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Prospective Durability Testing of a Vascular Access Phantom

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Introduction: We assessed the acoustic transmission, image quality, and vessel integrity of the Blue Phantom™ 2 Vessel Original Ultrasound Training Model with repeated use.

Methods: The study consisted of two phases. During the first phase, a portion of the Blue Phantom™ rubber matrix (without a simulated vessel) was placed over a two-tiered echogenic structure and was repeatedly punctured with a hollow bore 18-gauge needle in a 1 cm^2 area. During the second phase, a portion of the matrix with a simulated vessel was repeatedly punctured with another hollow bore 18-gauge needle. During both phases we obtained an ultrasound image using a high-frequency linear probe after every 100 needle punctures to assess the effect of repeated needle punctures on image quality, acoustic transmission, and simulated vessel integrity.

Results: Testing on the rubber matrix alone (first phase) without a vessel demonstrated a gradual decrease in image quality and visualization of the proximal and distal portions of the target structure, but they remained visible after 1,000 needle punctures. The second phase demonstrated excellent acoustic transmission and image quality on both transverse and longitudinal images of the rubber matrix and simulated vessel after 1,000 needle punctures. The anterior and posterior vessel walls and needle tip were well visualized without any signs of vessel leakage on still images or with compression and power Doppler.

Conclusion: The Blue Phantom™ 2 Vessel Original Ultrasound Training Model demonstrated excellent durability after 1,000 needle punctures in a 1- cm^2 area. Based on the length of simulated vessel in each model, it should support over 25,000 simulated attempts at vascular access. [West J Emerg Med. 2010; 11(4):302-305.]

INTRODUCTION

A large body of medical research advocates the use of ultrasound guidance when obtaining central and peripheral vascular access.[1-18] In addition, major governmental organizations have recommended using ultrasound guidance when obtaining central venous access.[19,20]

The increasing use of ultrasound guidance for vascular access has created an educational need. Vascular access phantoms that mimic human soft tissue and vascular structures allow for ultrasound-guided vascular access training without exposing patients to painful, risky procedures. While private corporations have begun producing these vascular access phantoms, they are often expensive and have not been subject to independent testing to ensure durability with repeated use.

The Blue Phantom™ (Kirkland, WA) 2 Vessel Original Ultrasound Training Model is commonly used to teach ultrasound-guided peripheral vascular access and therefore was selected for durability testing. It consists of a rubber matrix and fluid-filled tubes simulating human soft tissue and peripheral vascular structures, respectively. We conducted independent durability testing to assess its acoustic transmission, image quality, and vessel integrity with repeated use.

METHODS

The study, approved by the local institutional review committee consisted of two phases. During the first phase a

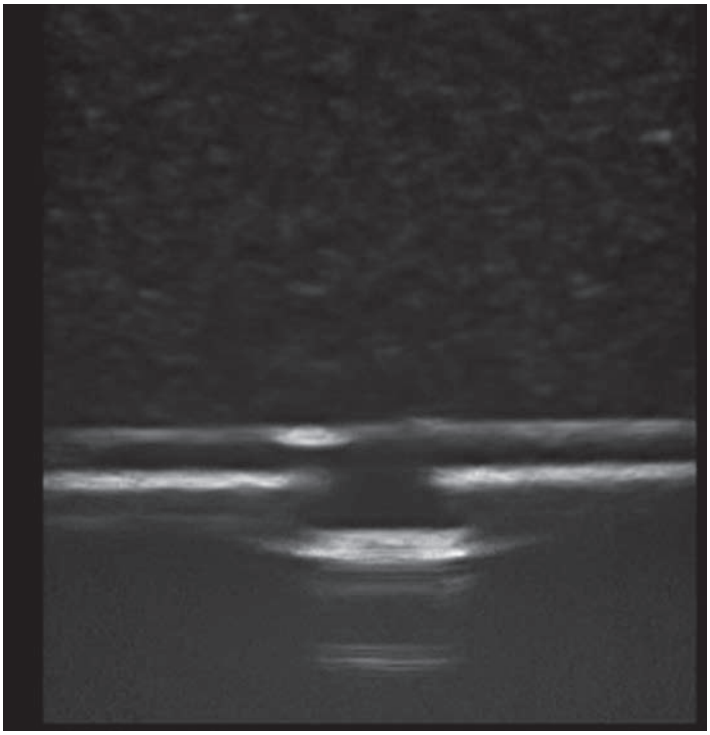

Figure 1. Image of the Blue Phantom™ rubber matrix placed over a two-tiered echogenic structure prior to any needle punctures.

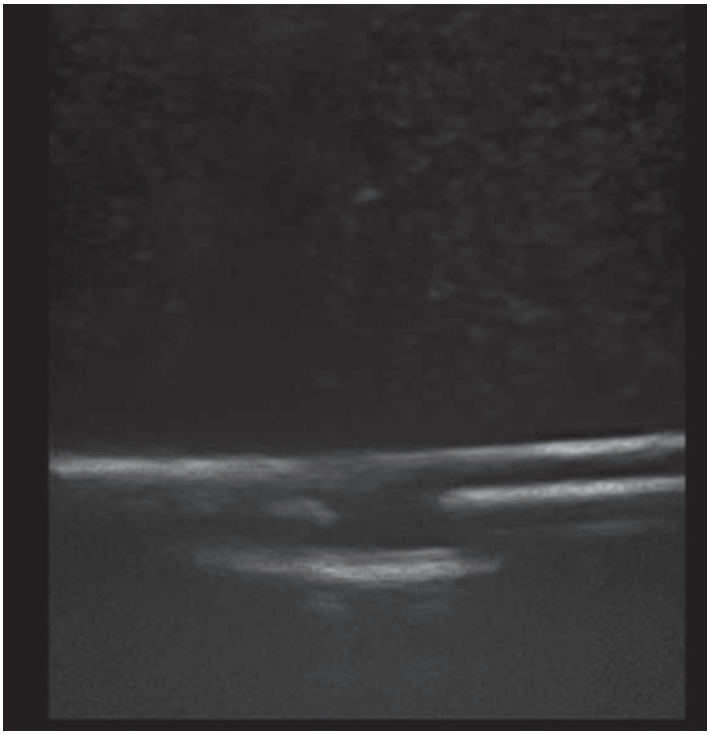

Figure 2. Image of the Blue Phantom™ rubber matrix placed over a two-tiered echogenic structure after 1,000 needle punctures in a 1 cm^2 area.

portion of the Blue Phantom™ rubber matrix (without a simulated vessel) was placed over an echogenic structure, in a water bath, and repeatedly punctured with a hollow bore 18-gauge needle in a 1 cm^2 area. We did this to test the acoustic transmission of the rubber matrix and visibility of the echogenic structure with repeated punctures. During the second phase we repeatedly punctured a portion of the matrix with a simulated vessel with another hollow bore 18-gauge needle in a 1 cm^2 area at a 45° angle. The simulated vessel was assessed for fluid leakage with active compression and power Doppler.

During both phases we obtained an ultrasound image using a Sonosite™ (Bothell, WA) M-Turbo ultrasound machine with a 25mm, 6-13 MHz linear probe after every 100 needle punctures to assess the effect of repeated needle punctures on image quality, acoustic transmission, and simulated vessel integrity. All settings (depth, gain, frequency, etc.) were unchanged during the acquisition of images. All images were obtained and later assessed qualitatively in digital format in an unblinded fashion by four board certified/eligible emergency physicians who were in an emergency ultrasound fellowship or had completed a fellowship. Both phases of the study were concluded after a total of 1,000 needle punctures.

RESULTS

The first phase of testing on the rubber matrix alone without a vessel demonstrated a gradual decrease in image quality and visualization of the proximal and distal portions of the target structure, but they remained visible after 1,000 needle punctures. (Figures 1-2)

The second phase of the study demonstrated excellent acoustic transmission and image quality on both short- and long-axis images of the rubber matrix and simulated vessel after 1,000 needle punctures. The anterior and posterior vessel walls and needle tip were well visualized without any signs of vessel leakage on still images or with compression and power Doppler. (Figures 3-6)

DISCUSSION

The Blue Phantom™ 2 Vessel Original Ultrasound Training Model demonstrated excellent durability after 1,000 needle punctures in a 1 cm^2 area. The rubber matrix demonstrated a gradual decrease in acoustic transmission, but this did not affect the ability to visualize the anterior and posterior walls of the simulated vessel or the needle tip. The integrity of the simulated vessel was well preserved without any signs of vessel leakage.

LIMITATIONS

This study tested only one of the many different commercially available vascular access phantoms; therefore, the results may not be applicable to other products on the market. In addition, because we only punctured the simulated vessel and rubber matrix with an 18-gauge needle, these results may not be reproduced if a different needle size or a catheter/needle combination is used. Despite the

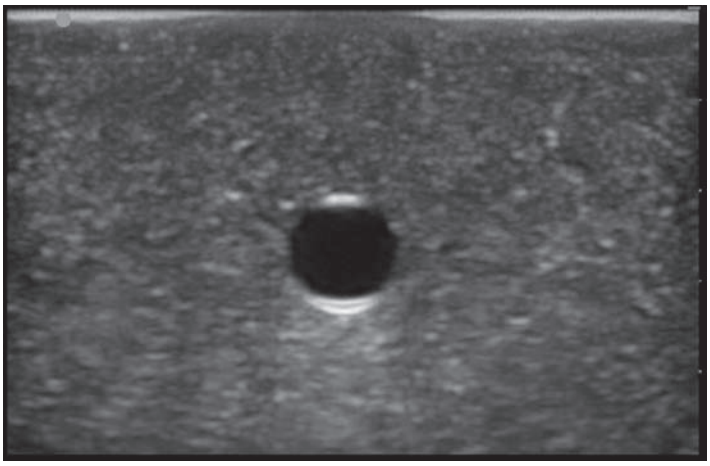

Figure 3. Short-axis image of the Blue Phantom™ rubber matrix and simulated vessel prior to any needle punctures.

