, 85, and 38 minutes, respectively.[8] Finally, we found that the mean duration of visits at public, non-profit, and for-profit teaching hospitals was 194, 248, and 217 minutes, respectively, showing significant differences between for-profit and non-profit hospitals. We observed similar but smaller variation between public, non-profit, and for-profit non-teaching hospitals possibly due to differing financial incentives.

Risk-adjusted Results.

Table 3 presents the regression coefficients[9] of our linear model estimated separately for teaching and non-teaching hospitals. The empirical estimates show that the mean duration of routine ED visits encountered by black/African American and Asian patients at teaching hospitals (non-teaching hospitals) were, respectively, 10.0 and 3.4% lower (3.6 and 13.8% higher) than the mean duration of routine ED visits encountered by white patients. The difference in mean duration of routine ED visits at teaching hospitals between Hispanic and white patients were not statistically significant. However, Hispanic patients, on average, experienced an 8.7% longer duration of ED visit when compared to white patients at non-teaching hospitals. These risk-adjusted results parallel our descriptive results, indicating that white patients, when compared to non-white patients, generally have longer ED stays at teaching hospitals (Figure 2) but shorter ED stays at non-teaching hospitals (Figure 3). Our results also support the findings of a previously published study[19] that found longer ED LOS for Black/African American non-Hispanic patients (10.6% longer) and Hispanic patients (13.9% longer) when compared to non-Hispanic white patients.

We also obtained valuable information associated with patients' ED stays in general. The regression results show that the mean duration of routine ED visits for female patients was

8. Trauma level designation was based on American College of Surgeons or state-specific designation. We found most of the trauma Level 1 centers within teaching hospitals. Less than 2 percent of them were located within non-teaching hospitals. While we were expecting all of them to be located within teaching hospitals, we still report the results assuming the possibility of having Level 1 trauma centers located within non-teaching hospitals.

9. We presented the empirical results of the linear regression model here. The estimates obtained from *the robust linear regression model* were parallel to our estimates of the linear regression model.

Table 2. Mean and median duration* of routine visits to hospital emergency departments by hospital and area characteristics.

	Teaching Hospitals					Non-Teaching Hospitals				
	All Visits	White	Black	Hispanic	Asian	All Visits	White	Black	Hispanic	Asian
Hospital State										
Arizona	256 (180)	259 (180)	254 (180)	247 (180)	238 (180)	202 (120)	201 (180)	216 (180)	202 (120)	222 (180)
Massachusetts	217 (170)	220 (173)	214 (162)	218 (171)	220 (174)	164 (124)	164 (124)	165 (122)	166 (125)	177 (131)
Utah	331 (180)	336 (180)	313 (180)	304 (180)	305 (180)	145 (60)	141 (60)	140 (60)	162 (60)	152 (60)
Hospital Location										
Rural	–	–	–	–	–	164 (120)	162 (120)	179 (122)	171 (120)	183 (126)
Urban	238 (180)	245 (180)	223 (168)	235 (180)	235 (180)	178 (120)	175 (120)	188 (122)	189 (120)	191 (125)
Ownership Status										
Public	194 (133)	197 (129)	180 (124)	198 (169)	187 (133)	144 (120)	146 (120)	132 (103)	136 (120)	140 (115)
For-profit	217 (140)	233 (173)	154 (60)	190 (120)	213 (141)	172 (120)	177 (120)	138 (60)	153 (60)	198 (120)
Non-profit	248 (180)	254 (180)	234 (173)	249 (180)	245 (180)	179 (120)	173 (120)	201 (147)	197 (137)	188 (131)
System Status										
Member	254 (180)	251 (180)	257 (171)	262 (180)	252 (180)	183 (120)	180 (120)	192 (124)	189 (120)	195 (127)
Non-member	214 (178)	233 (180)	191 (160)	197 (170)	215 (180)	158 (120)	154 (120)	166 (120)	178 (120)	170 (122)
Other Characteristics										
Non-trauma centers	220 (166)	233 (177)	175 (122)	208 (160)	220 (164)	180 (120)	177 (120)	188 (122)	193 (120)	196 (127)
Level 1 trauma centers**	269 (186)	273 (195)	252 (180)	273 (187)	256 (187)	218 (180)	217 (180)	222 (180)	218 (180)	202 (180)
Level 2 trauma centers	188 (161)	189 (162)	180 (148)	182 (151)	219 (181)	137 (67)	146 (97)	140 (100)	73 (30)	110 (30)
Level 3 trauma centers	174 (136)	179 (136)	212 (164)	173 (136)	–	133 (97)	128 (85)	176 (134)	150 (110)	183 (138)
Hospital Bed Size										
Small	207 (161)	229 (173)	179 (134)	190 (145)	198 (164)	161 (120)	159 (120)	173 (122)	175 (120)	166 (120)
Medium	173 (121)	179 (128)	145 (105)	159 (112)	160 (119)	161 (120)	158 (120)	157 (120)	177 (120)	185 (124)
Large	279 (190)	291 (217)	254 (180)	270 (183)	271 (188)	191 (125)	189 (125)	201 (139)	193 (120)	198 (132)
Median Household Income (x 1,000)***										
Under $39	242 (180)	260 (180)	244 (176)	228 (180)	225 (180)	170 (120)	168 (120)	180 (120)	173 (120)	186 (120)
$39–$49	231 (178)	237 (180)	206 (156)	239 (180)	241 (180)	184 (120)	178 (120)	203 (136)	199 (120)	213 (142)
$49–$64	241 (178)	247 (180)	213 (159)	250 (179)	236 (176)	177 (120)	173 (120)	182 (120)	194 (120)	187 (126)
Over $64	238 (180)	240 (180)	238 (171)	228 (179)	239 (180)	174 (121)	173 (121)	180 (122)	185 (120)	180 (128)

Note**:** Data include all hospital emergency department routine visits that are discharged for home or self care during 2008 in Arizona, Massachusetts, and Utah. Statistics are not reported whenever there are fewer than 10 observations in a particular cell. Median durations are in parentheses. We only present the descriptive results for major race groups here.
* Duration is measured in minutes as the difference between admission and discharge time for each visit.
** Less than 2 percent of Level 1 trauma centers were located within non-teaching hospitals.
*** This is a quartile classification of the estimated median household income of residents in the patient's ZIP Code.

5.4 and 4.9% longer than for male patients at teaching and non-teaching hospitals, respectively. The regression results also show that the mean duration of ED visits increases with patient age both at teaching and non-teaching hospitals. Our risk-adjusted results also suggest that uninsured patients generally have shorter ED stays when compared to Medicare enrollees. We also found significant variation in mean duration of routine ED visits across disease categories. Our risk-adjusted results were mostly parallel to our descriptive results (Table 1) indicating that patients diagnosed with neoplasm, endocrine, nutritional, and metabolic diseases and immunity disorders, diseases of blood and blood forming organs, and mental disorders generally experienced longer ED stays when compared to patients diagnosed with other conditions both at teaching and non-teaching hospitals.

Table 3 also presents the estimated effects of hospital characteristics on mean duration of routine ED visits. The results suggest that the mean duration of routine ED visits was higher at for-profit teaching hospitals and lower at for-profit non-teaching hospitals when compared to their respective

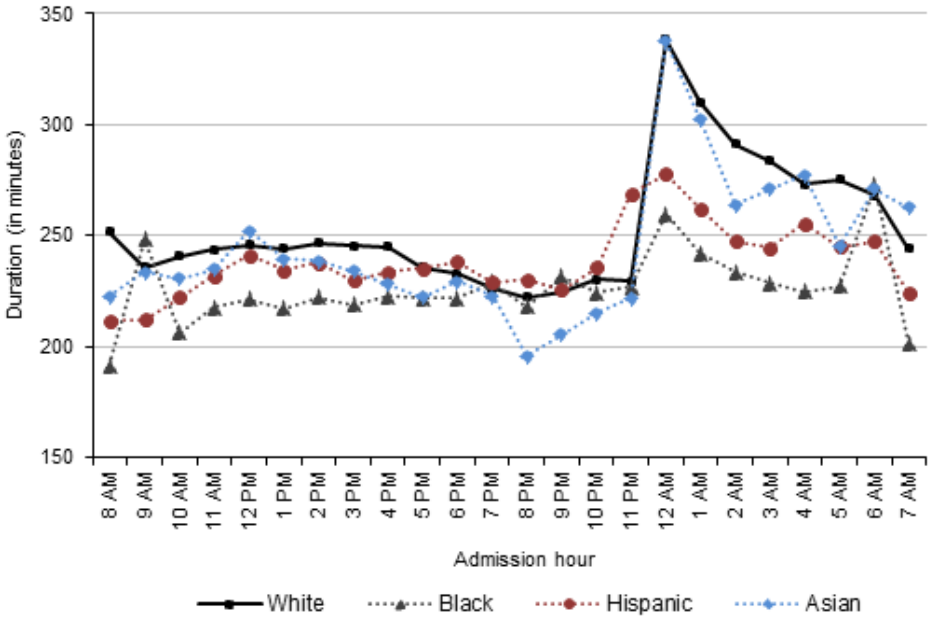

Figure 2. Mean duration of routine visits to the hospital emergency departments of teaching hospitals. Data include all hospital emergency department routine visits that are discharged for home or self care during 2008 in Arizona, Massachusetts, and Utah. Duration is measured in minutes as the difference between admission time and discharge time for each visit.

cohorts of teaching and non-teaching public hospitals. Patients at teaching hospitals with large bed size have ED stays about twice as long as patients at teaching hospitals with small bed size. The mean duration of ED stays at non-teaching hospitals with large bed size was only 7.5% longer than the mean duration of ED stays at non-teaching hospitals with small bed size. We also found that the mean duration of routine ED visits at Level 1 trauma centers was significantly longer than those at non-trauma centers regardless of the hospital teaching status. Additionally, we obtained crucial information regarding how admission day of the week and hospital volume affect the mean duration of routine ED visits. Our risk-adjusted results in Table 3 show that the mean duration of ED visits at teaching hospitals (non-teaching hospitals) was 4.1% (3.7%) longer on Mondays and 5.9% (4.1%) shorter on other weekdays when compared to the mean duration of ED visits on weekends. We also found a positive correlation between longer ED stays and the number of patients present at the ED prior to admission time both at teaching and non-teaching hospitals.

DISCUSSION

This analysis, based on a very large data set, reveals considerable variation in duration of routine ED visits across race groups at teaching and non-teaching hospitals. We computed the duration of each visit by taking the difference between admission and discharge times, which is the total time patients waited in ED rooms plus their treatment time. We documented racial disparity in duration of ED stays both at teaching and non-teaching hospitals. We found that white patients generally have shorter ED stays at teaching hospitals and longer ED stays at non-teaching hospitals when compared to non-white patients. These findings provide robust evidence of racial disparity, especially in non-teaching hospitals, that may be used by decision makers in both public and private healthcare arenas to improve the timeliness of the care provided in the ED and to understand the factors causing the racial disparity.

Some of our results are consistent with the characterization in the literature of care provided in the ED and are expected.[22,23] Level 1 trauma centers, for example, have comprehensive resources and are able to care for the most severely injured patients. One plausible explanation for longer ED stays is that Level 1 trauma centers provide the highest level of surgical care to seriously injured patients who may use more resources and whose treatments last longer. It is also plausible to assume that most Level 1 trauma centers provide leadership in education and research. We found that the mean duration of routine ED visits at non-trauma centers are longer than at Level 2 or Level 3 trauma centers, but it is not clear why.

Another important finding of our study is pertinent to uninsured patients. We found that the duration of routine ED visits encountered by uninsured patients are about the same as the mean duration of routine ED visits by all patients. More precisely, the mean duration of all routine ED visits was 238 and 175 minutes, respectively, at teaching and non-teaching hospitals, whereas the mean duration of ED stays encountered by uninsured patients was 239 and 171 minutes at their respective hospitals. We further found that the difference in mean duration of ED visits between uninsured patients and others is not sizable across race groups at either teaching or non-teaching hospitals. It is plausible to assume that both uninsured and insured patients receive similar quality of care once they are admitted to the ED and that both cohorts could

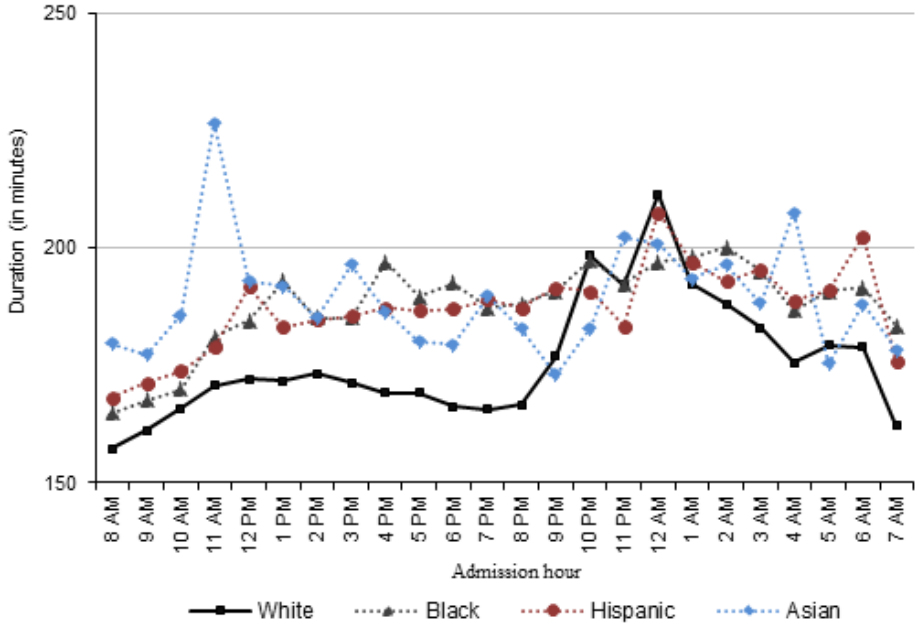

Figure 3. Mean duration of routine visits to the hospital emergency departments of non-teaching hospitals. Data include all hospital emergency department routine visits that are discharged for home or self care during 2008 in Arizona, Massachusetts, and Utah. Duration is measured in minutes as the difference between admission time and discharge time for each visit.

face similar barriers to healthcare access at hospital EDs.