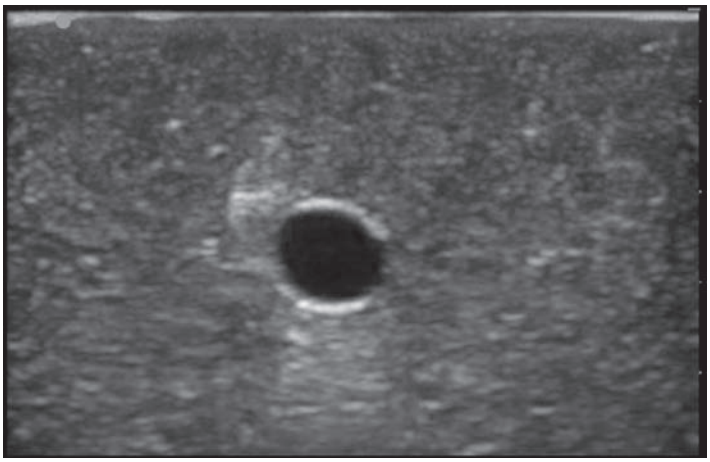

Figure 4. Short-axis image of the Blue Phantom™ rubber matrix and simulated vessel after 1,000 needle punctures in a 1 cm^2 area.

manufacturer's recommendation against this, some users who access the simulated vessel aspirate and then re-inject the fluid into the vessel, which often leads to air deposits in the phantom material. This practice and the air deposited can lead to more rapid image degradation than was seen in our study. Further research could address these variables.

CONCLUSION

If the full length of simulated vessel contained in this vascular access phantom is used (excluding the vessel on the ends of the phantom), each model should support over 25,000 simulated attempts at vascular access without significant degradation in the integrity of the simulated vessel or the ultrasound image produced.

SUPPORT DISCLOSURE

The Blue Phantom™ 2 Vessel Original Ultrasound Training Model was provided by the manufacturer for testing. They had no input into the study design or analysis of the results.

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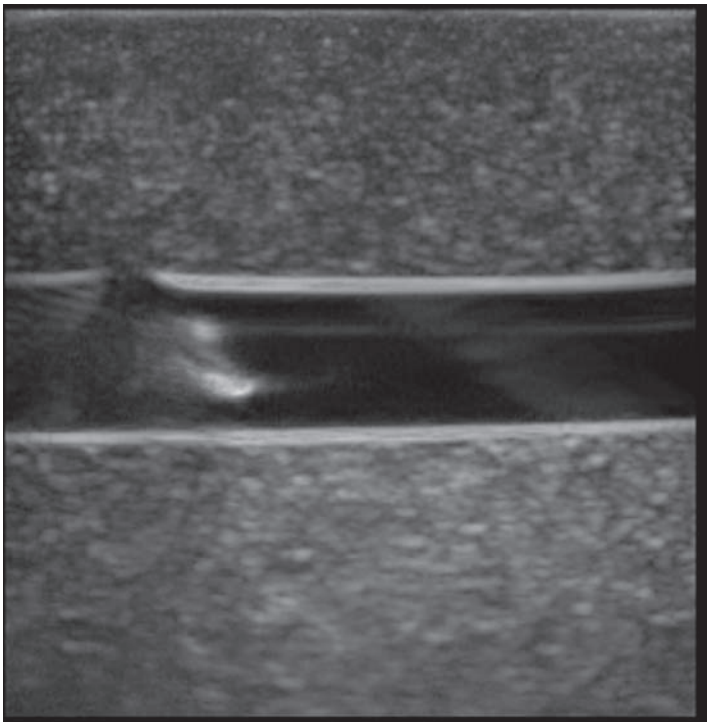

Figure 5. Long-axis image of the Blue Phantom™ rubber matrix, simulated vessel, and needle tip after the initial needle puncture.

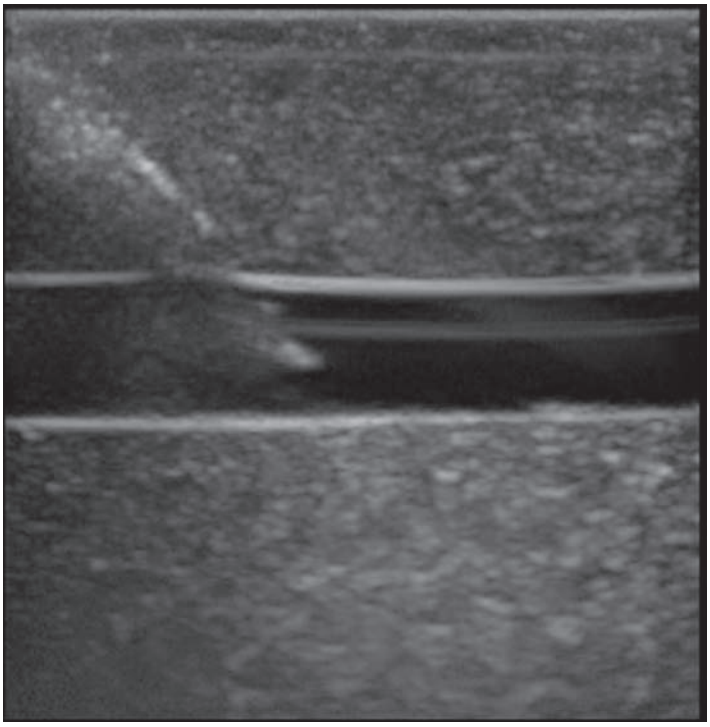

Figure 6. Long-axis image of the Blue Phantom™rubber matrix, simulated vessel, and needle tip after 1,000 needle punctures in a 1 cm^2 area at a 45° angle.

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Ultrasound Diagnosis of Bilateral Quadriceps Tendon Rupture After Statin Use

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Simultaneous bilateral quadriceps tendon rupture is a rare injury. We report the case of bilateral quadriceps tendon rupture sustained with minimal force while refereeing a football game. The injury was suspected to be associated with statin use as the patient had no other identifiable risk factors. The diagnosis was confirmed using bedside ultrasound. [West J Emerg Med. 2010; 11(4):306-309.]

INTRODUCTION

Simultaneous bilateral quadriceps tendon rupture is a rare injury. As of 2009, only 70 cases have been reported in the English literature. Although rare, most cases have been associated with chronic metabolic disturbances or inflammatory diseases in patients over the age of 50.[1] Iatrogenic causes of bilateral quadriceps rupture, including steroid and flouroquinolone use, have also been identified in the literature.[2-6] Although HMG-CoA reductase inhibitor (statin)-associated musculoskeletal complaints have been reported, few have involved tendon rupture.[7-11] We present a case of simultaneous bilateral quadriceps tendon rupture in which the only identifiable risk factor was statin use. The diagnosis was confirmed using bedside ultrasound.

CASE REPORT

A 56-year-old African-American male presented to the emergency department (ED) complaining of what he described as "torn muscles to the right and left knee." The patient stated that he was refereeing a football game and, while running, suddenly felt his right knee buckle. As he was falling to the ground, he also felt a pop in the left knee. The patient described severe pain to both knees and was unable to ambulate.

At the time of examination in the ED, the patient denied pain at rest, numbness or tingling. The patient did report swelling around the knees, particularly at the superior aspect.

The patient's past medical history was remarkable only for hyperlipidemia, for which he had been taking atorvastatin (lipitor), 20 mg once daily, for about three years. He stated he had stopped the medication three weeks prior to the injury and denied previously being on any other cholesterol-lowering agent. He denied other past medical history, specifically renal problems, hypertension, metabolic problems, joint diseases, previous orthopedic injuries or other chronic illnesses. He also denied other medication use, including steroids, herbal supplements or fluoroquinolones in the preceding six months. Furthermore, he denied previous musculoskeletal problems prior to or during treatment with atorvastatin. His past surgical, family and social histories were all unremarkable.

On physical exam, the patient was an athletic-appearing male who looked younger than his stated age, sitting up on the stretcher in no acute distress. Vital signs revealed a blood pressure of 149/75, but were otherwise within normal limits. All portions of the exam were unremarkable except for the musculoskeletal exam. Observation revealed swelling to both knees, left greater than right, without ecchymosis, skin lacerations or open fractures. He had visible defects superior to the patella bilaterally. There was tenderness to palpation of both distal quadriceps tendons. The thigh and leg compartments were soft. There was full passive range of motion of both knees with pain, but active range of motion was severely limited. The patient was unable to straight-leg-raise due to complete absence of knee extension bilaterally. There was full active range of motion of both ankles and 5/5 strength when tested. He was neurovascularly intact.

Anterior-posterior and lateral radiographs of the right and left knees showed a thickening of the quadriceps tendon with pre-patellar bursitis on the left and normal findings on the right.

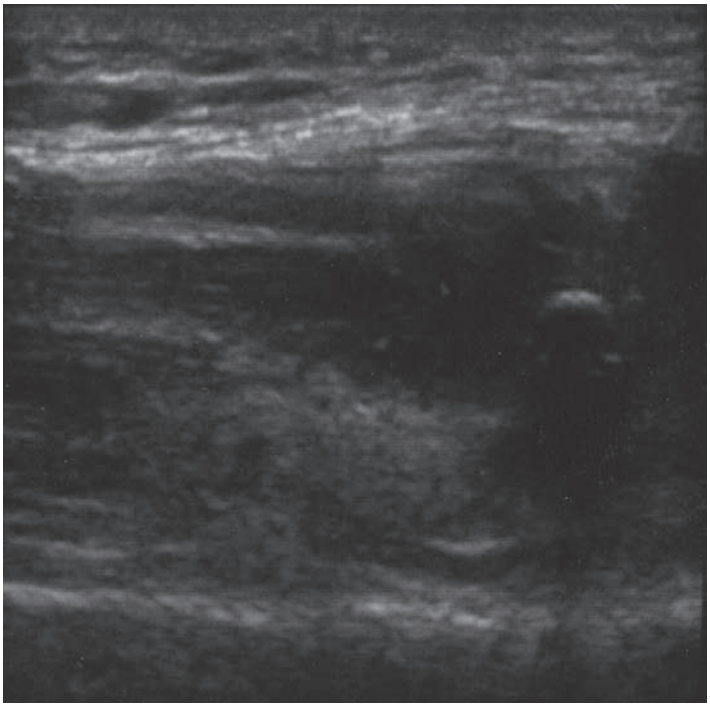

Figure 1. Sagittal view of right quadriceps tendon rupture

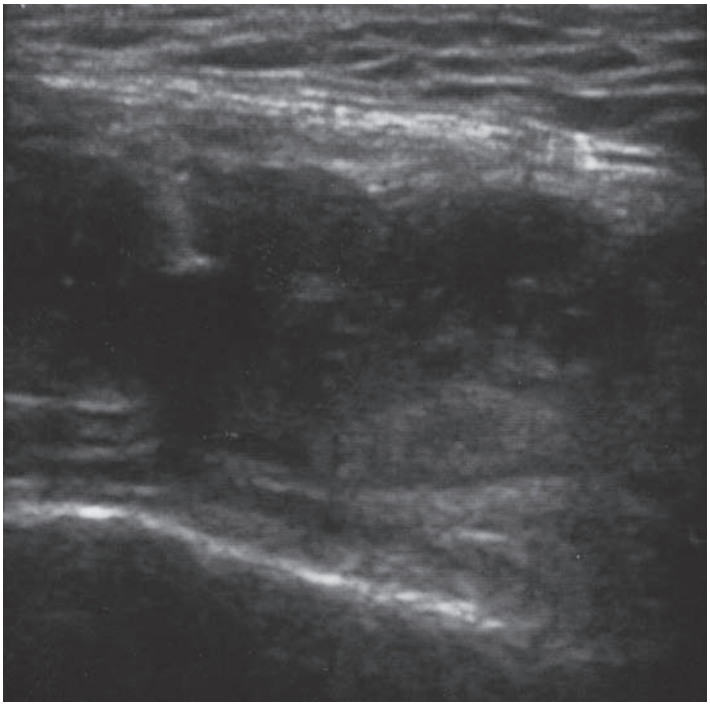

Figure 2. Transverse view of right quadriceps tendon rupture

Bedside ultrasound was performed for confirmation of suspected bilateral quadriceps tendon rupture. A linear probe was used to scan the patient bilaterally revealing complete disruption of both quadriceps tendons with anechoic fluid collections noted superiorly, representing hematomas. Both sides appeared similar on ultrasound, verifying the diagnosis of bilateral spontaneous quadriceps tendon ruptures (Figure 1 and Figure 2).