Some of these findings are worthy of further exploration. For example, we believe that since elderly patients frequently present to the ED with multiple complications, they require more ED resources during their visits, which causes them to have longer duration of visits. Similarly, we found that race is correlated with increase in duration of ED visits. When this race correlation is associated with a lower socio-economic status, some policymakers may choose to use interpreters, or perhaps social workers, to work with patients to increase their access to primary care and thereby decrease their use of the ED for non-emergency complaints.

LIMITATIONS

We computed the duration of each visit by taking the difference between admission and discharge times, which yields the total time patients waited in ED rooms plus their treatment time. Our measure of duration, unfortunately, does not separate waiting time and treatment time.

The data in the HCUP SEDD are based on ED encounters as the unit of analysis. Therefore, a given patient may have many visits represented in the data. As a result, the summary information reported under patient characteristics might overestimate or underestimate demographics for individual patients. This study also does not address the impact of financial incentives and other confounding factors across hospitals types on duration of ED visits.

Our analysis is confined to the routine ED visits presented in the HCUP SEDD. ED encounters that result in subsequent admission to the same hospital are not included in the analysis. Therefore, the relative number of patients admitted at the individual EDs may compromise this analysis as their presence may limit the resources available to patients on routine ED visits.

CONCLUSION

Our results show that the mean duration for a routine ED visit was 238 minutes at teaching hospitals and 173 minutes at non-teaching hospitals. When documenting the mean duration, we uncovered a significant racial disparity in mean duration of ED visits at non-teaching hospitals. Based on patient demographics and hospital characteristics, we identified several important factors that are associated with increased ED stays. We identified a direct relationship between increased duration of ED visits and patient race, age, gender, and severity of illness; and hospital location and ownership status. We observed substantial variation in mean duration of ED visits by race group between teaching and non-teaching hospitals. The mean duration of ED visits at teaching hospitals (non-teaching hospitals) for White, Black/African American, Hispanic, and Asian patients was 245, 223, 234, and 235 (173, 187, 186, and 189) minutes respectively. Our risk-adjusted findings show that the mean duration of ED visits for Black/African American and Asian patients was 10.0 and 3.4% lower (3.6 and 13.8% higher), respectively, than the mean duration of routine ED visits encountered by white patients at teaching hospitals (non-teaching hospitals). The mean duration of ED visits for Hispanic patients was 8.7% longer at non-teaching hospitals when compared to white patients. We did not find any disparity in duration of ED visits at teaching hospitals between white and Hispanic patients. We also found that female patients generally experienced longer ED stays than

Table 3. Estimated effects of patient and hospital characteristics on duration of routine visits to hospital emergency departments.

	Teaching Hospitals	Non-Teaching Hospitals
Race Group		
White [c]	.	.
Black	-0.105 ***	0.035 ***
Hispanic	0.002	0.083 ***
Asian	-0.035 ***	0.129 ***
Native	-0.024 ***	0.103 ***
Other	0.047 ***	0.103 ***
Gender		
Male [c]	.	.
Female	0.053 ***	0.048 ***
Age Group		
Under 15 [c]	.	.
15–24	0.142 ***	0.103 ***
25–44	0.180 ***	0.142 ***
45–64	0.248 ***	0.193 ***
65–74	0.296 ***	0.213 ***
Over 74	0.352 ***	0.288 ***
Insurance Coverage		
Medicare [c]	.	.
Medicaid	-0.100 ***	-0.123 ***
Private	0.003	0.024 ***
Other	-0.098 ***	-0.070 ***
Uninsured	-0.070 ***	-0.060 ***
Disease Category [3]		
Infectious and parasitic diseases	-0.41 ***	-0.54 ***
Neoplasm	0.155 ***	0.099 ***
Endocrine, nutritional, and metabolic diseases and immunity disorders	0.124 ***	0.167 ***
Diseases of the blood and blood-forming organs	0.269 ***	0.318 ***
Mental illness	0.205 ***	0.195 ***
Diseases of the nervous system and sense organs	0.051 ***	-0.001
Diseases of the circulatory system	0.118 ***	0.147 ***
Diseases of the respiratory system	-0.022 ***	0.043 ***
Diseases of the digestive system	0.097 ***	0.099 ***
Diseases of the genitourinary system	0.188 ***	0.188 ***
Complications of pregnancy, childbirth, and the puerperium	0.285 ***	0.218 ***
Diseases of the skin and subcutaneous tissue	-0.158 ***	-0.193 ***
Diseases of the musculoskeletal system and connective tissue	-0.012 ***	-0.054 ***
Congenital anomalies	0.126 ***	0.044 ***
Certain conditions originating in the perinatal period	-0.077 ***	-0.079 ***
Injury and poisoning	-0.110 ***	-0.141 ***
Other conditions [c]	.	.
Hospital State		
Arizona [c]	.	.
Massachusetts	0.288 ***	-0.001
Utah	-0.074 ***	-0.442 ***

Table 3 continued.

	Teaching Hospitals	Non-Teaching Hospitals
Hospital Location		
Rural [c]	.	.
Urban	.	0.013 ***
Ownership Status		
Public	.	.
For-profit	0.269 ***	-0.082 ***
Non-profit	-0.298 ***	-0.003
System Status		
Member	-0.025 ***	0.040 ***
Non-member [c]	.	.
Other Characteristics		
Non-trauma centers [c]	.	.
Level 1 trauma centers [2]	0.370 ***	0.253 ***
Level 2 trauma centers	0.064 ***	-0.294 ***
Level 3 trauma centers	-0.035 ***	-0.240 ***
Hospital Bed Size		
Small [c]	.	.
Medium	-0.614 ***	-0.019 ***
Large	0.784 ***	0.072 ***
Median Household Income (x 1,000) [4]		
Under $39 [c]	.	.
$39–$49	0.026 ***	0.103 ***
$49–$64	0.080 ***	0.115 ***
Over $64	0.118 ***	0.121 ***
Admission Day to Emergency Department		
Visit was on Monday	0.040 ***	0.036 ***
Visit was on non-Monday weekday [c]	.	.
Visit was on weekend	-0.061 ***	-0.042 ***
Number of patients at emergency department an hour before admission	0.029 ***	0.047 ***
Constant	4.875 ***	4.394 ***
Total number of visits	1,210,509	2,815,385
R-Square	0.180	0.141

Note: Data include all hospital emergency department routine visits that are discharged for home or self care during 2008 in Arizona, Massachusetts, and Utah.

[1] Dependent variable is the log of the duration measured in minutes as the difference between admission and discharge time for each visit.

[2] Less than 2 percent of Level 1 trauma centers were located within non-teaching hospitals.

[3] Disease categories are based on Clinical Classification Software, which is a diagnosis and procedure categorization scheme based on the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM).The HCUP SEDD do not differentiate between the primary diagnosis codes and other diagnosis codes. Therefore, we used all diagnosis codes reported for each visit when creating broader CCS disease categories. Further details about CCS disease codes are available at: http://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp#info.

[4] This is a quartile classification of the estimated median household income of residents in the patient's ZIP Code.

[c] The control group in regression analysis.

*** P<0.01; ** P<0.05; * P<0.10.

male patients. Elderly patients and patients diagnosed with neoplasm, endocrine, nutritional, and metabolic diseases and immunity disorders, diseases of blood and blood forming organs, and mental disorders generally experienced longer ED stays than did other patients. Consistent with the existing literature, our results suggest that, in the aggregate, lack of health insurance did not have a significant direct association with longer mean duration of ED visits. The mean duration of ED visits was substantially longer at non-profit hospitals when compared to for-profit hospitals, and at Level 1 trauma centers when compared to other trauma centers or non-trauma centers. Our findings may also inform public and private policymakers on a broad range of issues including, but not limited to, admission day of the week, hospital volume, and the impact of hospital bed size on the mean duration of ED visits.

ACKNOWLEDGEMENTS

We are grateful to Janette Walters of Social & Scientific Systems, Inc., for her excellent technical support, to the participants at the research seminars held in Center for Delivery, Organizations and Market (CDOM), at Agency for Healthcare Research and Quality (AHRQ), and to the referees and the editor for their invaluable comments. We also acknowledge the HCUP data collection partners: Arizona Department of Health Services, Massachusetts Division of Health Care Finance and Policy, and Utah Department of Health.

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

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Warming Intravenous Fluids for Improved Patient Comfort in the Emergency Department: A Pilot Crossover Randomized Controlled Trial

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Supervising Section Editor: Jeffrey Sankoff, MD
Submission history: Submitted August 17, 2012; Revisions received November 27, 2012; Accepted January 28, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.1.13303

Introduction: The purpose of this study was to test if intravenous (IV) fluids warmed to body temperature are associated with greater patient comfort than room temperature IV fluids in adult emergency department (ED) patients.

Methods: This was a pilot double-blind, crossover, randomized controlled trial. Enrolled subjects sequentially received boluses of body temperature (36ºC) and room temperature (22 ºC) IV fluid, with the order of boluses randomized. Each subject's level of discomfort was assessed prior to and after each bolus, using a 10 cm visual analog scale (Discomfort VAS), with higher scores indicating greater discomfort. We calculated the change in Discomfort VAS score associated with body temperature IV fluid (ΔVAS_{body}) and room temperature IV fluid (ΔVAS_{room}) by subtracting the score reported before the bolus from the score reported after that bolus. We compared changes in Discomfort VAS score with body temperature and room temperature IV fluid using the Wilcoxon matched-pairs signed-rank test.

Results: Twenty-seven subjects were included. Treatment with body temperature IV fluid was associated with a significant decrease in discomfort (median ΔVAS_{body}: -0.7 cm; interquartile range (IQR): -4.5 cm to +0.4 cm) compared to room temperature IV fluid (median ΔVAS_{room}: +1.2 cm; interquartile range: -0.1 cm to + 3.6 cm) (P = 0.001).

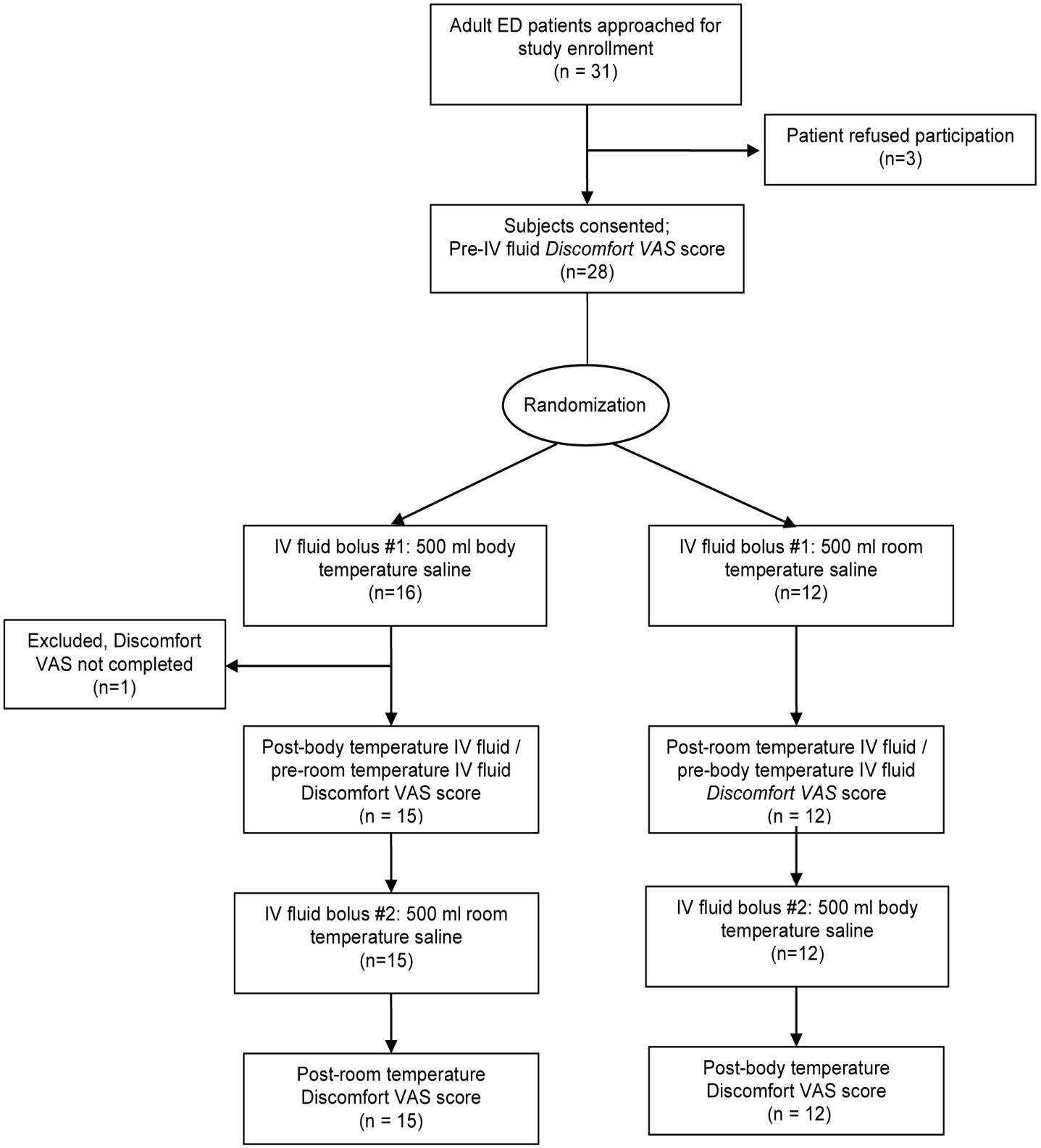
Conclusion: In this small trial of adult ED patients, infusing IV fluids warmed to body temperature was associated with improved comfort compared to standard, room temperature IV fluids. [West J Emerg Med. 2013;14(5):542–546.]

INTRODUCTION

Nearly one-quarter of emergency department (ED) patients in the United States are treated with intravenous (IV) fluids.[1] These fluids are typically stored at room temperature and infused into patients without prior warming. During infusion of room temperature IV fluids, some patients experience shivering, chills and discomfort.[2,3] Small studies of patients undergoing surgery suggest that warming IV fluids to body temperature prior to infusion may reduce shivering and improve patient comfort in the perioperative period.[2-7] However, the effect of warming IV fluids on patient comfort in the ED has not been evaluated. In this pilot study of adult ED patients, we compared the level of discomfort associated with infusion of IV fluids warmed to body temperature with those infused at room temperature.

METHODS

We conducted a double-blind, crossover, randomized controlled trial to test the impact of warming IV fluids to body



ED, emergency department; *IV*, intravenous; *mL,* milliliter; *VAS*, visual analog scale.
Figure 1. Flow diagram of subject participation.

temperature on patient comfort. Prior to the clinical study, we validated our method for warming IV fluid in a pre-trial validation study.

Pre-Trial Validation Study

IV fluids were warmed using the Safe & Warm IV Fluid Warmer Device (Safe & Warm, Seattle, Washington). Prior to enrolling patients, we tested the temperature of fluids infused with this device with an infusion set-up identical to that used in the clinical study. A 500 mL bag of normal saline was inserted into the insulated warming jacket of the device and connected to 295 cm of IV tubing and an infusion pump. An electronic thermometer was inserted into the distal end of the IV tubing, the location where an IV catheter would be connected to infuse fluid into a patient. A neoprene insulating sleeve enclosed all the IV tubing, preventing bedside personnel from feeling the temperature of fluid in the tubing. The insulated warming jacket within the device contained two sodium acetate heat packs. When the device was turned "on," the heat packs were activated and warmed the fluid. In simulated infusions, we pumped 500 mL bags of normal saline at 1000 mL/hour with the device turned on and off. With the device on, the temperature of fluid at the distal end of the tubing was 36ºC (body temperature) throughout the simulated infusion. When the device was off, the temperature of fluid was 22ºC (room temperature).

Clinical Study

This crossover, randomized controlled trial was approved by the local Institutional Review Board and conducted in a university-affiliated ED with approximately 61,000 visits annually. Inclusion criteria included: 1) acute illness preventing adequate oral hydration as judged by the treating physician; and 2) age 18-45 years. Exclusion criteria included: 1) critical illness requiring rapid IV fluid resuscitation; 2) severe (distracting) pain; 3) heart or kidney failure; and 4) cognitive impairment or language barrier preventing communication in English with investigators. All subjects sequentially received two 500 mL IV boluses of normal saline over 30 minutes, one warmed to body temperature (36ºC) and one at room temperature (22 ºC) (Figure 1). A dose of 500 mL of normal saline infused at 1000 mL/hour was chosen because this was the most common fluid bolus used clinically in our ED. The order of boluses was randomized in a simple 1:1 scheme with a random number generator. Randomization procedures and administration of the 2 fluid boluses were completed by a dedicated study nurse, the only person unblinded to fluid temperatures. Both body temperature and room temperature fluids were administered through the Safe & Warm IV Fluid Warmer Device as described in the *Pre-Trial Validation Study*. The device was turned on for infusion of body temperature fluid and off for room temperature fluid. Subjects reported their general level of bodily discomfort prior to and after each bolus, using a 10 cm visual analogue scale (Discomfort VAS), with 0 cm signifying no discomfort and 10 cm signifying the worst discomfort imaginable. The Discomfort VAS was modeled after the visual analog scale used for pain assessment.[8,9] After finishing both boluses, subjects were also asked which treatment they preferred overall (bolus #1 or bolus #2).

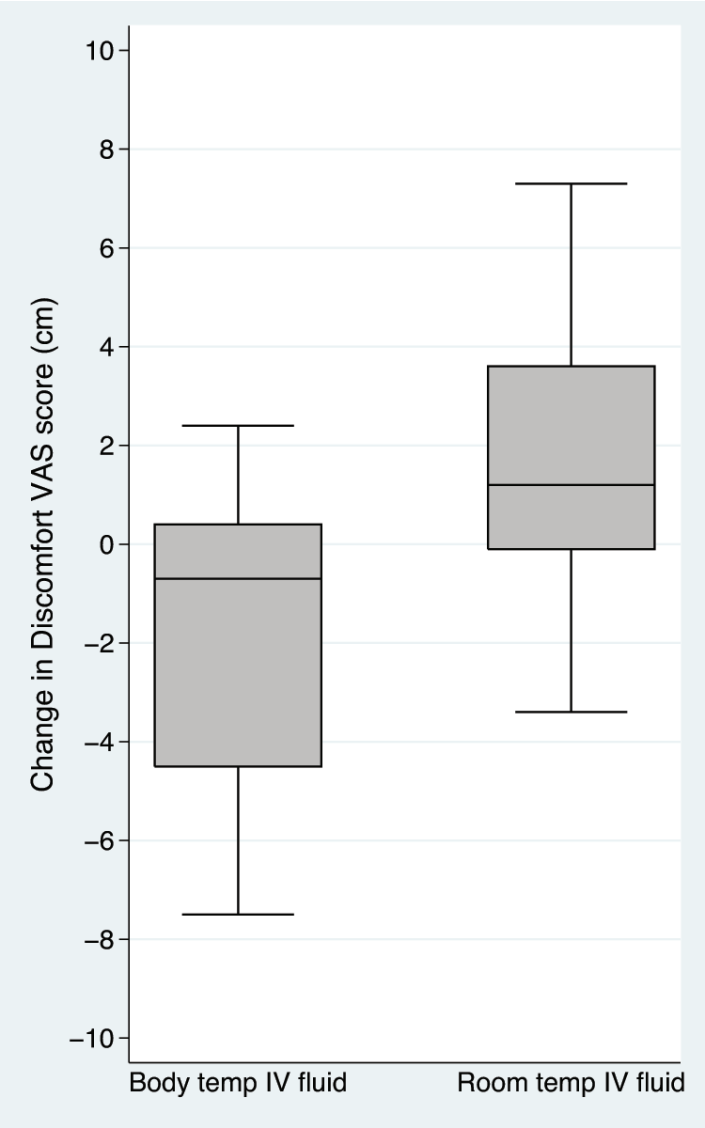
Statistical Analysis

For each subject, we calculated the change in Discomfort VAS score associated with body temperature IV fluid (ΔVAS_{body}) by subtracting the score reported before the body temperature bolus from the score reported after that bolus. Hence, a negative ΔVAS_{body} indicated a decrease in discomfort associated with body temperature fluid treatment. Similarly, we calculated the change in Discomfort VAS score associated with the room temperature fluid (ΔVAS_{room}) by subtracting the score reported before the room temperature bolus from the score reported after that bolus. The primary analysis involved comparing changes in Discomfort VAS associated with body temperature (ΔVAS_{body}) and room temperature (ΔVAS_{room}) fluid. We planned to perform this comparison with a paired t-test if the data were normally distributed or a Wilcoxon matched-pairs signed-rank test if the data were not normally distributed. We performed sample-size calculations using a paired t-test, type I error probability of 0.05, 80% power, and a standard deviation of 2 cm for the difference between ΔVAS_{body} and ΔVAS_{room}. At least 21 subjects were needed to detect a 1.3 cm difference in ΔVAS_{body} and ΔVAS_{room}. We based the goal of detectable difference of 1.3 cm on previous work showing that a 1.3 cm change on a visual analog scale for pain was clinically significant.[8,9]

We also calculated the proportion of subjects who stated a preference for body temperature over room temperature IV fluids and used the one-sample z-test to compare this to the null (proportion of 0.5). We completed statistical analyses using Stata 11.1 (Stata Corp, College Station, Texas). Two-tailed *P*-values < 0.05 were considered statistically significant.

RESULTS

Thirty-one patients were approached for enrollment; 28 patients consented, and 27 completed the protocol (Figure 1). Distributions for ΔVAS_{body} and ΔVAS_{room} did not approximate normal distribution, and analyses were completed with nonparametric statistics. Treatment with body temperature IV fluid was associated with a significant decrease in discomfort (median ΔVAS_{body}: -0.7 cm; interquartile range (IQR): -4.5 cm to +0.4 cm) compared to room temperature IV fluid (median ΔVAS_{room}: +1.2 cm; IQR: -0.1 cm to + 3.6 cm) (P = 0.001) (Figure 2). After receiving both boluses, 20/27 (74%; 95% confidence interval: 57% to 91%) subjects reported a preference for body temperature over room temperature fluid (P = 0.012).



cm, centimeter; *temp,* temperature

Figure 2. Box plot of the change in Discomfort Visual Analogue Scale (VAS) score associated with body temperature (ΔVAS_{body}) and room temperature (ΔVAS_{room}) intravenous (IV) fluid treatment. A negative change in Discomfort VAS score indicated the subject reported less discomfort after the IV fluid treatment than before the treatment. Within each box plot, the center line represents the median, the box contains the interquartile range, and whiskers represent the minimum and maximum values.

DISCUSSION

This pilot study suggests that warming IV fluids to body temperature before infusion is associated with improved comfort for ED patients compared to room temperature fluids. IV fluid treatment is often initiated in the ED to increase intravascular volume in dehydrated patients. In addition to achieving physiologic endpoints, such as normalization of vital signs, an important secondary goal of IV fluid treatment is to improve patient comfort. As the practice of emergency medicine has evolved, the specialty has increasingly recognized the importance of patient-centered care and promoting patient satisfaction and comfort.[10] When assessing the effectiveness of medical interventions, considering patient-centered outcomes in addition to physiologic endpoints is essential for meaningful evaluation.[11,12] Warming IV fluids prior to infusion may be a simple technique to improve the effectiveness of a commonly used ED treatment from the patient perspective. Given the promising results of this study, future research is indicated to study warmed IV fluids in the ED.

The median change on the Discomfort VAS associated with body temperature fluid was -0.7 cm, compared to +1.2 cm for room temperature fluid; therefore, body temperature fluid was associated with a median change of 1.9 cm toward less discomfort compared to room temperature fluid. The Discomfort VAS was modeled after the pain visual analog scale, which has been well-validated and is commonly used in the ED.[8,9] A change of 1.3 cm on the pain visual analog scale is considered clinically significant.[8,9] Therefore, the magnitude of difference between VAS scores with body temperature and room temperature fluids suggests that the statistical difference we found in Discomfort VAS scores may correlate with an important clinical difference. Further suggesting the difference is clinically important is our finding that 74% of subjects reported an overall preference for body temperature fluids.

LIMITATIONS

Several limitations to our study should be highlighted. This was a small study conducted to help plan a larger trial by testing the methods of warming IV fluids and preliminarily evaluating the potential impact of warming fluids on patient comfort. While our results showed a statistically significant reduction in patient discomfort with warmed IV fluids, further research is needed evaluating larger samples sizes and other outcomes, including cost-effectiveness and ease of implementation. In this study, warmed IV fluids were administered to one patient at a time by a dedicated study nurse. Therefore, while we believe use of the device is simple and potentially feasible in the ED, we were unable to evaluate usability of the device by end-users in this study.

CONCLUSION

Warming IV fluids to body temperature prior to infusion was associated with improved comfort for adult ED patients compared to standard, room temperature IV fluids in this pilot study. Future research is warranted to further investigate the effect of warmed IV fluids on patient-centered outcomes and the feasibility of warming IV fluids in the ED setting.

FUNDING

The Safe & Warm IV Fluid Warmer Device used in this trial was provided by Safe & Warm, Inc. Safe & Warm, Inc. had no role in the conduct of the study, interpretation of the data, or preparation of this manuscript.

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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. Safe & Warm, Inc. proided the warmers, but did not fund this research study.

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Perception of Noise by Emergency Department Nurses

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Supervising Section Editor: Juan F Acosta, DO, MS
Submission history: Submitted October 22, 2012; Revision received February 21, 2013; Accepted May 28, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.5.16215

Introduction: Noise in the emergency department (ED) may be perceived to be high by both patients and nurses alike. This increased noise level is hypothesized to be responsible for communication interference and subsequent disruption of complex procedures and decision-making. The objective of this study is to quantify ambient noise level in an ED while obtaining coincident subjective surveys from nurses in the assessment of actual versus perceived noise.

Methods: Data collected from surveys of ED nurses on each of 3 different dates revealed that sound levels within the selected ED were consistently at or below 70 decibels (dB) of sound as measured by a sound level meter. This level of sound is of the same decibel of normal conversation at a 3-5 foot distance. Nurses surveyed overwhelmingly rated noise as "low" or "not loud" irrespective of a variance (though predominantly within a 10 dB range) in actual sound decibel measurements.

Results: Years of experience of work within emergency departments proved the most consistent predictor of nurses' opinions on the frequency with which noise levels within the ED were louder than they should be, with more experienced nurses all ranking noise levels as "frequently" or "always" louder than they should be.