Following an orthopedic surgery consult in the ED, the patient was discharged with bilateral knee immobilizers, pain medication and outpatient surgery appointment. Six days later, intraoperative examination confirmed bilateral complete quadriceps tendon ruptures at the osseotendinous junction, and open repair was performed.

The patient was admitted for two days for pain control. While in the hospital the patient was found to be hypertensive and was started on metoprolol, 50 mg by mouth twice daily. According to the patient, the hypertension was likely secondary to pain because his primary doctor stopped the antihypertensive medication after which he had no problems with blood pressure control.

Once pain control was achieved with oral medications, the patient was discharged to a rehab facility for further care, where he remained for four days before discharged home. Instructions upon hospital discharge were to weight-bear as tolerated on both legs as long as the knee immobilizers were in place. Range-of-motion was gradually increased over the next four weeks.

Four months postoperatively the patient continued to be followed in the orthopedic clinic and had achieved 95 degrees of knee flexion bilaterally. However, the patient continued to suffer knee stiffness and was unable to ambulate four months following operative repair.

Investigation into possible causes of the patient's bilateral quadriceps tendon ruptures identified only oral statin administration as a suspected risk factor. Laboratory analysis revealed a normal comprehensive metabolic panel with a creatinine of 1.1 and normal serum calcium.

DICUSSION

We report a rare case of bilateral quadriceps tendon rupture associated with statin use. We performed a review of the English language literature using the National Library of Medicine and National Institutes of Health database and identified only 70 cases. The first case of bilateral quadriceps tendon rupture was reported by Steiner and Palmer in 1949.[12] The majority of bilateral quadriceps tendon rupture have occurred in men over 50, and in those with risk factors such as obesity, diabetes mellitus, chronic renal failure and hyperparathyroidism.[1,13-18] Of the reported cases in our review, none were clearly associated with statin use.

Although there are no reported cases of bilateral quadriceps tendon rupture associated with statin use, these cholesterol-lowering agents have been reported to be associated with the development of musculoskeletal complaints, including tendonitis and unilateral tendon rupture.[7-10] For example, in a study of 96 patients with tendonitis or tendon rupture believed to be associated with statin use, 14 ruptures involved the quadriceps tendon but none were bilateral.[10] Although unproven, several case reports

suggest an association between tendon injury and statin therapy.[11,19] In addition, several tendinopathies have been reported involving a statin combined with ezetimibe, another cholesterol-lowering agent.[20-21] A recent case-control study examining the association between statins and tendon rupture found no significant association compared with control groups.[22] Thus the association of statin use and tendon rupture remains ill-defined.

There are several hypotheses that attempt to explain the association of statin use with tendon injury. The exact cause remains unresolved, but a combination of suppressive effects on matrix metalloproteinase activity and prostaglandin E2 activity is thought to play a major role.[20,23-24] These enzymes are active in the remodeling process in tendons, but when disrupted could potentially lead to tendon weakening or even rupture.

Multiple large clinical trials have demonstrated the efficacy of statins as cholesterol-lowering agents and in their ability to decrease the risk of myocardial infarctions, angina and revascularization procedures in patients with coronary artery disease.[25-29] Knowledge of the cases of tendon injury that do occur and the classes of patients that may be more at risk for developing certain adverse reactions could allow for prevention in some individuals.

As the prevalence of obesity and type II diabetes mellitus increases in the United States, many Americans are being treated for hyperlipidemia with statins. It is possible that statin-associated tendinopathy and tendon rupture will become more frequent, and physicians should be aware of the possible relationship between statin therapy and tendon rupture when treating their patients with cholesterol-lowering medications.

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Ultrasound-Guided Three-In-One Nerve Block for Femur Fractures

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Femur fractures typically affect elderly patients with multiple co-morbidities. Pain control can be difficult, requiring intensive nursing and physician care as elderly patients may manifest cardiovascular and respiratory complications from opiate administration. Ultrasound (US)-guided three-in-one (3-in-1) femoral nerve block (FNB) is an option for pain management in patients with femur fractures, as it provides regional anesthesia to the femoral, obturator and lateral cutaneous nerves. Our goal is to provide medical education regarding the use of US-guided 3-in-1FNB as a rapid and easy procedure that may provide optimal patient care in patients with femur fractures. [West J Emerg Med. 2010; 11(4):310-313.]

INTRODUCTION

Ultrasound (US)-guided three-in-one (3-in-1) femoral nerve block (FNB) involves visual identification of the femoral nerve sheath and subsequent infiltration of anesthetic. The literature has found this nerve block to be a simple, safe and time efficient maneuver providing rapid and effective anesthesia.[1-9] The use of US-guidance has also been shown to decrease the opioid and volume of local anesthetic requirement for pain management.[1,3,10-12]

Studies have found that emergency physicians (EP) can safely and effectively accomplish 3-in-1 FNBs as analgesia for hip fractures in the emergency department (ED).[1-3] Our training involved a 20-minute didactic session that included anatomy review and review of US images of the femoral artery, nerve and vein. We discussed a review of the materials and pharmacology, then physicians observed one procedure followed by a supervised procedure. All physicians were comfortable performing US-guided 3-in-1 FNBs at their first patient encounter.

Three-in-one FNBs provide rapid, effective pain relief and have also been shown to decrease the opioid requirement for pain management. In a study by Antonis patients receiving US-guided 3-in-1 nerve blocks had dramatic decreases in visual analog scale (VAS) pain scores and opioid requirement for pain control.[1] The mean baseline VAS score in the nerve block group was 84, and a mean score at 240 minutes was 13.8. The mean four-hour morphine use was 5.5 mg in the nerve block and 15.5 mg in the comparison group.

In a study by Fletcher et al.[5] patients receiving 3-in-1 nerve blocks recorded a faster time to reach the lowest pain score 2.88 hours versus 5.81 hours for control patients receiving intravenous morphine. Also, nerve block recipients required significantly less morphine per hour to control their pain 0.49 mg/hr versus 1.2 mg/hr.[5] Oberndorfer et al. found the duration of analgesia was longer and the volume of local anesthetic was significantly reduced with US compared with nerve stimulator (NS) guidance.[8] Finally, there were two blocks in the NS group that failed. There were no failures with direct visualization using US.[8]

METHODS

Indications

All patients with femoral fractures are optimal candidates for US-guided 3-in-1 FNBs. The FNB is especially helpful in patients with significant opiate tolerance, opiate allergy and patients with co-morbidities. Patients with difficult anatomical landmarks such as obese patients, patients having previous operations in this area, or those with anatomical abnormalities are also considered optimal candidates as US-guidance provides direct visualization of the major anatomic structures.[3]

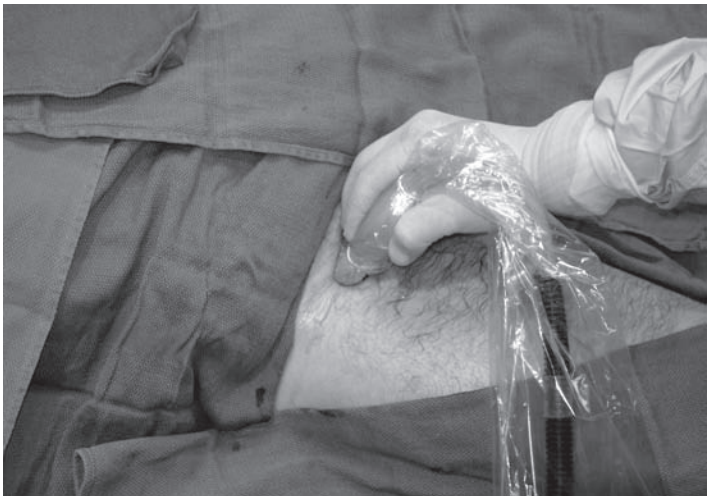

Figure 1. Ultrasound probe on right side of patient's groin

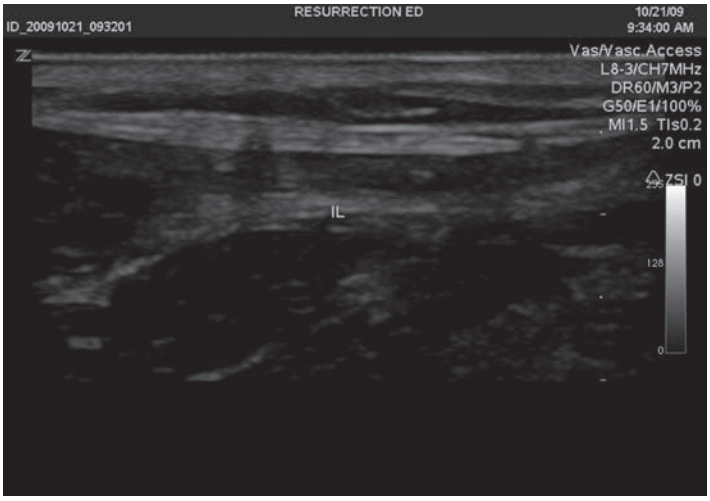

Figure 2. Inguinal ligament (IL).