Conclusion: Individual variance existed in how nurses felt that noise level affected work function. ED nurses' perception of noise is perceived to be low and generally not interfering with their cognitive function. [West J Emerg Med. 2013;14(5):547–550.]

INTRODUCTION

Ambient noise in the work environment may be perceived as a nuisance which could negatively impact the well-being and productivity of those who are exposed to it.[1] Noise in the emergency department (ED) may be perceived to be high by both patients and nurses alike.[2] This increased noise level is hypothesized to be responsible for communication interference and subsequent disruption of complex procedures and decision-making.[2] The objective of this study is to quantify ambient noise level in an ED while obtaining coincident subjective surveys from nurses in the assessment of actual versus perceived noise.

METHODS

A single hospital ED was selected for use in data collection. It is a busy urban teaching hospital with an annual patient volume approaching 50,000. The hospital's institutional review board approved the study.

A multi-range sound level meter was calibrated and set to parameters consistent with Occupational Safety and Health Administration regulatory testing, both range/frequency rating (high) as well as response time (slow), on each of 3 separate dates on which data was collected. The sound level meter was then positioned adjacent to ED nurses on the counter top while they completed a survey regarding the current noise. The nurses verbally consented to participate in the survey. They were blinded to the purpose of the study and its attempts to correlate actual versus perceived noise levels. The surveys contained questions relating noise level to the medical work environment suitable for completing cognitive tasks as well as for a healing environment for patients.

Upon completion of the survey, the data collector recorded the corresponding sound level as displayed on the sound level meter during completion of the survey. Data was collected on 3 separate dates during April 2007 during

shift change, between day shift and afternoon shift, and subsequently evaluated. A total of 55 surveys were completed for evaluation. Nurses were allowed to complete a survey only once per shift, though a few nurses completed an additional survey done on a different day.

RESULTS

Fifty-five ED nurses (RNs) were enrolled and completed surveys. All surveys were completed at a time when the sound level meter registered a sound level at or below 70 decibels (dB), a level consistent with normal conversation at a 3-5 feet distance.

In evaluating actual versus perceived noise, the registered sound level from the sound decibel reading device was compared to how staff subjectively rated the concomitant ambient noise level on a scale of low, not loud, moderate, loud, and very loud (Figure 1).

The majority of staff surveyed ranked the ambient noise level at the time of the survey as "low" or "not loud", regardless of the corresponding sound level as measured in dB by the sound level meter. All surveys were completed at times when the sound level meter registered sound levels at or below 70 dB. All but 6 of 55 total completed surveys were completed at a time when the sound level meter registered a reading between 60-70 dB. The 6 out-of-range readings were all less than 60 dB. The results of the subjective survey may reflect the fact that the human ear necessitates a decibel change of approximately 5 dB to notice a change in volume and 10 dB to judge a sound as twice as loud.[5]

All surveys and sound measurements were obtained in non-patient-care areas of the ED. The possibility that noise levels at the patient bedside, particularly during resuscitation situations when clinical decision-making is critical and patient demand for a healing environment high, may be different than those measured in non-patient-care areas.

Significantly, years of experience working within an ED appeared to be the most consistent predictor of how staff answered the question of whether noise levels within the ED were greater than they should be. Those nurses with greater than 10 years of experience working in emergency departments *all* answered that question as "frequently" or "always", while *none* of the nurses with less than 1 year of experience answered the question as "always".

Responses to staff answering the question, "Do you believe the noise in the Emergency Department is louder than it should be?" was compared with years of experience working in emergency medicine. In this case the nurses with the lower number of years working in the ED perceived the noise levels to be frequently higher than they should be.

Nurses' responses were collected regarding the effect of ambient noise on work environment and perceived cognitive functioning during medication calculation, charting and phone report. These responses grouped together as a possible effect on cognitive function. The cognitive function results showed that 32% of nurses felt their cognitive function was never affected by noise, 21% answered "rarely" and 33% said "sometimes". "frequently" and "always" only accounted for 14%.

The nurses were finally asked if they felt the noise levels affected the patients' healing environment; 39% of responses were "never" or "rarely", an additional 37% said "sometimes" and 24% responding "frequently" or "always".

DISCUSSION

The impact of noise on clinical decision-making has previously been studied in operating rooms. A study by

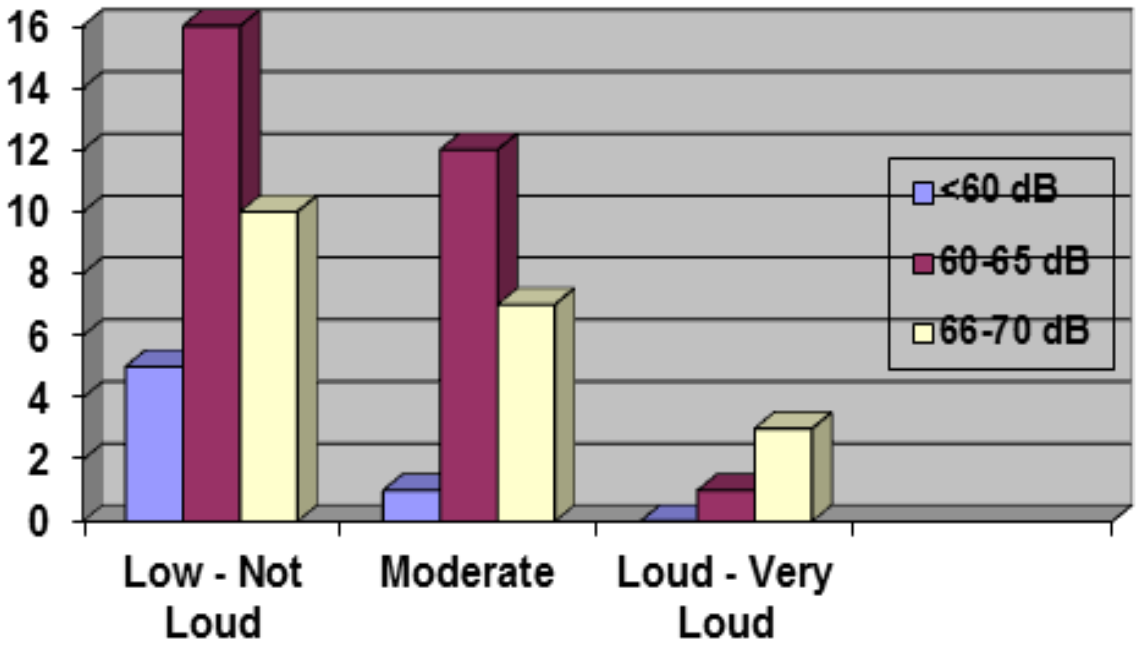


Figure 1: Actual sound level and number of response (y-axis) compared with subjective nurses reporting of noise level (x-axis).

Murthy and Malhotra in India concluded that operating room noise reduced mental efficiency and short-term memory in anesthesia residents.[3]

The presumption that emergency departments are noisy has not previously been well described objectively in medical literature. However, a study by Park et al[4] of radiology residents, ambient noise in the ED setting and its effect on the accuracy of diagnosing rib fractures was measured. In this study, it was concluded that physicians accustomed to reading x-rays in quiet environments performed better under quiet conditions than noisy conditions; whereas the accuracy of physicians accustomed to a noisy environment was unaffected by the presence of ambient noise.[4]

Sound level decibel loudness for environmental noise is well established for a variety of ranges.[5] Included are those ranges specific to the sound level meter used in this study. Normal conversation at 3 feet is considered 60-70dB, while city traffic as experienced inside a car is 85dB and in a subway 95dB.

There was inconsistency with nurses reporting of noise level interfering with their work function. The only group of respondents that did not classify work interruption as "frequent" or "always" were those whose coincident sound levels (per the sound level meter) were less than 60 dB. A 2002 evaluation of noise within a post-anesthesia care unit suggests that excess noise, of which conversation is the most common cause, can cause adverse physiological and psychological effects on patients as well as increase mistakes amongst medical professionals.[6]

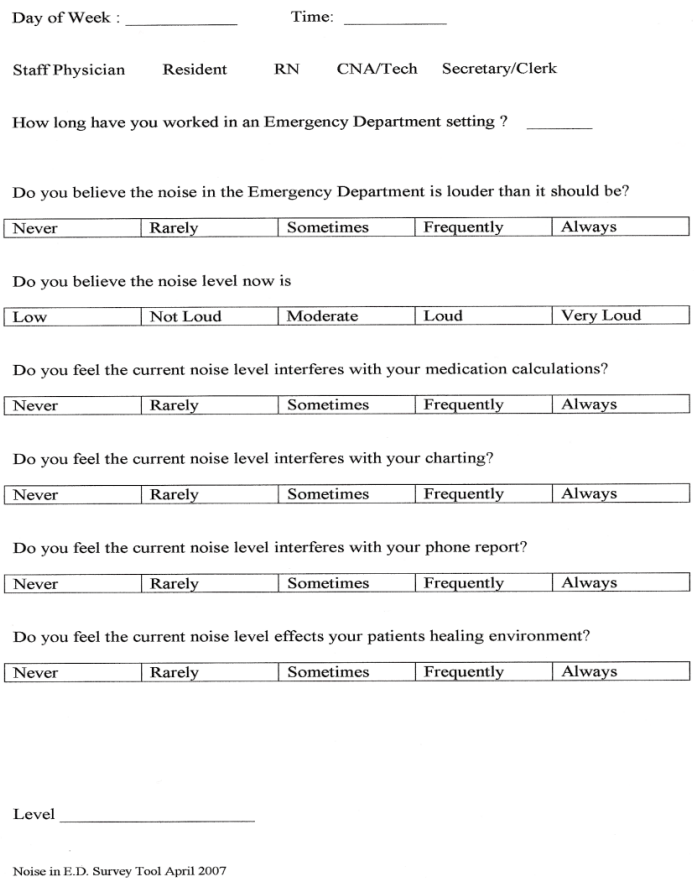
No consistent patterns existed in the data collected regarding nurses' opinions on how current sound levels affected patients' healing environment.

LIMITATIONS

Data collection occurred only in non-patient-care areas of the ED, e.g. at the nurses' station and not in patient rooms. The use of the term "noise" in the survey may have been ambiguous as some nurses interpret noise to be routine ambient ED staff conversation as well as medical device alarms or even family members and telephone calls. "Noise" may be alternatively interpreted as any sound that results in interruption in cognitive function or transmission of messaging as opposed to just sounds.

CONCLUSION

This study intended to evaluate and quantify sound levels within a selected ED. These objective measurements were then correlated with nurses' opinions regarding noise levels. Data collected on each of three different dates revealed that sound levels within the selected ED were consistently at or below 70 dB of sound as measured by a sound level meter. This level of sound is of the same decibel of normal conversation at a 3-5 foot distance. Nurses surveyed overwhelmingly rated noise as "low" or "not loud" irrespective of a variance (though predominantly within a 10 dB range) in actual sound decibel measurements. Years of experience of work within emergency departments proved the most consistent predictor of nurses' opinions on the frequency with which noise levels within the ED were louder than they should be, with more experienced nurses all ranking noise levels as "frequently" or "always" louder than they should be. Individual variance existed in how nurses felt that noise level affected work function. Further studies could include physicians as part of the survey group and comparing their perceptions with nursing staff. Patients' perceptions of noise levels could also be compared against ED noise and inpatient noise. Further studies are necessary to determine if a correlation exists between perceived sound level and actual work function as far as whether noise results in distractions significant enough for errors to occur.



Day of Week : _____ Time: _____

Staff Physician Resident RN CNA/Tech Secretary/Clerk

How long have you worked in an Emergency Department setting ? _____

Do you believe the noise in the Emergency Department is louder than it should be?

Never	Rarely	Sometimes	Frequently	Always

Do you believe the noise level now is

Low	Not Loud	Moderate	Loud	Very Loud

Do you feel the current noise level interferes with your medication calculations?

Never	Rarely	Sometimes	Frequently	Always

Do you feel the current noise level interferes with your charting?

Never	Rarely	Sometimes	Frequently	Always

Do you feel the current noise level interferes with your phone report?

Never	Rarely	Sometimes	Frequently	Always

Do you feel the current noise level effects your patients healing environment?

Never	Rarely	Sometimes	Frequently	Always

Level _____

Noise in E.D. Survey Tool April 2007

Figure 2: Questionnaire.

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

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Measuring Power in an Emergency Department to Improve Processes and Decrease the Length of Stay to their Optimum Value

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Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.5.16258

Many emergency departments (EDs) compare themselves to national productivity benchmarks, such as the average patients/hour or relative value units (RVUs)/hour. Making these comparisons does not provide a tool to determine which processes need improvement, most urgently, within the ED to improve efficiency. Furthermore, there has been no clear means to determine how to set reasonable goals based on the capabilities of the particular ED under study. Determining the power of a process is a tool that can provide the ED with these missing pieces of information. [West J Emerg Med. 2013;14(5):551–554.]

BACKGROUND

A previous paper describes how to measure an emergency physician's work by combining clinical hours, patients seen, and relative value units into a single metric.[1] This article will use the same concept, but instead combines length of stay (LOS) hours, patients (PTs) seen, and relative value units (RVUs) to determine the workload of a specific process. Most any activity performed in an ED could be considered a process. Common examples are discharged patients or admitted patients.

Measuring the workload of a process requires 3 specific terms. Let us start by learning how these 3 terms give us a measure of the workload. The more time patients spend in the ED, the more labor is required from the staff to care for and monitor those patients. Therefore, the LOS hours is a factor contributing to the workload. Another factor is the number of patients that create those LOS hours. Clearly if more patients are in the ED, then more resources are required to care for those patients. A third factor contributing to the workload is the level of difficulty or effort required. A reasonable measure of difficulty or effort is the amount of physician RVUs that were performed on a patient. We are not restricted to these specific terms, but combining these 3 terms into a single metric in the manner shown in the cited article gives a reasonable measure of the total workload of a specific process.

Next we need to realize that workload is not the final measure we care about. What is important is how well we are performing the work involved in a given process. The measure that tells us how well we are performing work is power. Power is defined as the rate at which the workload is being accomplished and is one measure of efficiency. It is determined by dividing the workload of the process by the time spent on this process, in this case the LOS hours. The more work the ED can handle per LOS hour, the more powerful the process becomes.

In a given ED, it might turn out that the workload of discharges is accomplished with 100% power. If the corresponding power of admissions was only 85%, you now know that the admission process is performing less work per unit of time than the discharge process. A well- performing ED would be expected to perform all equivalent work in equal amounts of time. Once we know that the admission process is not as powerful as the others, we can now make it a priority for improvement. The power measurement is meaningful even when the workload amount is different for the various processes.

By means of an example, this article will show how to use power to quantify the level of performance of a process. This approach leaves the well-running processes alone while concentrating on the weaker ones. We don't have to change the entire ED to improve the inefficient processes. Another advantage to quantifying power, or efficiency, is that we need not select arbitrary process improvement changes. It is often said that this year we are going to improve a specific goal by 10%, arbitrarily. If we quantify the power of processes in an ED, we can predict what change is required to get the level of performance of which we are capable. It will be shown by example how to avoid arbitrary goal changes and instead select the optimum goal.

Table 1. Power based on length of stay (LOS).

Disposition	LOS hours	% LOS	Workload	Power
Discharged	2,000	51.0%	51.0%	100%
Admitted	1,200	30.6%	30.6%	100%
Observation	625	15.9%	15.9%	100%
Transferred	100	2.5%	2.5%	100%
Total	3,925	100.0%	100.0%	100.0%

EXPLANATION OF TERMS

Length of stay hours are defined as the cumulative time that patients are in the ED. Relative value units are considered one measure of the level of effort that is put into a patient while they are in the ED. LOS hours, patients, and RVUs all use the resources within an ED. The workload of a given process is defined as the average of their LOS hours, number of patients, and number of RVUs, where each of these is expressed as a percentage of their respective totals. Combining these terms into a single measure gives us a measure of the total workload of a given process. For example, let's say that discharged patients were in the ED 50% of the total hours that all patients were in the department. At the same time this group included 48% of the total patients while acquiring 60% of the total RVUs. The average of these 3 terms, 52.7%, is the workload of the discharged patients on the ED. The statistical relevance of this measure is explained in a previous article.[1] We are not limited to terms like LOS hours, patients, and RVUs, but they are a reasonable terms for the purpose of our example.

Once the term for workload is defined, the power that goes into this work can be determined. Power is the rate at which work is accomplished. So taking the workload and dividing it by the time invested in that workload, the LOS, gives the power of that process. The more powerful processes are capable of handling more patients and RVUs for a given amount of time and are considered to be more efficient.

EXAMPLE

The key to understanding the value of the power of your processes is to first look at LOS. To be clear, LOS is not the average LOS/patient. It is the cumulative hours that all the patients involved in a particular process spend in the ED. As we progress through the example, you will see how linking other meaningful data to the LOS and determining the power gives a better picture of how various processes are performing. Assume we are interested in the 4 basic dispositions of the ED, which are patients discharged, admitted, placed in observation status, and transferred. We are not limited to these categories. For example the International Classification of Diseases (ICD) diagnoses or age groups (stroke, acute coronary syndromes, orthopedic trauma, pediatrics) are other valuable categories to explore.

Table 1 lists the cumulative LOS hours for each of the department's dispositions. With this single set of information, our conclusions are limited. At most we might be able to conclude that if we were going to consider making any changes, we might look at the discharge process first because it involves the highest workload. So improvements here should have the biggest impact. The power says all of the processes at this point are actually equal. Before making changes based on this information, maybe we first need to include more meaningful data.

Next look not only at the LOS hours but also the number of patients that make up those hours (Table 2). Combining these 2 terms changes the workload and power results. The process for getting patients into observation status is doing quite well while the other 3 dispositions are less powerful at 96.7%. At this point we would have to conclude that we better improve the discharge, admission, and transfer processes. Realize that we could also make a similar conclusion by comparing the LOS/PT for our dispositions. As we proceed we will notice that LOS/PT will no longer contribute to the decision-making process.

We can further improve our understanding of the influences on our LOS by considering the effort we put into the patients while in the department (Table 3). Here we included the RVUs associated with each disposition to calculate the combined workload and power. Notice that each time new data is included, the workload and power change, but the LOS/PT has not. This is why the LOS/PT is not a reliable variable to consider when measuring performance. Looking at the LOS/PT in Table 3 would lead us to the same conclusion we had from Table 2. However, looking at the power in Table 3 leads us to a more informed and different conclusion. We now conclude that the discharge and observation processes are doing well with higher power values compared to the admission and transfer processes.

IMPACT OF POWER

Let's now look at the impact of using the results of Table 3. We know we should improve both the admissions and transfer processes. The workload of the admission process is much greater than the transfer process. Therefore, to have the greatest overall impact, it is reasonable to put our efforts into improving the admission process first. Since the workload of the admission process is 26% of our total workload, we would like to spend no more than 26% of our total LOS hours on these patients. Therefore, a reasonable goal would be 26% of the 3,925 total hours, or 1,020 hours as the goal for the ED's LOS hours for the admitted patients. Table 4 shows the results for achieving the 1,020 LOS hours with all else remaining the same. By concentrating on the worst process and reducing the admitted patients to 3.4 LOS hours/PT, the overall ED LOS hours/PT decreased by 5% to 3.57 hours/PT.

If we were to focus on the LOS/PT numbers in Table 4, we might be tempted to think that discharges and transfers are what need improvement because they have the highest LOS

Table 2. Power based on length of stay (LOS) and patients.

Disposition	LOS hours	Patients	% LOS	% Patients	Workload	Power	LOS/Patient
Discharged	2,000	500	51.0%	47.6%	49.3%	96.7%	4.00
Admitted	1,200	300	30.6%	28.6%	29.6%	96.7%	4.00
Observation	625	225	15.9%	21.4%	18.7%	117.3%	2.78
Transferred	100	25	2.5%	2.4%	2.5%	96.7%	4.00
Total	3,925	1,050	100.0%	100.0%	100.0%	100.0%	3.74

Table 3. Power based on length of stay (LOS), patients and relative value units (RVU).

Disposition	LOS hours	Patients	RVUs	% LOS	% Patients	% RVUs	Workload	Power	LOS/Patient
Discharged	2,000	500	800	51.0%	47.6%	60.2%	52.9%	103.8%	4.00
Admitted	1,200	300	250	30.6%	28.6%	18.8%	26.0%	85.0%	4.00
Observation	625	225	250	15.9%	21.4%	18.8%	18.7%	117.5%	2.78
Transferred	100	25	30	2.5%	2.4%	2.3%	2.4%	94.0%	4.00
Total	3,925	1,050	1,330	100.0%	100.0%	100.0%	100.0%	100.0%	3.74

Table 4. Improving the admitted patients length of stay (LOS) hours.

Disposition	LOS hours	Patients	RVUs	% LOS	% Patients	% RVUs	Workload	Power	LOS/Patient
Discharged	2,000	500	800	53.4%	47.6%	60.2%	53.7%	100.6%	4.00
Admitted	1,020	300	250	27.2%	28.6%	18.8%	24.9%	91.3%	3.40
Observation	625	225	250	16.7%	21.4%	18.8%	19.0%	113.7%	2.78
Transferred	100	25	30	2.7%	2.4%	2.3%	2.4%	91.2%	4.00
Total	3,745	1,050	1,330	100.0%	100.0%	100.0%	100.0%	100.0%	3.57

RVU, relative value unit

hours/PT. Discharges should be left alone for now because the better power result of 100.6% tells us that for those patients we are doing about 4 hours of work, so their LOS hours/PT is reasonable. The admitted patients have improved to a 3.4 hours/PT but are still at the lower power of 91.3%. While their LOS decreased we still are not performing 3.4 hours of work on these patients, compared to the other types of work performed in the ED. At this point we need to continue to work towards getting them out of the department sooner. They are taking up valuable workspace in the ED that could be better used.

The reason the power for admissions did not achieve 100% with this one change is because this process is iterative. Each time changes are made, relative comparisons are given to find the new, less powerful process. In this example, after the initial changes are implemented, we see by looking at the power that admissions and transfers still need further process improvements. This method provides calculable and reasonable step-by-step, rather than arbitrary, changes.

COMMENTS

Measuring power provides a tool that gives insight into what processes are a priority for improvement. This approach does not involve comparing the ED to a national benchmark; it compares the ED to itself to find its own weaknesses. While it may be interesting to know how an ED compares to other departments, knowing this does not give insight into how to make improvements within your department. This power approach can provide two distinct advantages. It shows what processes need attention. It also provides a reasonable magnitude of changes for new goals. This method depends on the type of resources and department dynamics (e.g. morale) currently available to the ED rather than a comparison to an outside source. Once all processes are at their best possible power, then the ED is performing at its highest level. Further improvement in the ED would most likely require improving the type of resources available to the department or the state of the department.

LIMITATIONS

This model assumes that other factors not accounted for remain constant. These factors would include the physician, nursing and ancillary staff, as well as typical support services such as x-ray, ultrasound, and consultants for example. Workload measurements for nursing and ancillary staff could be included with the 3 factors used in this example as additional information becomes available.

The results of this method do not depend on revenue or

the RVU reimbursement rate. It does assume that an RVU is a reasonable measure of the effort performed. If other meaningful measurements are available, they could replace the RVU or be included with the three current factors to enhance the results. Since RVU reimbursement rates can vary, it would be reasonable to accept a less powerful process for those with higher revenue returns. Taking revenue into account along with the power of a process is the next logical step.

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

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When a Patient Declines Curative Care: Management of a Ruptured Aortic Aneurysm

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Supervising Section Editor: Rick McPheeters, DO
Submission history: Submitted April 8,2013; Revision received April 26, 2013; Accepted May 2, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.5.17913

The management of major vascular emergencies in the emergency department (ED) involves rapid, aggressive resuscitation followed by emergent definitive surgery. However, for some patients this traditional approach may not be consistent with their goals and values. We explore the appropriate way to determine best treatment practices when patients elect to forego curative care in the ED, while reviewing such a case. We present the case of a 72-year-old patient who presented to the ED with a ruptured abdominal aortic aneurysm, but refused surgery. We discuss the transition of the patient from a curative to a comfort care approach with appropriate direct referral to hospice from the ED. Using principles of autonomy, decision-making capacity, informed consent, prognostication, and goals-of-care, ED clinicians are best able to align their approach with patients' goals and values. [West J Emerg Med. 2013;14(5):555–558.]

INTRODUCTION

The priority of traditional emergency department (ED) care is on the resuscitation and stabilization of the acutely ill or injured patient. The ED is a safety net for many patients with an advanced chronic illness who present with critical "crisis" and terminal events.[1-5] The traditional, aggressive ED approach may not suit the needs of such patients and optimal care plans are best tailored to patient goals and values.[5,6] ED clinicians caring for these patients may therefore have to rapidly adapt and shift their focus from a disease-directed resuscitation to comfort care, a challenging task for many ED clinicians who may feel unprepared and untrained for such scenarios.[7-10] We present the case of a patient with underlying chronic illnesses who presents to the ED with a "catastrophic" event and whose values are not aligned with resuscitative ED care. We then discuss a framework that may assist ED clinicians faced with the transition of a patient from a curative to comfort care-based approach.

CASE REPORT

A 72-year-old female ex-smoker with a past medical history significant for hypertension, abdominal aortic aneurysm, severe chronic obstructive pulmonary disease, and lung cancer presented to the ED with progressively increasing left-sided abdominal pain over 24 hours. The patient was tearful and anxious. Her vital signs included blood pressure of 150/90 mmHg, oral temperature of 36.5°C (97.8 °F), pulse 120 beats/minute, respiratory rate 26 breaths/minute, and 97% oxygen saturation by pulse-oximeter. She was adherent to her albuterol inhaler and labetalol regimen. Physical examination revealed a slightly distended abdomen with guarding and significant tenderness over the left lower quadrant. The rest of her examination, including bilateral pulses, was normal. A bedside FAST (focused assessment with sonography for trauma) examination was positive for free intra-peritoneal fluid. Computed tomography imaging revealed an 8 cm (transverse diameter) aortic aneurysm with evidence of contained rupture and displacement of abdominal organs by the large left sided peri-aortic hematoma (Figure). The patient informed staff that she was aware of her diagnosis and condition and had refused surgery 5 years prior. During her initial resuscitation, the patient had a discussion regarding operative management with the vascular surgeon and ED clinician. She again refused any major surgical interventions due to her concern that she could be ventilator dependent for some time, an outcome she felt was unacceptable.

Therefore, we present a framework for shared informed decision-making, exploring the pathway of our patient's

Table. Rapid Overall Goals-of-Care Conversation in the emergency department.[12-15]

Skill	Description
Determine the legal decision-maker	If patient unable to make decisions review any completed advance directives.
Communicate prognosis	Answer the two fundamental questions: "What is wrong with patient?" and "What will happen to her/him?" Summarize the "big picture" in a few sentences—use the word "dying" if appropriate Frame the discussion as "hoping for the best but planning for the worst."
Use appropriate language	We want to ensure you receive the kind of treatment you want. Your comfort and dignity will be our top priority. Let us discuss how we can work towards your wish to stay home or pain-free or…
Elicit patient preferences with open ended questions	Knowing that time is short, what is most important to you? What are you expecting in the next few hours, days, weeks…? What kind of results are you hoping for? What do you hope to avoid at all costs? Have you seen or been with someone who had a particularly good death or a particularly bad death? Please tell me about it.
Make recommendations	Example, "According to what you want/what you want for [the patient], I would/would not recommend…."

transition from a curative (disease-directed) to a comfort care (symptom-directed) approach.