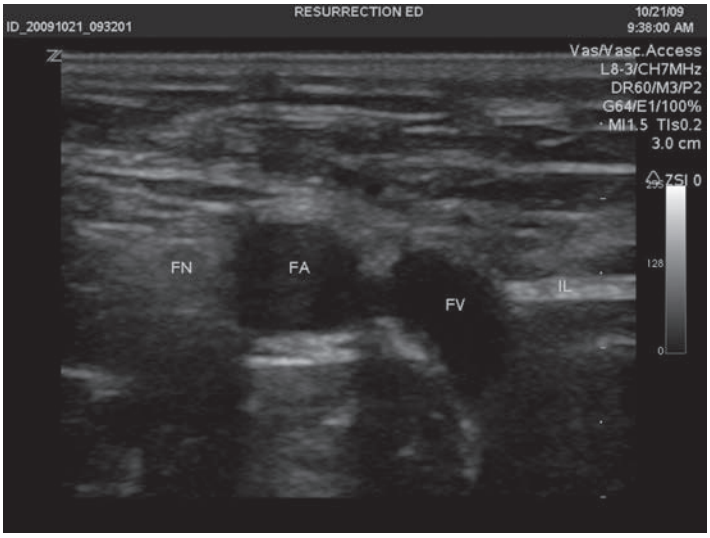

Figure 3a. Ultrasound image of femoral vein (FV), artery (FA), nerve (FN) and inguinal ligament (IL).

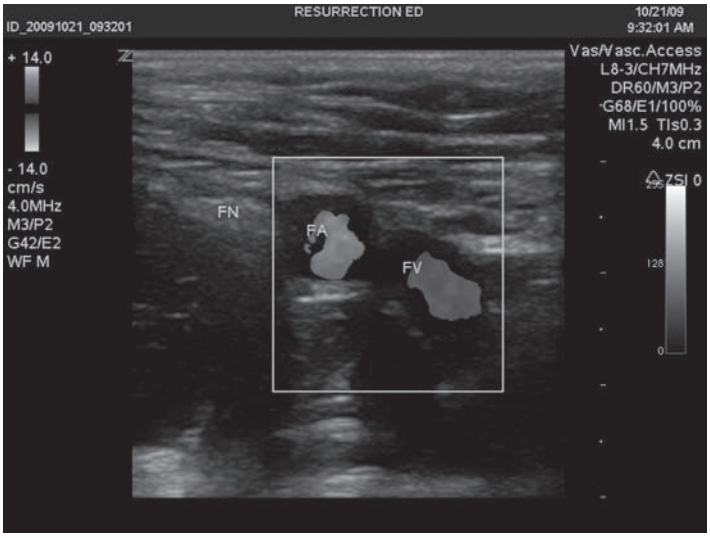

Figure 3b. Ultrasound image of femoral vein (FV), artery (FA), and nerve (FN) with color flow doppler.

This procedure makes it easier to obtain optimal radiographic images from which orthopedic surgeons can base treatment. Finally, although classically the 3-in-1 FNB was used for femoral neck or trochanteric fractures, further research shows that it is also effective for more distal femoral shaft fractures, in anterior cruciate ligament reconstructions, total knee arthroplasty, knee arthroscopy and open knee surgery.[13-23]

Contraindications

Contraindications include patients with a known hypersensitivity to bupivacaine or to any local anesthetic agent of the amide-type or to other components of bupivacaine hydrochloride solutions. Other contraindications include patients with local or systemic infection or patients with an abnormal neurological exam in that limb or perceived risk of compartment syndrome, which requires serial sensory exams that would be impeded by the FNB. Relative contraindications include bleeding diathesis or anticoagulation.

Equipment/Supplies

This procedure requires: US machine with a linear (vascular) transducer, with a frequency range of 7-12 MHz.; betadine; 4x4s; 21 gauge 3.5 inch spinal needle; 20 ml of bupivacaine 0.5%; sterile gloves; sterile covering for the probe (a sterile glove can work if specialized covering is not available); and sterile US gel (or sterile lubricant if gel unavailable).

Procedure: Two-Practitioner Technique

Patient is positioned supine with legs slightly abducted: the groin is prepped and draped in sterile fashion. The US is placed to the right of the patient's bed, and US gel is applied to the probe, which is held by an assistant. Sterile gloves are donned and the sterile probe cover (or another sterile glove) is placed over the probe. Sterile gel is then applied to the outer portion of the sterile covering. The physician applies the probe to the patient's groin with the probe's indicator (either

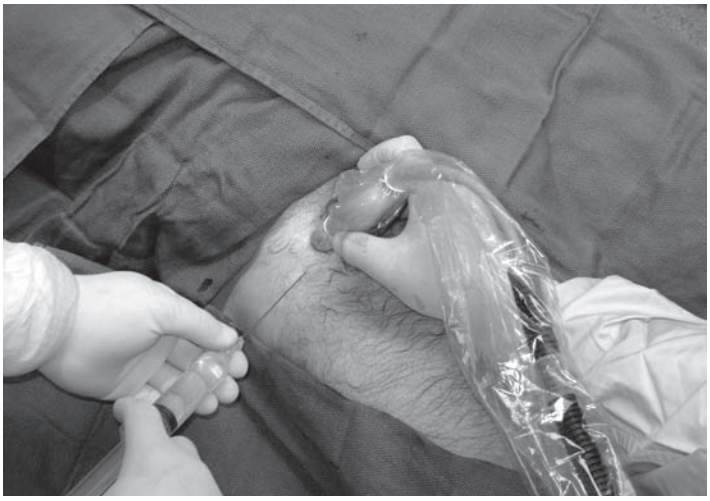

Figure 4. Lateral approach of 21 gauge spinal needle with 20 ml of bupivacaine 0.5% on patient's right side.

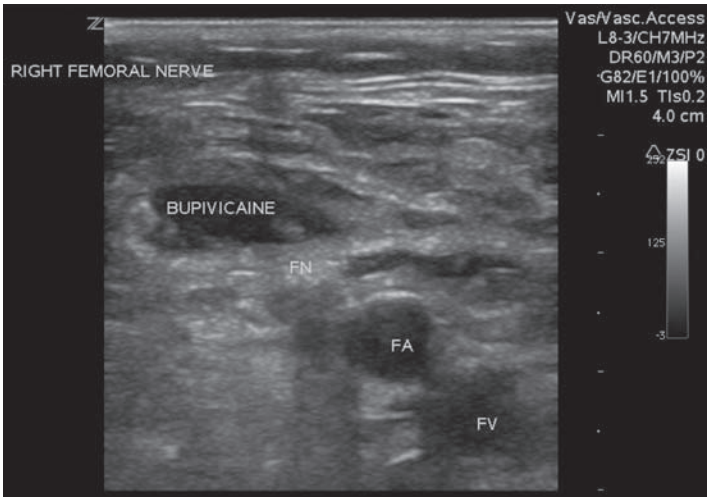

Figure 5. Ultrasound image of femoral vein (FV), artery (FA), nerve (FN) and inguinal ligament (IL) and expanding bupivacaine around FN.

a small notch, light, or nub) pointing towards the patient's right (Figure 1). The inguinal ligament is noted as a linear hyperechoic structure, and as the probe is slid caudad, the large femoral vein and the non-compressible femoral artery are identified. Lateral to these structures, the femoral nerve sheath is visualized and appears as a hyperechoic triangular structure (Figure 2). A small skin wheal over the target site with bupivacaine is made. Depending on physician preference, the physician can hold the US probe, and use his/her other hand to make the injection or an assistant can hold the probe in the groin while the physician makes the injection. The injection is made using a 21-gauge spinal needle attached to a syringe with 20 ml of 0.5% bupivacaine, which is inserted 2 cm distal to the inguinal ligament in a lateral to medial direction at a 30-degree angle (Figure 3). It can be technically challenging to tract the location of the needle tip during needle insertion therefore we suggest fanning the transducer. Once the needle comes into view on the US monitor, the tip is positioned as close as possible to the femoral nerve and aspiration can be done to insure there is no infiltration into a vessel. The anesthetic is spread in a cephalad direction and appears as an expanding hypoechoic area within the fascial space surrounding the nerve sheath (Figure 4). The following thigh nerves are anesthetized: femoral, obturator and lateral cutaneous. Distal pressure is applied during and shortly after injection.

Complications

Literature regarding complications specifically to US-guided FNB is sparse. We assume that complications of this procedure include any adverse reaction to administration of the bupivacaine including allergic reactions, fatal arrhythmias and death. Due to the close proximity to the femoral artery, intra-arterial injection is a possibility, although it is minimized with direct visualization with real-time US needle guidance.[9] Nerve injuries following accidental femoral nerve impalement and intraneural injection of local anesthetic have been reported without major adverse sequelae.[23] We did not have any complications to report.

DISCUSSION

FNBs have been used postoperatively after hip repair and replacements for many years. Anesthesiologists have been applying these nerve blocks under NS guidance to achieve precise application to the nerve. Studies in adults and children have shown that US-guided FNBs are both technically superior and decrease the opioid and volume of local anesthetic requirement for pain management compared to NS guidance.[1,3,10-12]

Injecting less local anesthetic is of particular importance in cardiovascular-compromised patients, in whom cardiovascular side effects can be prevented.[3] Significantly decreasing patient's morphine requirement to achieve pain control is favorable for patients with underlying cardiopulmonary disease, opiate allergy or intolerance and would require less intensive nursing and physician management.

EPs can effectively accomplish US-guided FNBs as they are easy to learn, provide faster, longer pain relief with smaller volume of local anesthetic compared with NS guidance and should be considered in all patients with femoral fractures.[1,3,11] Training using cadaveric US-guided peripheral nerve blocks have been reported.[24] Online educational resources and videos include: http://www.usra.ca/fem2_vid and http://www.nysora.com. Accessed January 27, 2009.

CONCLUSION

US-guided FNB is a safe and easy procedure that can be

performed with minimal US training in the ED for femoral fractures. The 3-in-1 FNB provides rapid, effective anesthesia and has also been shown to decrease the opioid and volume of local anesthetic requirement for pain management. Finally, with informal questioning, we received very favorable feedback from our orthopedic surgeons, nursing staff and great satisfaction from our patients.

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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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Variability in Ultrasound Education among Emergency Medicine Residencies

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Objective: Education in emergency ultrasound (EUS) has become an essential part of emergency medicine (EM) resident training. In 2009, comprehensive residency training guidelines were published to ensure proficiency in ultrasound education. The American College of Emergency Physicians (ACEP) recommends that 150 ultrasound exams be performed for physician competency. Our goal is to evaluate the current ultrasound practices among EM residency programs and assess the need for further formalization of EUS training.