DISCUSSION

The patient presentation as described above posed major ED management challenges/issues, such as:

1. Does the patient have decision-making capacity, and is she able to fully understand the consequences of surgery refusal?
2. How does the ED provider hold a rapid goals-of-care discussion to elicit her values and concerns?
3. How does the ED provider shift approach and transition the patient from curative to comfort-based care?

Issue#1: Refusal for curative care (surgery) and assessing decision-making capacity

We applied the ethical principles of autonomy and available guidelines for determining decision-making capacity and informed consent to assist our patient care.[11] *Autonomy* (self-determination) refers to a person's ability to make his or her own decisions, including health-related choices, based on personal values and beliefs. For a valid, informed refusal (similar to informed consent) we consider the following: 1) the patient must have *decision-making capacity*; 2) information related to significant risks and magnitude of harm must be provided explicitly; 3) the patient must demonstrate comprehension of the information; and 4) refusal must be voluntary and without coercion.[11]

In healthcare settings, we assume that all adults have the medical decision-making capacity to accept/refuse a plan of care unless there is evidence in the history, behavior, or physical examination that suggests that this capacity has been significantly compromised. Decision-making capacity is dynamic and decision-relative (a patient may be able to make a simple decision, but not a complex one).[11] A patient may only need a *low* level decision-making capacity to consent for a low-risk, high-magnitude-of-benefit procedure, but would likely need a *high* level of capacity when refusing the same. It is also important to note that "competence" is a legal term and determined by court (for example, a person may not be competent to handle their finances but still have medical decision-making capacity). Medical decision-making is obviously more challenging if the patient lacks decision-making capacity, and surrogates or healthcare proxies need to make inferences based on known patient values.[11]

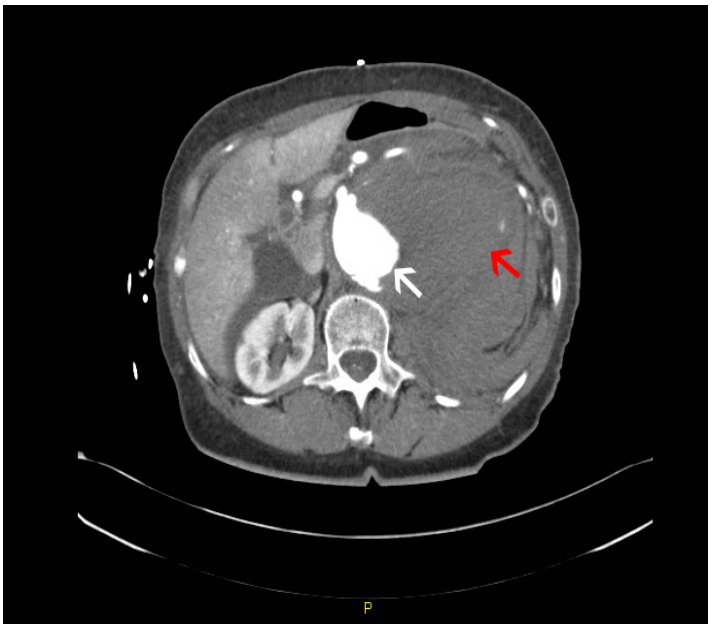

Figure. Computed tomography of the abdomen and pelvis (large peri-aortic hematoma [red] with abdominal aortic aneurysm [white].

Our patient demonstrated decision-making capacity to refuse surgical care based on her ability to: 1) receive information regarding her catastrophic vascular emergency; 2) deliberate and weigh the risks of the procedure itself and the procedure refusal, including imminent death; and 3) defend, as well as verbalize her choice based on her values and perceived quality of life.

Issue#2 Shared informed decision-making (goals-of-care ED discussion)

Patient management is ideally based on a shared decision model where therapy is aligned to the patient's values. If deterioration is imminent or rapid, decisions are needed regarding the use of life-sustaining treatments (e.g., intubation for respiratory failure), and a focused discussion around goals-of-care must occur in the ED (Table).[6,12,13] Goals-of-care discussions aid in discovering where the patient wants to go and what he wants to avoid so we can then recommend the best treatment plan to achieve his objectives.[13,14] For example, advance directives (ADs) are documents that are completed by a patient when he or she *has* decision-making capacity and provide direction for care at a *future* time when the person may become unable to make such decisions, such as *instructional* directives (do-not-hospitalize or do-not-intubate) or *proxy* directive or designation of the durable power of attorney for healthcare. The key to understanding the patient's goals is the "why" behind a decision as opposed to the "yes" and "no" answers. Unveiling the patient's underlying refusal of care may be paramount to establishing trust and allowing communication in a timely manner.[14] Therefore, it is best to determine the overall concerns and goals before addressing specific issues such as cardio-pulmonary resuscitation.[12,13,15] The way we ask the patients questions often determines their responses. Clinicians must be cognizant of their language, tone, and presentation when discussing goals-of-care to patients. The framing effect may lead to adverse decision-making on behalf of the patient. The patient/family may feel abandoned if statements with a negative connotation are used. For example, "Do you want us to discontinue care or do you want us to stop aggressive therapy?" Emergency clinicians and all clinicians of the treatment team should use suitable language in the setting of end-of-life discussions in patients with a terminal chronic illness (Table).[12,13,15] The treatment team should present the patient with alternatives should the patient choose to forego the optimum plan.

Based on the goals-of-care conversation, we determined that our patient understood her prognosis and knew that she was going to die in a short period of time (hours to days). Her main concerns were receiving adequate pain control and being with loved ones for the remainder of her time. She expressed no fear of imminent death, but was fearful of dying "on the table-all alone;" and even if she were to survive the major operation, she expressed no desire to live "tied to machines."

Issue#3 Transition of the patient from curative to a comfort care approach in the ED

A seamless shift from curative to comfort care-based approach may be needed once patient goals are clarified. It is imperative to emphasize non-abandonment of the patient by expressed words and actions. Optimal symptom control and addressing the physical, as well as psychosocial and spiritual needs of the patient, is essential during this transition. These steps are best accomplished by involvement of a palliative care consultation team (if available) or an appropriate referral to hospice in the ED.[12-16] Hospice care is provided by a multidisciplinary team that includes a physician, nurses, social workers, chaplaincy support, home health aides, volunteers, and therapists. Members of the hospice team meet regularly to set patient care plans, discuss ongoing issues, and make regular visits to assess the patient for needed care and support services. Hospice care plans include the management of the pain and other distressing symptoms; provision of symptom and comfort-related medications, medical supplies and equipment; assistance with emotional, psychosocial, and spiritual aspects of dying; caregiver support and guidance on how to care for the patient; speech and physical therapy; short-term inpatient care when symptoms become difficult to manage at home for those actively dying or when the caregiver needs respite time; and bereavement care to the surviving family and caregivers for one year after patient death. Sometimes, based on the dying patient's wishes and needs, a safe disposition to home under hospice care may be possible from the ED.[12-16]

We optimized care for the patient's distressing physical symptoms of pain and anxiety with use of a continuous morphine drip and intermittent use of lorazepam.[16] The patient was moved to a private ED room while awaiting a hospital bed to ensure privacy to the family. All monitors were turned off to create a calmer setting. A timely and appropriate referral to hospice was made from the ED. Thirty-six hours after admission, the patient died in-hospital surrounded by her family and chaplain. Ongoing bereavement support was provided to family survivors as part of hospice services.[16] Both the staff and family expressed satisfaction with the quality of end-of-life care provided.

CONCLUSION

When resuscitative care is not desired, a tailored approach is required for optimal ED management of the imminently dying patient. Therapy is thus aligned to the values and goals-of-care of the patient. Integrating basic palliative care principles into practice may assist ED clinicians in transitioning their patient from a curative to comfort care-based approach at end-of-life and support family at this challenging time.

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

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Medical-legal Issues in the Agitated Patient: Cases and Caveats

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Supervising Section Editor: Michael Wilson, MD, PhD
Submission history: Submitted October 30, 2012; Revision received February 8, 2013; Accepted April 2, 2013
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2013.4.16132
[West J Emerg Med. 2013;14(5):559–565.]

INTRODUCTION

More than any other area of emergency medicine, legal issues are paramount when caring for an agitated patient. It is imperative to have a clear understanding of these issues to avoid exposure to liability. These medico-legal issues can arise at the onset, during, and at discharge of care and create several duties. At the initiation of care, the doctor has a duty to evaluate for competence and the patient's ability to consent. Once care has begun, patients may require restraint if they become combative or violent. If restraints are placed, the physician has a duty to protect the patient and should fill out all appropriate paperwork as they have decided to take away the patient's liberty. Use of restraints may precipitate issues of battery and false imprisonment. Finally, prior to discharge, the physician has a duty to determine if there have been any direct threats made regarding a third party and if there is a duty to warn. These medico-legal issues will be illustrated using actual court cases. The purpose of this paper is to educate practicing emergency physicians (EP) on high-risk legal issues concerning the agitated patient, so that liability can be avoided.

METHODS

The authors with a combined 15 years of medico-legal experience developed a focused list of topics and concerns with regards to liability concerning the agitated patient. For the purposes of this paper, an agitated patient was one considered to be violent, delirious, or presenting with a psychiatric emergency. Cases that applied to these topics were then individually and randomly selected. For each topic, an attempt was made to identify both a classic/defining legal case followed by a more current example.

Consent/Competence/Restraint

Before undesired medical care can be undertaken, the EP must first understand the components and requirements of informed consent. Traditionally, patients have the right to determine if and when they want medical care and what care they desire.[1,2] Patients enter into contractual obligations with physicians by granting permission for medical care and treatment. This is referred to as consent for treatment. An analysis of what constitutes consent and the related topic of competence is helpful in determining what care should be provided to the agitated patient in the emergency department (ED) (Figure 1).[3]

Informed consent is consent of a patient or other recipient of services based on the principles of autonomy and privacy. Seven criteria define informed consent:

(1) Competence to understand and to decide,
(2) Voluntary decision making,
(3) Disclosure of material information,
(4) Recommendation of a plan,
(5) Comprehension of terms (3) and (4),
(6) Decision in favor of a plan, and
(7) Authorization of the plan.

A person gives informed consent only if all of these criteria are met. If all of the criteria are met except that the person rejects the plan, that person makes an informed refusal.

Figure 1. Definition of informed consent.[6]

Consent is defined as a voluntary agreement by a person in the possession and exercise of sufficient mental capacity to make an intelligent choice to do something proposed by another.[4] Consent is generally considered as either implied or expressed. Implied consent is defined as the signs, actions, facts, or inaction that raises the presumption of voluntary agreement. Thus, a patient presenting to an ED for assistance by himself or via another concerned person or agency, would generally be considered as providing implied consent. [4] The exception would be if the patient is competent and refusing. Another specific example would be when a patient holds his arm out for a blood sample draw. The action, without words, implies consent. Expressed consent is when the patient, in verbal or written form, gives consent for a procedure. If consent is given verbally, it is optimal for the provider to document this on the chart. As the severity and importance of the decision increases, the provider should consider written

rather than verbal consent. Usually, whether to use verbal versus written consent is a personal practice decision of the provider.

Individuals are entitled to make decisions about their healthcare if they are deemed competent. Competency is defined as the capacity of a person to act on his/her own behalf; the ability to understand information presented, to appreciate the consequences of acting–or not acting–on that information, and to make a choice.[4] Seven criteria must be met in order to obtain informed consent (Figure 1). Adults are presumed competent to grant consent for proposed medical treatment. An incompetent adult patient who is incapacitated by physical or mental illness and is unable to understand the nature and consequences of his or her actions cannot give valid consent to proposed treatment. In the case of an incapacitated adult, consent must be obtained from someone who is authorized to consent. This may be someone that the patient requested when competent through a "durable power of attorney," or if a court has decided the patient is incompetent, the patient's court-appointed guardian must authorize treatment. If a physician has determined that a patient is incapable of comprehending the nature and consequences of his or her conduct but the patient has not been judged incompetent, most courts will accept the consent of the patient's next of kin. It is wise to document that the family desired and approved the proposed treatment. This "substituted consent" is not ideal because each individual is considered the true authority on deciding his or her care.[1,2,4]

The law usually presumes patient consent in an emergency. Courts have supported EP actions, without consent, when the purpose was to preserve the patient's life or health.[2,5] Courts assume that a reasonable, competent adult would want to be healthy. Specifically in the case of an agitated patient, the EP can safely assume that the act of presenting to the ED is at least an implied consent for evaluation and treatment. The EP should quickly decide if the patient is competent. If competent, the patient must give express consent before proceeding, but otherwise the physician is at liberty to provide care. Documentation of factors that led to the decision on competence is imperative, and supportive documentation of coworkers present is optimal. For example, having another present physician state on the chart "I agree," will be extremely supportive if legal action is taken later by the patient. If time permits, an actual court order is ideal. If the family is present, explaining the need for action, and documenting their support is essential. The more life-threatening the emergency, the more the physician should be willing to proceed with the plan of care. If competency is not able to be determined, it is best to err on the side of treatment and safety. Battery and false imprisonment are much easier to defend than passive negligence. In these situations, it is imperative to document that (1) an emergency existed, (2) there was an inability to get consent, and (3) the treatment was for the patient's benefit.[1]

A classic case that illustrates the court's analysis of consent and capacity is *Craig L. Miller v. Rhode Island Hospital et al.*[7] The patient, Miller, drank several alcoholic beverages and then was involved in a serious motor vehicle accident. Miller was transported to Rhode Island Hospital where his blood alcohol level was found to be 0.233. He complained of pain in his head, eyes, back, and ribs, as well as blurry vision because of the blood in his eyes. Because of his level of intoxication and the nature of Miller's accident, "physicians decided to perform a diagnostic peritoneal lavage. (At that time, a standard procedure under conditions concerning for internal bleeding.)"[8] After discussion of the procedure with the patient, Miller refused. However, it was determined that he was not competent to make this decision based on his level of intoxication. He was physically restrained and the procedure was performed anyway. The patient later brought suit for battery.[7]

The Supreme Court of Rhode Island held that medical competency was the relevant standard for physicians to judge conscious patients in these circumstances (ie, whether the patient is able to reasonably understand the medical condition and the nature of any proposed medical procedure, including the risks, benefits, and available alternatives). In this case, the court decided in favor of the defendant hospital. The court concluded, "A patient's intoxication may have the propensity to impair the patient's ability to give informed consent." [7]

Another landmark case that further illustrates this issue was *Youngberg v. Romeo*.[9] Romeo was a mentally retarded patient. Until the age of 26, he lived with his parents, but after his father died his mother was not able to care for him or control his violent behavior. She requested that he be permanently admitted to a Pennsylvania institution. While committed, he suffered several injuries, both from his own violence and the reactions of other residents. On multiple occasions he was physically restrained against his wishes. His mother became concerned with these injuries and objected to his treatment on several occasions before filing suit against the institution, claiming that the patient had constitutional rights to safe conditions of confinement, freedom from bodily restraint, and training and development of needed skills. She felt the institution knew, or should have known, about his injuries, but failed to take appropriate preventive procedures.[9]

In *Romeo*, the Supreme Court of the United States supported involuntarily restraining a patient for safety reasons. The court has given great respect and latitude to physicians regarding violent patients, stating, "We have established that the patient retains liberty interests in safety and freedom from bodily restraint. Yet these interests are not absolute, there are occasions in which it is necessary for the state to restrain the movement of residents – for example, to protect them as well as others from violence."[9] The Model Penal Code allows "an exception from the assault statute for physicians… who act in good faith in accordance with the accepted medical therapy."[10]

ACEP endorses the following principles regarding patient restraints:
- Restraints should be individualized and afford as much dignity to the patient as the situation allows.
- Any restraints should be humanely and professionally administered.
- Protocols to ensure patient safety should be developed to address observation and treatment during the period of restraint and periodic assessment as to the need and means of restraint.
- The use of restraint should be carefully documented. Such documentation should include the reasons for and the means of restraint and the periodic assessment of the restrained patient.
- The method of restraint should be the least restrictive necessary for the protection of the patient and others.
- ACEP opposes any requirement by hospital representatives or medical staffs that emergency physicians provide inpatient restraint or seclusion orders. Patient restraint or seclusion comprehensive patient assessment[25], and the emergency physician's principal legal and ethical responsibility is to patients who present to be seen and treated in the emergency department.[26]
- The use of restraints should conform to applicable laws, rules, regulations, and accreditation standards.

Figure 2. American College of Emergency Physicians policy statement: use of patient restraints.[27]

Duty to Protect

Realize, when you deprive someone of his/her freedom, you assume a "fiduciary responsibility." A fiduciary is similar to a parent, guardian, or prison. It is a relationship of responsibility for the health and welfare of someone else. The importance of liability and responsibility for monitoring a patient after he has been restrained was illustrated in the case *Estate of Doe v. ABC Ambulance*.[11] A 32-year-old schizophrenic threatened to kill his psychologist and was taken to the ED. When informed that he was going to be involuntarily admitted, he became violent. The patient was physically restrained in 4-point restraints, chemically sedated, attached to a gurney on a backboard, and turned upside down. A towel was then placed over his mouth to prevent spitting and a sheet was laid over him to decrease outside stimulus. His complaints of inability to breathe were ignored. When being transferred later to the psychiatric ward, it was noticed that one of his protruding hands was blue. The patient was uncovered and found to be in cardiopulmonary arrest from which he did not recover. His estate was awarded $2 million.

A similar event occurred in *Larry Gazda v. Pima County.*[12] Wendy Gazda was a 32-year-old patient who died of restraint asphyxia while being held facedown by up to 5 mental-health technicians and security guards in a struggle that lasted 15 to 30 minutes. She ended up with her face in a pillow that had been placed on the floor to protect her head. She was turned over after she became still and somebody noticed her hand had turned blue. Her father argued that his daughter was "negligently, unreasonably and violently restrained" by untrained and poorly supervised staff. After the death, state and federal investigations uncovered numerous deficiencies in the hospital's training and staffing, as well as in its policies and procedures. The hospital settled for $105,000.[12] These cases illustrate the lethal risks when restraints are used and the importance of ensuring safe administration.

Every provider or hospital should have a systematic approach to the safe restraint of patients. The American College of Emergency Physicians has proposed a model policy on the use of patient restraints (Figure 2). The Joint Commission has published an extensive guideline on requirements for the use of restraints. It can be seen at crisis prevention website.[29] It would be optimal for all ED providers to be familiar and comply with this document.

Battery

Battery is the intentional infliction of a harmful or offensive bodily contact. (See Figure 3 for complete definition.) One does not have to be hurt but merely suffer damage to one's dignity.[13] Courts are very protective of the "sanctity of person," "bodily integrity," and "personal autonomy" as a fundamental personal right.[14] To be "intentional" simply implies that the actor wanted to do the action, regardless of whether the intent was to help the patient. A physician must never physically invade or touch a competent patient without his/her consent, or the physician may be liable for battery. Recoverable damages can be "general," such as compensation for the harm done, and "special," such as compensation for medical charges, lost wages, and other

The formal definitions contained in the Restatement (Second) of Torts:

§13. BATTERY: HARMFUL CONTACT

An actor is subject to liability to another for battery if

(a) he acts intending to cause a harmful or offensive contact with the person of the other or third person, or an imminent apprehension of such a contact, and

(b) a harmful contact with the person of the other directly or indirectly results.

§18. BATTERY: OFFENSIVE CONTACT

(1) An actor is subject to liability to another for battery if

(a) he acts intending to cause a harmful or offensive contact with the person of the other or third person, or an imminent apprehension of such a contact, and

(b) an offensive contact with the person of the other directly or indirectly results.

Figure 3. Definition of battery.

expenses. These may not be covered by standard medical malpractice insurance.

A defining case of battery was *Pugsley v. Privette* in which a 44-year-old woman agreed to undergo an elective exploratory laparotomy to identify the etiology of vaginal bleeding.[15] As this was not an emergent case, the patient signed a standard consent form prior to the surgery. However, the patient repeatedly requested to have her general surgeon present alongside the gynecologist. Although the chief of surgery initially agreed to be present, at the start of the patient's surgery he was unable to be found and the patient reiterated that she did not want to continue with the operation under those circumstances. Despite her requests, the patient was anesthetized and a bilateral oophorectomy was performed. During the procedure, her ureter was damaged and the patient underwent a protracted postoperative course. The patient sued for medical malpractice and battery. The physicians were not found liable for malpractice as ureteral injury is a known and recognized complication, but the patient was awarded $75,000 in damages for battery.[15]

This relates to an agitated patient as well. If a physician restrains a competent patient for convenience without clear indication for physical contact, they can still be liable for battery.

False Imprisonment

False imprisonment is the intentional infliction of a confinement. It represents confinement and deprivation of personal liberty, for any length of time, without consent.[16] (See Figure 4 for complete definition.) Physical restraints do not need to be placed on a patient to be considered false imprisonment. Just the threat of physical harm, such as a large security guard posted at the patient's doorway, is still considered withholding the patient's right to leave. Damages may be awarded, even in the absence of physical harm, for inconvenience, mental suffering, and humiliation. These may not be covered by standard malpractice insurance policies.

A patient must be deemed incompetent and a danger to himself or someone else before his rights may be taken away and the patient placed in restraints and kept in the hospital against his wishes. If a patient does not wish to stay but has not been deemed incapable of making this decision, the hospital and its staff can be held accountable for false imprisonment. A classic case is *Barker v. Netcare Corp*.[17] Janice Barker presented to Netcare for mental evaluation after reportedly being raped the week before. On arrival the patient was distraught and agitated. The psychiatrist on call was contacted and ordered Lithium and Lorazepam to calm the patient. These did not seem to affect the patient and she was overheard making vague statements about being "put out of her misery." The social worker interviewed the patient and felt she should be a voluntary holdover to stay until a psychiatrist could formally evaluate her in the morning. Barker initially agreed but later left the hospital for a short amount of time. On her return, the patient was offered a shower and was heard banging her head against the wall while in the bathroom. Barker was offered the choice to stay in the hospital or be discharged home with her husband. However, Barker was unable to reach him and became more agitated. The patient again left the hospital, but this time was brought back by campus police as hospital employees were concerned about her mental state due to banging her head against the wall, inability to reach her husband, and the patient only wearing a hospital gown while outside. On return, Barker was placed in physical restraints, as she was now significantly more argumentative, although by nursing report, not combative. Barker was also restrained chemically with Benztropine and Haloperidol. Despite restraints being placed, the hospital failed to commence emergency involuntary commitment proceedings in accordance with Ohio law. Later, Barker brought suit for false imprisonment. The jury found that staff had intentionally restrained or confined Barker without lawful privilege and without consent. The jury found that medical staff acted with insult and actual malice and awarded Barker $150,000 in damages.[17] This case demonstrates that even if the staff feels they are doing what is best for the patient, if the proper protocols are not followed, it is still considered false imprisonment.

Another case where the hospital had good intentions but did not follow proper protocol is *Heath v. Peachtree Parkwood Hospital, Inc*.[18] A woman was held in a psychiatric facility for 3 days without her consent. As in the previous case, no papers for involuntary commitment were completed. After this period, an evaluation determined her to be a danger, and involuntary commitment papers were completed. She successfully sued the physicians and hospital that cared for her during the initial 3 days but absolved the later treating physicians.[18] Both cases emphasize the importance of proper statutory documentation.

The formal definitions contained in the Restatement (Second) of Torts:
§35. FALSE IMPRISONMENT
(1) An actor is subject to liability to another for false imprisonment if
(a) he acts intending to confine the other or a third person within the boundaries fixed by the actor, and
(b) his act directly or indirectly results in such a confinement of the other, and
(c) the other is conscious of the confinement or is harmed by it.
(2) An act which is not done with the intention stated in Subsection (1,a) does not make the actor liable to the other for merely transitory or otherwise harmless confinement, although the act involves an unreasonable risk of imposing it and therefore would be negligent or reckless if the risk threatened bodily harm.

Figure 4. Definition of false imprisonment.[16]

Table. Duty to warn - various state law.[28]

States that Mandate Duty to Warn	Arizona, California, Colorado, Connecticut, Delaware, Idaho, Illinois, Indiana, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Montana, Nebraska, New Hampshire, New Jersey, Ohio, Pennsylvania, Tennessee, Utah, Vermont, Virginia, Washington, Wisconsin
States that are "Permissive" (May Report, Not Required)	Alaska, Arkansas, Washington, District of Columbia, Florida, Hawaii, Iowa, Mississippi, Missouri, New Mexico, New York, Oklahoma, Oregon, Rhode Island, South Carolina, South Dakota, Texas, West Virginia, Wyoming
No Duty to Warn	Alabama, North Carolina
No State Position	Georgia, Kansas, Maine, Nevada, North Dakota

Every state has a law defining the procedure for holding patients against their will, and the EP should become familiar with the state's statutes in which he or she practices. In the preceding cases, it is clear that if physicians comply with the state law and procedural paperwork they will be given great latitude in holding someone for a period of time to further evaluate and assess the danger. The EP must immediately document and fill out appropriate forms when restraining or involuntarily committing a violent patient.

Duty to Warn

An expectation of confidentiality between physician and patient is an essential component of the therapeutic relationship. This duty to maintain confidentiality enables the sharing of personal and sensitive patient information in order to best serve the patient. The landmark case of *Tarasoff v. Regents of University of California* established a new duty for a physician to warn a third party regardless of this duty to confidentiality by concluding that the "protective privilege ends where the public peril begins." [19]

In *Tarasoff v. Regents of University of California*, the parents of Tatiana Tarasoff argued to the California Supreme Court that their daughter's death occurred after the defendants negligently failed to warn them that the killer had confided his intention to kill Tatiana to his treating psychologist, Dr. Lawrence Moore. Campus police, on the request of Dr. Moore, had briefly detained Prosenjit Poddar, after Poddar confided his intention to kill Tatiana Tarasoff. Neither the victim nor her parents were made aware of Poddar's intention before he subsequently killed her. The plaintiffs alleged that the defendant therapist did in fact predict that Poddar would kill and that harm to a third party was foreseeable. The court found that therapists not only had a duty to their patients, but also a duty to warn a third party of foreseeable violence.[19] This was the first case where the courts deemed third-party safety superseded patient confidentiality. As can be seen from this case, the physician cannot just inform security forces or the police; the intended third party must be warned to the best effort of the physician for the physician to have met this duty.

Actions are considered foreseeable when a specific person(s) is named as the target. When the patient states a wish to "blow up the postal service," there is no specific target, therefore, no duty to warn. The California Supreme Court upheld that "in the absence of a readily identifiable foreseeable victim, there is no duty to warn." The existence of an identifiable group of potential victims is insufficient to create a duty to warn.[20]

The physician's duty to warn has been supported in other states since the Tarasoff case, as in *Dorothy McGrath et al v. Barnes Hospital et al*.[21] In this Missouri court case, a paranoid schizophrenic being treated in an inpatient setting admitted several times to having thoughts of stabbing his mother with a kitchen knife. Reportedly, he had made this statement many times in the past and so no attempt was made to warn his parents prior to release from the inpatient care setting. The night that he was released to the care of his parents he stabbed both of them, killing his father and severely injuring his mother. The hospital was sued successfully by the patient's surviving mother for failure to warn, despite a defense that the family was already aware of this risk of violence given his long history of mental illness. The court awarded $2 million.