Methods: We generated a survey using an online survey tool and administered via the internet. The survey consisted of 25 questions that included multiple choice and free text answers. These online survey links were sent via email to EM ultrasound directors at all 149 American College of Graduate Medical Education EM residency programs in April 2008. We surveyed programs regarding EUS curriculum and residency proficiency requirements and descriptive statistics were used to report the survey findings.

Results: Sixty-five residency programs responded to the survey. The average number of ultrasound exams required by programs for EUS competency was 137 scans. However, the majority of programs 42/65 (64%) require their residents to obtain 150 scans or greater for competency. Fifty-one out of 64 (79%) programs reported having a structured ultrasound curriculum while 14/64 (21%) of programs reported that EUS training is primarily resident self-directed. In terms of faculty credentialing, 29/62 (47%) of residency programs have greater than 50% of faculty credentialed. Forty-four out of 61 (72%) programs make EUS a required rotation. Thirty-four out of 63 (54%) programs felt that they were meeting all their goals for resident EUS education.

Conclusion: Currently discrepancies exist between EM residency programs in ultrasound curriculum and perceived needs for achieving proficiency in EUS. Although a majority of residency programs require 150 ultrasound exams or more to achieve resident competency, overall the average number of scans required by all programs is 137 exams. This number is less than that recommended by ACEP for physician competency. These data suggest that guidelines are needed to help standardize ultrasound training for all EM residency programs. [West J Emerg Med 2010; 11(4):314-318.]

INTRODUCTION

Education in emergency ultrasound (EUS) has become an essential part of emergency medicine (EM) resident training. However, it is unclear what degree of standardization exists among EM residency programs in terms of ultrasound training. In the past, several organizations, including the American College of Emergency Physicians (ACEP), Society for Academic Emergency Medicine (SAEM) and American

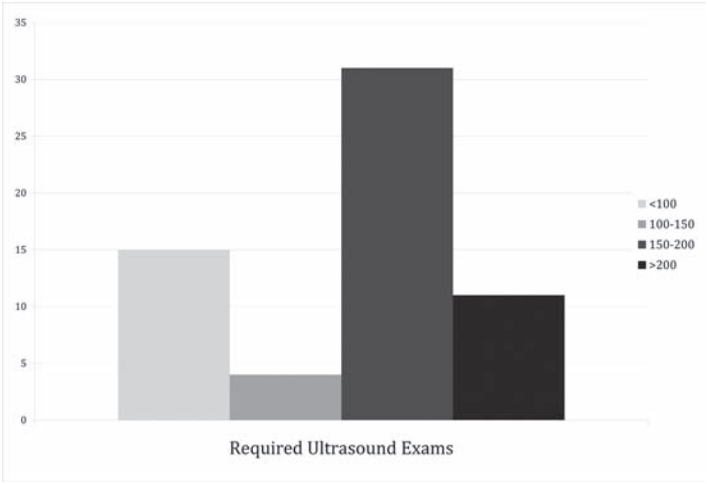

Figure 1. Number of ultrasound scans required by emergency medicine programs for resident competency.

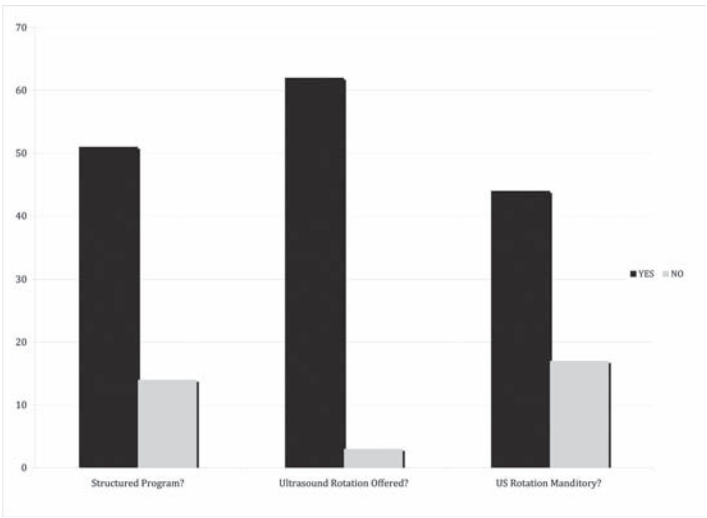

Figure 2. Structure of ultrasound programs' education.

Academy of Emergency Medicine (AAEM), have issued position statements or guidelines regarding the use of ultrasound by emergency physicians.[1-3] These guidelines served as a standard for many residency programs in developing their EUS education and curriculum.

In 2009, ACEP issued a policy statement that outlined guidelines for residency EUS education.[4] It follows previously developed guidelines, which were not evidence-based and were developed for practicing emergency physicians with little previous residency ultrasound training.[5] The most recent published data surveying the status of ultrasound training was performed in 2001.[6] The goal of our study was to evaluate the current ultrasound practices among EM residency programs through a survey of programs.

METHODS

We generated a survey using an online survey tool and administered it via the internet. The survey consisted of 25 questions, which included multiple choice and free text answers regarding residency programs' EUS requirements, structure of their ultrasound curriculum, number of credentialed faculty, method of quality assurance and overall perceptions of their own curriculum. We sent a link to this online survey via email to EM ultrasound directors, program coordinators and residency program directors at all Accreditation Council for Graduate Medical Education (ACGME) EM residency programs in April 2008. The survey was anonymous; no identifier linked individual surveys to individual programs.

After one month, a second email was sent to all programs directors and, if available, ultrasound directors, requesting survey completion. The survey was closed and the data collected in May 2008. Data were analyzed using descriptive statistics.

RESULTS

A total of 65 out of 149 (44%) ACGME EM residency programs responded to the survey. The average number of ultrasound scans required for EUS competency across all reporting residencies was 137. The majority of programs, 42/65 (67%) required greater than 150 scans, 9/65 (13.8%) required greater than 200 scans, while four programs had no specified number of scans for competency. For programs reporting a competency requirement the range was 25 to 300 scans (Figure 1).

A majority of reporting programs, 51/64 (79%) had a structured ultrasound curriculum, while the remainder of programs report that EUS training is primarily resident self-directed. A formal ultrasound rotation is offered at 62/65 (95%) of residencies but is required at only 44/65 (72%) of these programs (Figure 2). Residencies reported variability in the length of formal ultrasound rotations offered. Of 62 programs that responded, nine (15%) reported that they offer 1-2 weeks of ultrasound rotation, while 29 (47%) offered a 2-4 week ultrasound rotation. Finally, 23 (37%) of the residencies offered an ultrasound rotation longer than four weeks (Figure 3).

Multiple forms of instructional media educated residents about EUS. The majority (80%) use lecture-based education to train their residents in ultrasound. In addition to lectures, 36% of reporting residencies use some form of online education to train their residents (Figure 4). Fifteen programs responded when asked the number of hours they commit to ultrasound-related lectures during the course of resident training. On average residents received 34 hours of ultrasound-specific lectures during their training. Of the programs that reported faculty involvement in training, the average number of dedicated faculty hands-on instruction was 46 hours during the course of residency training; however, only 15 programs responded to this question (Figure 6).

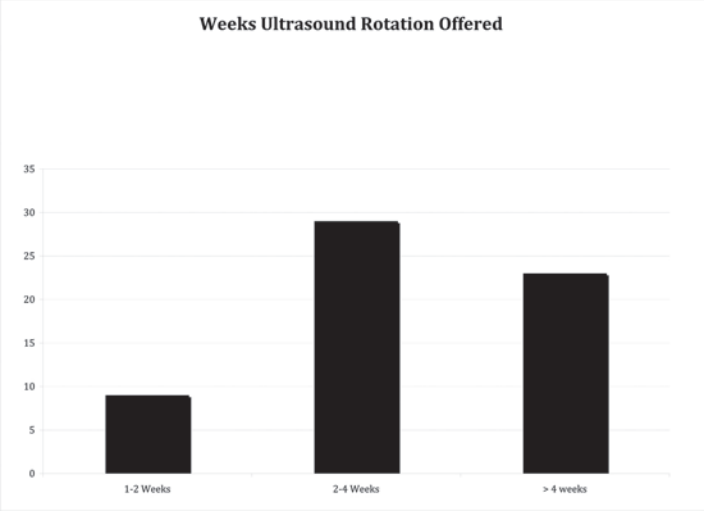

Figure 3. Number of weeks of ultrasound rotation available to residents.

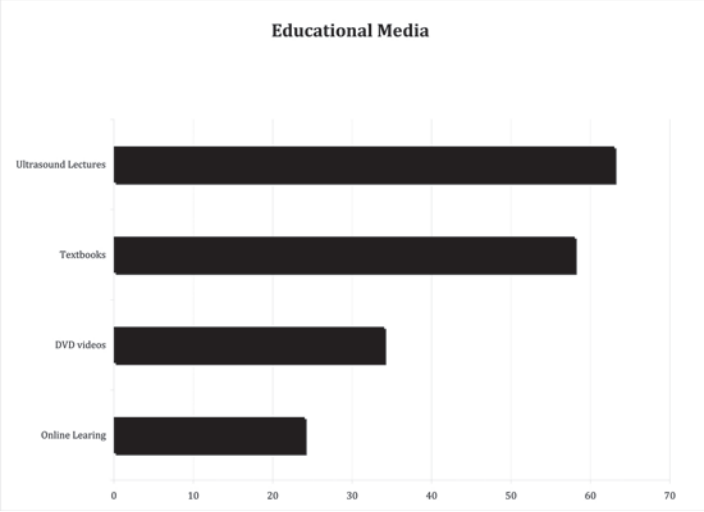

Figure 4. Types of media used for ultrasound education.

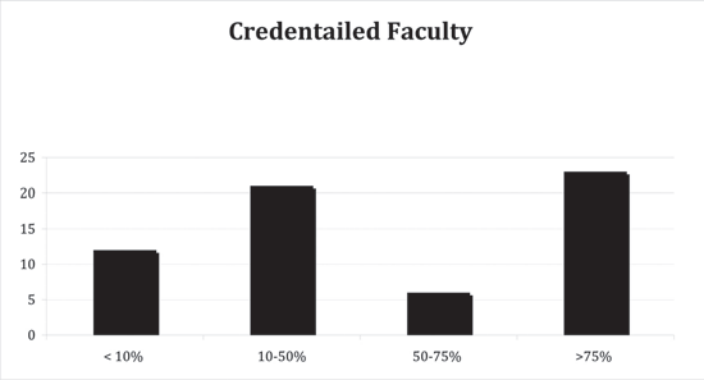

Figure 5. Percentage of faculty credentialed to use ultrasound in the emergency department.