In general, clinicians should exercise their duty to warn and protect when 3 elements are met. First, a clearly identifiable person or group is at risk. Second, risk of harm includes severe bodily injury, death, or psychological harm. Third, the danger is imminent and creates a sense of urgency.[22]

Later in California, the court further developed the Tarasoff ruling in *Ewing v. Goldstein* to include acting on third-party information that indicates a possible threat. The parents of a patient informed his psychiatrist that their son planned on killing his ex-girlfriend's new boyfriend. The psychiatrist did have the patient admitted to a psychiatric hospital but did not warn the intended victim. On the patient's release, he killed the new boyfriend and then committed suicide. The court ruled that the psychiatrist had a duty to warn because he had information about a foreseeable event.[23,24]

The Duty to Warn mandate is determined on a state-by-state basis; it is not a national or federal law. While many states have ruled similarly to California it is not universal, and clinicians should be familiar with the law in their jurisdictions. However, it is very easy, no matter which state you live in, to notify all parties involved and not worry about your state's law. It is very unlikely that a court would rule against a physician who intentionally violates HIPAA in order to protect another person. The table demonstrates the various Duty to Warn state policies as of early 2011.

DISCUSSION

It is clear that inattention to key legal concepts when caring for an agitated patient may lead to significant liability and personal financial risk. First, a physician must determine a patient's ability to give (or refuse) consent for treatment [competence/consent]. Second, if a patient's liberty has been taken away, it is the physician's responsibility to ensure the patient's health and safety [duty to protect]. Third, no one should touch or hold a patient against his will except in the case of an emergency and the proper paperwork has been filled out [battery/false imprisonment]. Last, if direct threats have been made during the patient's encounter the physician has a responsibility to inform the third party of possible danger [duty to warn].

LIMITATIONS

Cases were individually selected at random by the authors if they directly applied to this focused topic. An extensive search using a legal engine was not done, and there may be other relevant cases. The goal of our study was to briefly educate and illustrate a selected medical legal issue in emergency medicine using a limited number of classic and current cases.

CONCLUSION

In caring for an agitated patient in emergency medicine, multiple areas of medico-legal risk arise, including competence/consent, duty to protect, battery/ false imprisonment, and duty to warn. As compared to the standard practice of the specialty, these topics, intuitively, occur more frequently. This paper has demonstrated that multiple court cases support the conclusion that it behooves the practicing emergency physician to be familiar with these concepts in order to avoid liability.

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

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In Response to "Education on Prehospital Pain Management: A Follow-up Study"

DOI: 10.5811/westjem.2013.5.18059
French SC, Chan SB, Ramaker J: Education On Prehospital Pain Management: A Follow-Up Study. *West J Emerg Med*. 2013;14(2):96-102.

To the Editor:

French et al should be congratulated for reporting their study of the effects of an educational intervention on prehospital care management of pain.[1] Following the educational intervention paramedics certainly improved their management of pain– but there remain some unanswered questions on the intervention and the outcome.

First of all the intervention was quite substantial and multifaceted. However it is interesting to ask what facet of the intervention caused the positive outcomes. Could a shorter (1 or 2 hour) intervention resulted in a similar outcome? Could the same outcome have been achieved as a result of an e-learning intervention or print-based learning materials? Is it possible that the surveys themselves had an effect on the changed management? These questions cannot be answered from the current results as all learners received the same intervention. Perhaps a further follow up study might be conducted where different groups of learners receive different interventions. In this way more effective and more efficient interventions might be uncovered.

Secondly the educational intervention was not costed; nor indeed was any cost utility assigned to the outcomes. Low cost educational interventions that result in more efficient care and as a result lower cost care are obviously the interventions most sought after by educators and educational providers alike. However this is only possible when interventions and their outcomes are properly and thoroughly costed.

Kieran Walsh, FRCPI

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

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1. French SC, Chan SB, Ramaker J. Education on prehospital pain management: a follow-up study. *West J Emerg Med*. 2013;14(2):96-102.

DOI: 10.5811/westjem.2013.5.18112

In reply:

We would like to thank Dr. Walsh for highlighting two additional aspects of education which concern many of us. We incorporated this investigational study into our already established monthly 3 hour continuing education (CE) session provided for paramedics in our emergency medical services system; therefore, this study added no additional costs to the program. It would, however, be helpful to learn if a shorter session on pain assessment and management would be just as effective. This would allow us to add additional topics to the 3 hour CE session thus making the time more efficient. Dividing the paramedics into subgroups to apply different types of educational tools would be quite simple with our model. We could separate them on the basis of the 3 different shifts they work within a station or according to the different station locations within each suburban village.

Cost is all too important when it comes to delivering CE. We educate paramedics from fire services during their regularly scheduled shifts so no additional pay for personnel time is required. Our private ambulance providers are required to attend CE during their off-shift time; however, other private providers throughout Illinois and throughout the country are compensated for attending CE. Identifying more efficient methods to provide CE would make better use of the paramedics' time and save costs for those ambulance/fire services which pay for time spent in attendance at CE sessions. We have also looked at providing CE which is either videotaped for later playback or conferenced live video in order to decrease the number of CE sessions that the paid infield nurse educators have to provide and to include additional paramedics at other locations.

Thanks again to Dr. Walsh for identifying additional questions to the education intervention that we hope to address in future studies.

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In Response to "Temperature and Violent Crime in Dallas, Texas: Relationships and Implications of Climate Change"

DOI: 10.5811/westjem.2013.5.17833
Gamble JL, Hess JJ: Temperature and Violent Crime in Dallas, Texas: Relationships and Implications of Climate Change. *West J Emerg Med*. 2012;13(3):239–246.

To the editor:

We were interested to read Gamble and Hess's study finding that the daily incidence of violent crime in Dallas increased with temperatures up to 90°F (32.2°C), but decreased above this threshold. On this basis, their abstract surprisingly concludes that "higher ambient temperatures expected with climate change…. are not likely to be accompanied by markedly higher rates of violent crime" (p .239). This conclusion contrasts with the findings of previous studies.[1-3]

Unfortunately, the authors did not attempt to actually estimate the magnitude of future warming that would be sufficient to bring about a decrease in aggregate annual violent crime, which will differ from the inflection point of the relationship between daily temperature and violent crime. We therefore used the piecewise regression model reported by the authors in order to investigate how annual aggravated assault incidence in Dallas is likely to be affected by changes in mean temperature. We focus on aggravated assault given that this was the crime for which a marked effect of temperature was reported. Temperature data for Dallas International Airport in 1999 was collected from the NCDC[4]. 1999 was used as a reference point being the last year in the series investigated by Gamble and Hess.

The simulation was conducted as follows. For each of a range of hypothetical annual temperature anomalies from -5 to +20°F, the annual anomaly was added to the actual mean temperature in each day of 1999 to obtain an annual series of daily temperatures. The piecewise regression model was then used to obtain the predicted number of assaults for each day of the series. These were then summed over the course of the year.

Our simulation suggests that the mean temperature in Dallas would have to increase by around 13°F (7.2°C) before subsequent temperature increases would begin to reduce annual aggravated assaults. At this point, the model predicts an extra 146 annual aggravated assaults per 100,000 population in comparison to a world with zero warming. Before this point, temperature increases would continue to increase assaults. Notably, a temperature increase of 13°F would be substantially greater than the warming likely by the end of the 21st century on the basis of regional climate projections for central North America.[5] As such, the inflection point in the temperature-violence relation appears to occur at too high a temperature to be of much comfort for those concerned with the implications of climate change for human violence in the medium term.

However, it is important to note that this analysis provides only *conditional* predictions about how many extra assaults are likely to arise in Dallas given a particular magnitude of warming, in comparison to an identical Dallas *without* this warming. The world of the future will be different from today's in many ways other than simply being warmer. An unconditional forecast of future violent crime rates would need to take into account multiple predictors of crime, as well as temporal trends unrelated to global warming—such as the decreasing trend in violent crime in Dallas over the last two decades.[6]

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DOI: 10.5811/westjem.2013.5.18221

In reply:

We note a number of concerns regarding the accompanying letter to the editor. First, while our conclusions do contrast with the findings of some previous studies, our findings are consistent with the curvilinear affect found in a number of others, notably those conducted by Rotton and Cohn and earlier hypothesized by Baron and Bell.[1-5] As we note, it may be reasonable to conclude that the true relationship is curvilinear, but that daily temperatures in northern locales rarely reach and surpass the threshold at which the incidence of aggravated crimes might decline.

In addition, we need a more robust approach to assess the likely behavior of the response curve to warming temperatures (see Figure 2). As we noted in our paper, it is not clear whether the curve relating temperature to violent crime will remain stable in a warming climate or if it will shift. The sensitivity analysis presented in the letter to the editor seems to assume that the curve will remain stable, the crime incidence function will remain unchanged, and that total crime will increase as temperatures warm by a change of 13°F. We hypothesize that the curve may move to the right with increased temperature and the passage of time. Such a shift would be consistent with anticipated acclimatization or the institution of effective adaptation measures, such as the introduction of air conditioning in buildings not currently equipped or more widespread public health watch/warning systems, and would not necessarily result in a change in the area under the curve despite consistently higher temperatures. This hypothesis deserves further study across time and across locations in order to tease out the effects of human behavior or psychology on vulnerability as well as the effects of different climate regimes that may vary by latitude.

Finally, the sensitivity analysis described in the letter is, on the one hand, an interesting extension of the findings we present. There are, however, issues associated with doing an analysis that uses an aggregate assault count rather than actual daily counts to estimate daily effects. Using an aggregate annual count for 1999 will not account for a number of factors that may vary from day to day or season to season and that may exert an independent effect on daily assaults. Using the annual aggregate count may over- or under-estimate the effect of temperature on aggravated assaults and may do so unevenly.

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

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Call for Papers

Gender-Specific Research in Emergency Medicine:
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The 2014 *Academic Emergency Medicine* Consensus Conference, **Gender-Specific Research in Emergency Medicine** will be held on Wednesday, May 14, 2014, immediately preceding the SAEM Annual Meeting Dallas, TX. Original papers on the this topic, if accepted, will be published together with the conference proceedings in the December 2014 issue of *Academic Emergency Medicine.*

Gender-specific medicine is the "science of how normal human biology differs between men and women and how the manifestations, mechanisms and treatment of disease vary as a function of gender." While gender-specific medicine incorporates advances in reproductive health issues, the AEM consensus conference will focus on broad disease-specific EM issues that are relevant to both women and men. The key domains of the conference are cardiovascular/resuscitation, cerebrovascular, pain, trauma/injury/violence, diagnostic imaging, mental health and substance abuse.

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3) Build a multinational interdisciplinary consortium to study gender medicine for acute conditions.

Accepted manuscripts will describe relevant research concepts in gender-specific areas with priority placed on differential disease risk, vulnerability, progression and outcomes. They may include work in clinical/translational, health systems, policy or basic sciences research. Descriptions of specific research, projects, or collaborations may be used for illustrative purposes but should not comprise the core of the submission. Original contributions describing relevant research or concepts on these or similar topics will be considered, and original high-quality research may also be submitted alone or in conjunction with concept papers. Papers will be considered for publication in the December 2014 issue of *Academic Emergency Medicine* if received by Monday, March 11, 2014. All submissions will undergo peer review and publication cannot be guaranteed.

For queries, please contact Marna Rayl Greenberg, DO, MPH (Marna.Greenberg@lvh.com) or Basmah Safdar, MD (basmah.safdar@yale.edu) the 2014 Consensus Conference Co-Chairs.

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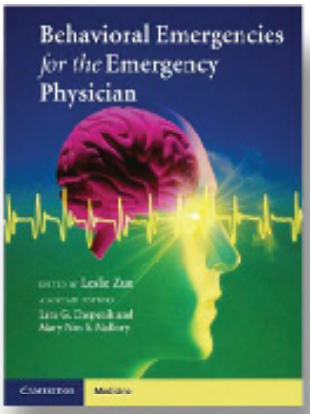
- Psychiatric Boarders

Tentative Agenda (Day 2-Dec 13)

- Reduction of Frequent Users
- Danger to Others
- Patient and Family Perception
- Dealing with Difficult Patients
- Caring for the Care Givers
- Community Resources
- Patient Safety and Liability Concerns
- Accountable Care Organizations
- Informed Consent and Civil Commitment
- Billing and Reimbursement and ICD 10
- EMTALA
- Scientific Session
- Peer Involvement

Every registrant receives a copy of the textbook



Invited Speakers

Jon Berlin
Rebecca Brendel
Arjun Chenmugam
Lara Chepenik
Glenn Currier
John Draper
Barry Feldman
Laura Ginett
Roberta Glick
Rachel Glick
Robert Greenberg
Greg Larkin
Mary Nan Mallory
Kim Nordstrom
Divy Ravindranath
Sheri Richardt
Jack Rozel
Richard Shih
Robert Tarver
Ken Thompson
Gary Vilke
Chuck Weiss
Richard Wild
Michael Wilson
Scott Zeller
Leslie Zun

Pre-conference seminar on December 11 sponsored by IBHI

Full Day Program on Improving Flow and Meeting Accreditation Expectations on Length of Stay

For more information on the *IBHI Full Day Pre-Conference Seminar* contact:

Peter Brown at (518) 732-7176 or Peter@ibhi.net

www.ibhi.net/ibhi-seminar-dec-11-2013-in-orlando

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Trena Burke, MPA Conference Manager
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