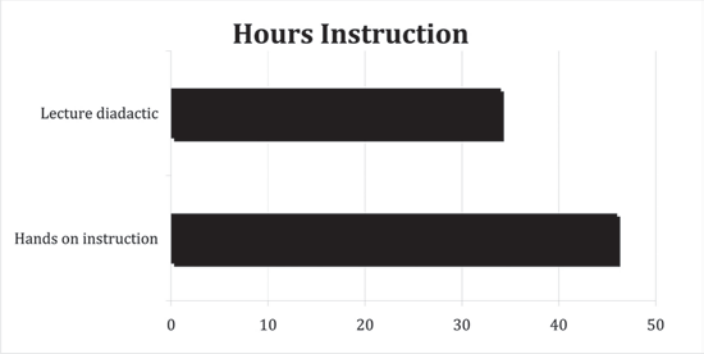

Figure 6. Hours of formal resident instruction.

In terms of faculty credentialing, 29/62 (47%) of residency programs have greater than 50% of faculty credentialed. A large majority, 62/64 (96%) of credentialed faculty reported using ultrasound in patient care decisions (Figure 5).

A majority of programs, 47/64 (73%) felt no adversity within their hospital to emergency department use of ultrasound and EM resident ultrasound education.

Approximately half, 34/63 (54%) of programs reported meeting all of their goals for resident EUS. Only 5/63 (7.9%) reported not meeting their ultrasound program goals.

Figure 7 reports the different types of ultrasound modalities that EM residents are currently being trained in.

DISCUSSION

Ultrasound education is becoming an increasingly important part of EM residency training. EM organizations such as ACEP have developed guidelines for residency training in different ultrasound modalities.[4] There are no recent surveys that report the current state of emergency ultrasound training or how residency programs have implemented these guidelines.

Although our data show discrepancies in ultrasound training among all residency programs, we found that progress has been made in EUS training when we compared our data to past surveys. Review of the 2001 study by Counselman et al. suggests there have been significant increases in the number of hours of dedicated ultrasound didactic training. In 2001, 76%, of programs offered between 1-20 hours of formal didactic training while our survey respondents in 2008 reported a total average of 34 hours dedicated to ultrasound didactics and lectures.[6] Also, in terms of hands-on resident ultrasound training, there has been an even greater increase. In the 2001 survey, 83% of programs offered less than 20 hours of direct, hands-on resident ultrasound training. In contrast, we found that residents received an average of 46 hours of direct, hands-on training for all reporting programs.

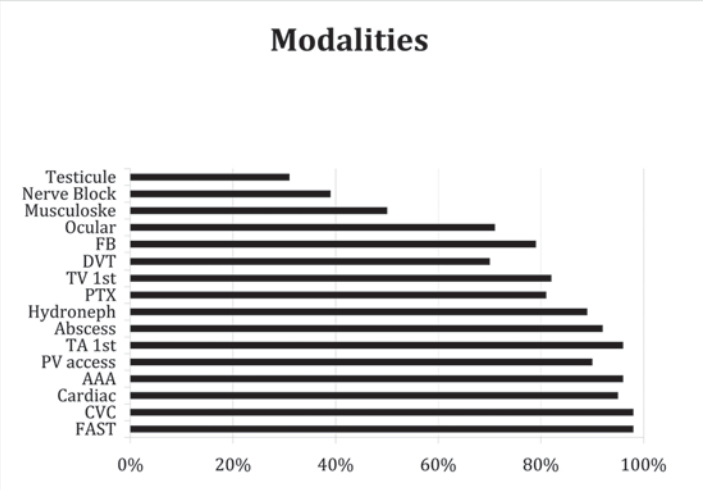

Figure 7. Percentage of programs that provide instruction in selected ultrasound modalities.

Interestingly, programs are now reporting ultrasound training in more advanced applications. Most of the earlier literature surveying residency training reported training in only six or seven core EUS applications.[6] Our data set indicates that more than 50% of the responding programs offer training in 13 applications.

Faculty credentialing appears to be another area of advancement with 61% of programs reporting half of their faculty credentialed in ultrasound. Furthermore, 94% of programs reported credentialed faculty using ultrasound in patient care decisions. These numbers suggest a growing percentage of faculties in residency programs using ultrasound for patient care and passing that practice on to future emergency physicians.

One area we have identified for improvement is in requirements for resident competency. The average number of scans required among all programs was 137, which is slightly less than that suggested as a guideline for physician competency by ACEP. Furthermore, we noticed a large discrepancy in the number of required scans between residency programs. The majority of programs (64%) required more than 150 ultrasound exams for competency. This is a considerable improvement in comparison to a survey study by Witting in 1998, in which only one program reported meeting SAEM guidelines.[7] It is also worth noting that 14% of respondents required greater than 200 ultrasound exams for residency competency. Only a small percentage of programs reported requiring significantly less than the benchmark of 150 ultrasound exams.

While ACEP has established this number, it is uncertain whether 150 ultrasound exams is an important benchmark to achieve in obtaining EUS competency. ACEP points out that these guidelines are not evidence based.[8] In fact, we are unaware of any study that demonstrates a particular number of ultrasound exams to correlate with competency. However, these results do demonstrate that the majority of programs in the United States are requiring greater than 150 ultrasound exams for resident competency.

Our survey found that a majority (80%) of programs considered their ultrasound program highly structured with 72% of programs requiring mandatory ultrasound rotation and training. There is considerable advancement in EUS training when one considers that in a survey by Cook and Roepke 10 years ago only 50% of programs reported offering any training in emergency ultrasound.[9]

Finally, it appears that despite the relative infancy of EUS, 73% of the reporting programs in our study stated there is low institutional opposition to training residents in emergency ultrasound.

LIMITATIONS

The study has several limitations. Only 65 of the 149 EM residency programs responded to our survey. The fact that there was only a 44% response rate is a significant limitation of this data set. However, the data suggest that residencies with well-developed ultrasound programs may have been more likely to respond. This is witnessed by the fact that a disproportionate percentage, 26/65 (40%) of programs responding offer a fellowship, a number higher than the expected number of fellowships available. Therefore, although we are unable to characterize the use of ultrasound in the 84 programs that did not respond to our survey, the data set can be assessed as a best-case scenario since those programs that failed to respond are likely to have less developed ultrasound curricula.

CONCLUSION

Currently there exist discrepancies among EM residency programs in ultrasound curricula and perceived needs for achieving proficiency in EUS. Although a majority of residency programs responding to the survey require 150 ultrasound exams or more to achieve resident competency, overall the average number of scans required by all programs is 137 exams. This number is slightly less than that recommended by ACEP for physician competency. There currently exists a feeling among emergency ultrasound educators that formal competency assessment and testing will be needed in the near future for the credentialing of physicians in the use of emergency bedside ultrasound. With this there also exists the possibility that competency testing in EUS will be a separate certification from the EM board-testing process. Our data suggest that discrepancies currently exist among residency programs in the level and quality of ultrasound training. These findings suggest that further guidelines help standardize ultrasound training for all EM residency programs may be warranted.

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Ultrasound Use and "Overuse"

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The U.S. Department of Health and Human Services Office of the Inspector General has issued a report concerning "high use" and "questionable use" ultrasound. Findings include those geographic areas where occurrences are most frequent, as well as the most common elements that characterize questionable use. While not its primary focus, emergency physician performed bedside ultrasound is within the scope of the report. Implications for emergency ultrasound are discussed and practice recommendations made for minimizing regulatory exposure for emergency physicians and departments. [West J Emerg Med. 2010; 11(4):319-321.]

BACKGROUND

In July 2009, the U.S. Department of Health and Human Services Office of the Inspector General (OIG) reported results of an investigation concerning "high use" and "questionable use" of ultrasound.[1] OIG identified counties exhibiting high ultrasound use and determined whether reimbursement claims had certain "questionable characteristics." The office examined Ultrasound Part B technical component claims for 2007. Of 41 million identified, a technical component was billed in 18.8 million. Further exclusions resulted in a final data set of 17 million claims involving beneficiaries in 3,239 counties.

They assessed two variables of use: 1) average annual ultrasound charges per beneficiary and 2) percentage of beneficiaries who received ultrasound services. Twenty counties were found to occupy the top one percent of both of these measures (Figure 1). They accounted for 16% of Medicare's ultrasound costs despite being populated by only 6% of its beneficiaries. Part B spent an average of $171 per beneficiary in the high-use counties compared to $55 in the rest of the country. Use for the top 20 counties appears in Table 1.

The OIG then examined the claims for presence of certain attributes it deemed "questionable." Five assessed characteristics were:

1. Absence of a preceding service claim from the ordering physician.
2. Use of suspect combinations of billing codes, "such as billing for both a complete abdominal scan and a scan of an individual organ within the abdominal cavity."

Figure 1. Geographic distribution of the Top 20 ultrasound "high-use" counties

3. Occurrence of more than five ultrasounds provided to the beneficiary on the same day by the same provider.
4. Beneficiaries who had ultrasounds billed by more than five providers.
5. Missing or invalid ordering physician identifiers.

The OIG discovered that the first was by far the most frequent, occurring in 17% of claims. The remaining four occurred each with frequencies < 2%.

Final OIG recommendations to the Centers for Medicare and Medicaid Services (CMS) call for CMS to monitor for and act on questionable claims. Potential action includes

Table 1. Top 20 "high-use" county beneficiaries and costs

Country and State	Beneficiary Population	Percentage of Beneficiaries Receiving Ultrasound	Allowed Charges for Ultrasound	Average Charges per Beneficiary
Kings, NY	213,049	35%	$50,067,967	$235
Miami-Dade, FL	182,733	42%	$42,374,761	$232
Nassau, NY	182,738	39%	$36,985,652	$202
Willacy, TX	2,692	41%	$524,329	$195
Suffolk, NY	189,873	35%	$34,399,935	$181
Queens, NY	194,434	33%	$34,250,651	$176
Richmond, NY	41,697	32%	$6,850,116	$164
Palm Beach, FL	182,177	40%	$27,980,686	$154
Charlotte, FL	34,351	42%	$4,961,687	$144
Union, NJ	67,657	31%	$9,747,483	$144
Middlesex, NJ	94,291	33%	$13,306,923	$141
Saint Lucie, FL	40,111	37%	$5,519,626	$138
Macomb, MI	113,766	33%	$15,543,312	$137
Broward, FL	136,416	33%	$18,461,816	$135
De Soto, FL	4,779	37%	$641,599	$134
Ocean, NH	114,346	35%	$15,338,042	$134
Marion, FL	73,343	39%	$9,748,060	$133
Indian River, FL	30,932	38%	$3,993,748	$129
Sarasota, FL	97,804	36%	$12,066,955	$123
Walker, AL	12,636	35%	$1,558,896	$123

individual review prior to payment. CMS concurred, reporting they would, "take appropriate action to forward the listing of questionable claims to the recovery audit contractors [RACs] and Medicare administrative contractors [MACs]."

IMPLICATIONS FOR EMERGENCY ULTRASOUND

To what extent does the OIG report impact current emergency department (ED) practice? Does standard clinician-performed bedside ultrasound in the ED risk raising red flags to the government or its bounty hunters?

As the technical component of hospital-based ED ultrasound is billed (if at all) to Part-A, OIG's specific audit of Part-B technical component claims indicates focus elsewhere; it's unlikely that OIG had explicit interest in EDs. Emergency physician (EP) groups generally do not bill for the technical component and instead, via the -26 modifier, explicitly limit claims to the professional component. Maintaining distance from OIG/CMS' newfound interest is an additional reason to continue this practice.

We should not, however, conclude that ED ultrasound remains uninteresting to regulators. OIG's conclusions appear to extend to all of Part B ultrasound, notwithstanding the study's audit of only technical component claims. Per the report's overview: "Compared to other types of diagnostic imaging machines, which can cost millions of dollars to acquire and install, ultrasound machines are relatively inexpensive. Providers can buy used machines for under $5,000 and roll them into examining rooms on carts." The OIG appears to presume that inexpensive fraud/abuse is more frequently committed than fraud/abuse requiring greater investment. While perhaps displaying greatest concern for fraudulent low budget "diagnostic mills," OIG's portrayal of "rolling in the machine" does accurately describe this physical element of ED practice.

The most common "questionable" ultrasound claim characteristic identified by OIG was the "[absence] of a prior service claim from the doctor who ordered the ultrasound." This refers to an ultrasound ordered and performed without a preceding Evaluation & Management encounter to generate an ultrasound-addressable question. It is almost inconceivable that an ED ultrasound would be billed without an associated EP's evaluation and management (E&M) code billed concurrently. Therefore, the most common questionable claim would likely never occur in legitimate emergency medicine practice.

Also determined to be questionable were "[instances] of more than five ultrasound services provided to the same beneficiary on the same day by the same provider." Can reasonable ED practice inadvertently trigger scrutiny via this criterion? In its White Paper [2] and Update [3] on coding and

billing, the American College of Emergency Physicians enumerates multiple ultrasound CPT codes that can be appropriately billed for a single acute patient. The initial evaluation of undifferentiated shock can require numerous diverse insonations,[4] all generating CPTs. Serial focused assessments with sonography for trauma (FASTs) are an established ultrasound use for the trauma patient with changing clinical condition. To the above examples, the reader is invited to additionally assume that patients are female and possibly pregnant. It's easily conceivable that these and other patients receiving legitimate ultrasound imaging could transgress this OIG "Rule of 5" on a single ED encounter with a single ED provider. If justification for such "questionable characteristic" ultrasounds is clearly reflected in the patient record, it's unlikely that the studies would fail scrutiny. They might, however, still generate initial scrutiny, possibly resulting in individual reimbursement delay and/or consequent wider audit of claims.

The OIG also assigned "questionable" status to the characteristic: "Beneficiaries who had ultrasound services billed for them [in a single year] by more than five providers." Are there ED patients at risk of triggering this criterion? Anyone who presents frequently to the ED with chest pain might frequently receive bedside echocardiography for assessment of pericardiditic effusion. A critically ill ED patient could undergo several diagnostic scans (e.g. serial eFASTs) and ultrasound-guided procedures. Following intensive care unit admission, intensivists or radiologists performing more of the same could add to the total. Even in the course of a single hospitalization, such a patient could transgress this OIG "Other Rule of 5." Once again, appropriate documentation demonstrating medical justification/necessity is the best cure for later scrutiny.

Do any of the OIG's geographic findings implicate ED ultrasonography? Metropolitan and suburban downstate New York counties figure prominently among the top half-dozen identified as "high-use." This region is also distinguished by a higher prevalence of emergency ultrasound (EUS) fellowships. This is almost certainly a correlation without causation. The OIG does note that such high-use counties have generally higher ultrasound provider-to-beneficiary ratios than remaining counties. In fact, the ratio is approximately tripled. The contribution of EUS fellowships to overall provider numbers is likely negligible. Additionally, the prominence of South Florida counties characterized as "high-use" is without similar correlation and likely reflects an older and sicker population, as well as a higher provider/beneficiary ratio. Consistent with other interpretations in this commentary, the above does not prominently place emergency medicine on the OIG ultrasound radar screen, but neither does it explicitly remove it. An ED's geographic location could be future cause for increased CMS scrutiny.

CONCLUSION

EPs in general, and those performing bedside ultrasound in particular, are experienced with life in the fish bowl. With its recent report, the OIG joins the ranks of on looking ichthyologists. EUS practitioners and their coding and billing agents should keep abreast of regulatory developments and their implications as discussed above. Evidence-based, medically indicated and competently performed imaging should be practiced by appropriately credentialed physicians and be accurately reflected in the medical record. Physician group practices and hospitals should stand ready to appeal the adverse audit.[5] Emergency medicine specialty societies should monitor for problems encountered by members, and lobby to correct any abusive enforcement practices by the government or its contractors.

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Ultrasound Detection of Lung Hepatization

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Bedside ultrasound interrogation of the thorax can aid the clinician in determining the cause of the respiratory dysfunction. Often plain radiographs are not sufficient to differentiate pathology. We present a case in which bedside ultrasound defined the pathology without the need for further imaging. [West J Emerg Med. 2010; 11(4):322-323.]

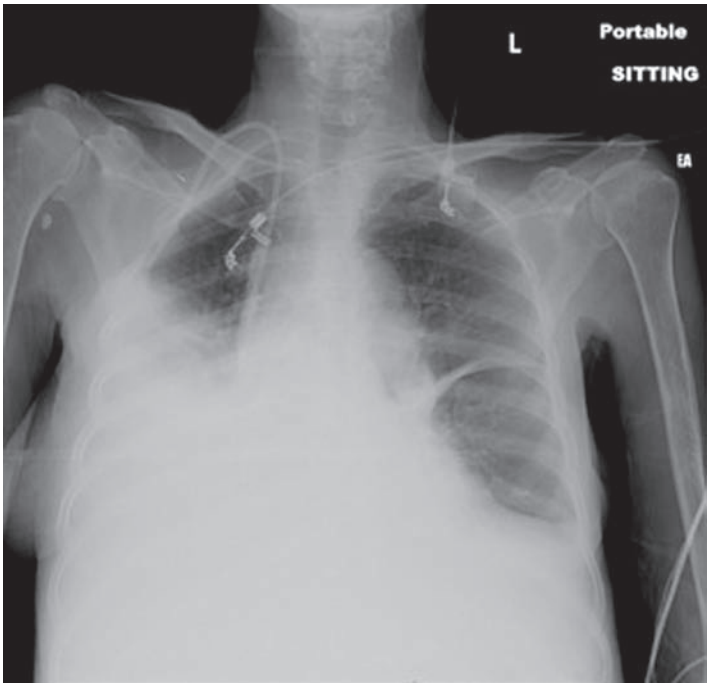

Figure 1. Portable upright chest radiograph reveals bilateral pleural effusion.

A 60-year-old female with a history of esophageal cancer, status-post radiation and chemotherapy, was transferred from a skilled nursing facility to the emergency department for shortness of breath. On exam, the patient was found to be cachectic and have oxygen desaturations to the mid 80s with minimal movement, bilateral rhonchi, and an ascitic abdomen. A portable chest radiograph (Figure 1) was officially read as bilateral pleural effusions, which were greater on the right side than the left. Ultrasounds of the right lower thorax (Figure 2 A and B) are shown above.

When a chest radiograph shows an opaque hemithorax, ultrasound of the thorax can be useful for deciphering the underlying etiology and morphology.[1,2] Sonographically normal lung is identified by sliding at the pleural-pulmonary interface and reverberation and comet tail artifacts produced by the air inside the lungs.[3] Compared to normal lung, consolidation on ultrasound has a relatively hypoechoic heterogeneous echotexture.[2] Because consolidation appears isoechoic with the liver it has been referred to as lung "hepatization." The margin around the consolidation as it abuts normal aerated lung is blurred and irregular. Consolidation on ultrasound also contains air bronchograms analogous to air bronchograms seen on chest radiograph. Sonographic air bronchograms appear as multiple hyperechoic millimeter-long, lentil-shaped air inlets or as hyperechoic branching tubular structures within the consolidated lung parenchyma.[2,4] A moderate amount of literature exists detailing the utility of ultrasound for the detection of pulmonary consolidation, with ultrasound demonstrating a higher level of sensitivity than both auscultation and chest radiography.[3,5]

On ultrasound, atalectasis also contains air bronchograms and can look similar to consolidation. However, air bronchograms in atalectasis look more crowded and parallel to one another.[5] Atalectasis also tends to appear biconcave and be found floating in a large pleural effusion.[2] Pleural effusions on ultrasound appear as anechoic or hypoechoic areas between the visceral and parietal pleura.[4]

In this case, the ultrasound revealed that the opaque

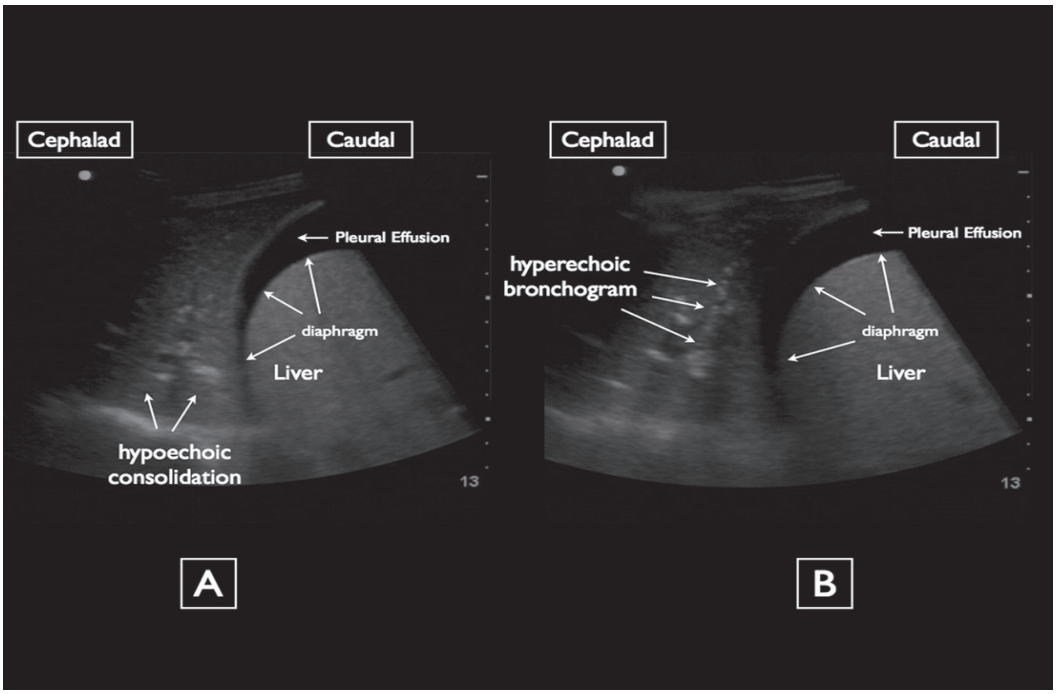

Figure 2. A) Ultrasound of the right lower thorax. B) Ultrasound of the right lower thorax.

hemithorax on chest radiograph was not a large pleural effusion necessitating thoracentesis, but instead a large area of consolidation with a concomitant small effusion. Empiric antibiotic therapy was immediately initiated, and further imaging was cancelled.

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Occupancy Rates and Emergency Department Work Index Scores Correlate with Leaving Without Being Seen

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Objective: Two crowding metrics are often used to measure emergency department (ED) crowding: the occupancy rate and the emergency department work index (EDWIN) score. To evaluate these metrics for applicability in our community ED, we sought to measure their correlation with the number of patients who left without being seen (LWBS) and determine if either, or both, correlated with our daily LWBS rate. We hypothesized a statistically significant positive correlation between the number of patients who LWBS and both crowding metrics.

Methods: We performed a retrospective observational study by reviewing data on all patients who LWBS from December 1, 2007, to February 29, 2008. Occupancy rates and EDWIN scores were obtained through our electronic patient tracking board. We identified LWBS status by searching the final disposition entered into our electronic medical record. We measured the correlation between each crowding metric averaged over each 24-hour day and the number of patients who LWBS per 24-hour day using Spearman's rank correlation, and created receiver operator characteristic (ROC) curves to quantify the discriminatory power of occupancy rate and EDWIN score for predicting more than two patients per day who LWBS.

Results: We identified 1,193 patients who LWBS during the study period, including patients who registered but then left the waiting room (733), as well as those who left before: registration (71), triage (75), seeing a physician (260), or final disposition (54). The number of patients who LWBS per day ranged from one to 30, with a mean of 13 and median of 11 (IQR 6 to 19). The daily number of patients who LWBS showed a positive correlation with the average daily occupancy rate (Spearman's rho = 0.771, p = 0.01) and with average daily EDWIN score (Spearman's rho = 0.67, p< .001). Area under the ROC curve for occupancy rate was .97 (95% CI .93 to 1.0) and for EDWIN score was .94 (95% CI .89 to 1.0).

Conclusion: Average daily occupancy rates and EDWIN scores both correlate positively with, and have excellent discriminatory power for, the number of patients who LWBS in our ED; however, the scale of our EDWIN scores differs from that obtained at other institutions. For studies of crowding, occupancy rate may be the more useful metric due to its ease of calculation. [West J Emerg Med. 2010; 11(4):324-328.]

INTRODUCTION

The problem of emergency department (ED) crowding continues to plague healthcare systems around the world. ED crowding has been associated with increased risks of death or disability, treatment delays, ambulance diversion, and patients leaving without being seen, among other problems.[1-8] Patients who leave without being seen (LWBS) risk not receiving appropriate or timely medical care and represent a particular failure of the medical system.[9-13]

Earlier studies have shown that the number of these patients who leave before being seen by a physician is affected by multiple factors, with one common factor being the level of

ED crowding; nevertheless, studies of the effect of crowding on LWBS patients have primarily examined university-based academic medical centers or public county hospitals.[9-12, 14-16] As the problem of hospital and ED crowding continues to grow, more methods to quantify levels of crowding are being developed, with the emergency department work index (EDWIN) score favored by some groups, and occupancy rate favored by others.[16-27]

To evaluate further the characteristics of two crowding metrics in our community hospital ED, we sought to measure the correlation between the degree of crowding, measured by the occupancy rate and by a modified EDWIN score available on our electronic tracking board, and the number of patients who LWBS. We hypothesized a statistically significant positive correlation between the number of patients who LWBS and both crowding metrics.

METHODS

Study design

We performed a retrospective analysis of all patients who registered in our ED between December 1, 2007 and February 29, 2008. The study was approved by our Institutional Review Board with a waiver of informed consent.

Setting and selection of participants

This study was conducted in a community teaching hospital with a 50-bed ED that is designated a Level 1 trauma center with an annual ED census of 85,000 visits per year and almost 700 inpatient beds. The hospital has an emergency medicine residency program in a PGY 1-3 format. All patients who arrived to the ED and gave sufficient information to be listed on our electronic tracking board were considered eligible for counting. We obtained daily counts of all patients who LWBS via our electronic medical record (EMR) system.

Methods of measurement

The occupancy rate is defined by the total number of patients in the ED divided by the number of licensed ED beds. The EDWIN score is defined as $\Sigma n_i t_i / N_a (B_T - B_A)$, where n_i = number of patients in the ED in triage category i, t_i = triage category, N_a = number of attending physicians on duty, B_T = number of treatment bays, and B_A = number of admitted patients in the ED. Triage category is defined by the Emergency Severity Index (ESI)[28], which is in widespread use in North America; for the EDWIN score, to assign higher numerical values to higher severity patients, the ESI is reversed from the standard ordinal ranking of triage categories so that ESI level 1 patients, who have the highest acuity, are assigned a value of 5, ESI level 2 patients are given a value of 4, continuing down to ESI level 5 patients (lowest acuity) being assigned a value of 1. The EDWIN score from our tracking board varies from the original in that admitted patients are not removed from the numerator in the calculation of our score (whereas in the original description admitted patients were removed from the numerator) and the total number of bays counted (B_T) includes all available spaces, including hallway beds, rather than only licensed treatment bays. This last modification is necessary to avoid possible "divide by zero" computational errors, and results in a lowering of the numerical value of our score when compared to the original description.

Data collection and processing

We obtained occupancy rates and EDWIN scores at 20-minute intervals, 24 hours per day, via automatic sampling of our electronic patient tracking board through a remote server. To collect these data, we used a VBScript (Microsoft, Redmond, Washington) running on a remote server that automated the acquisition of data from our electronic tracking board.

We identified patients as having LWBS if they were given one of four disposition designations in our EMR: (1) left before registration, (2) left before triage, (3) left before being seen by a physician, or (4) left before final disposition.

Primary data analysis

We measured the correlation between each crowding metric averaged over each 24-hour day and the number of patients who LWBS per 24-hour day using Spearman's rank correlation. We created receiver operator characteristic (ROC) curves to quantify the discriminatory power of occupancy rate and EDWIN score for predicting more than two patients per day who LWBS, based on prior recommendations that LWBS rates of 1% or less should be the target rate for EDs.[9] We performed our analyses with SPSS version 15.0 (SPSS Inc., Chicago, IL).

RESULTS

Site Characteristics

We identified 1,193 patients who LWBS during the study period. The majority of these patients (733) registered at the ED greeting station, then left the waiting room prior to being called to triage or back into an ED exam room or hallway spot. The remainder of these patients left before various stages of their visit, including 71 who left before full registration, 75 who left before triage, 260 who left before seeing a physician, and 54 who left before final disposition. The number of patients who LWBS per day ranged from one to 30, with a mean of 13, and a median of 11 (IQR 6 to 19). The average daily occupancy rate ranged from 65% to 170%, with a mean of 126%, and median of 127% (IQR 112% to 144%). The average daily EDWIN score ranged from 0.18 to 0.48, with a mean of 0.31, and a median of 0.31 (IQR 0.27 to 0.34). The average number of patients presenting to the ED in each month of our study was as follows: 7,316 in December 2007, 7,482 in January 2008, and 7,217 in February 2008. The average time to triage in each month was 18 minutes, 20 minutes, and 21 minutes, respectively. The average time

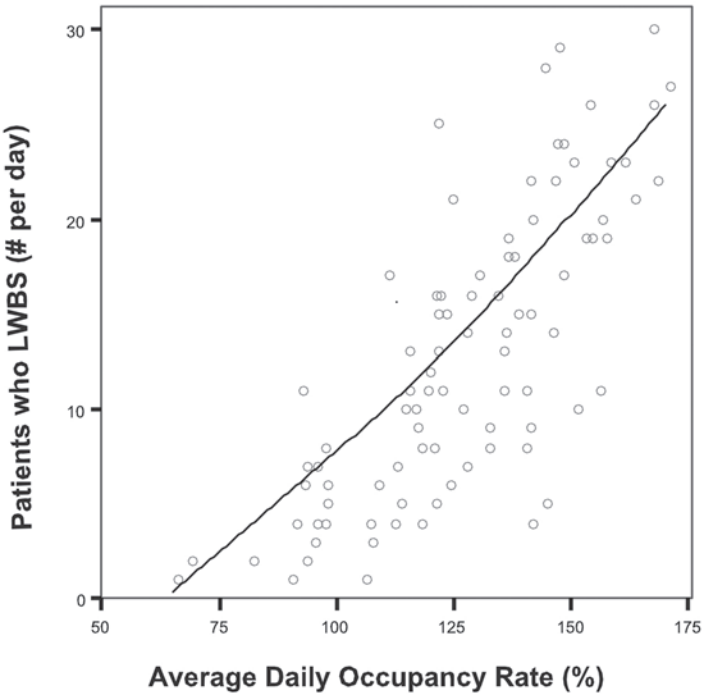

Figure 1. Correlation between daily number of patients who left without being seen (LWBS) and average daily occupancy rate.

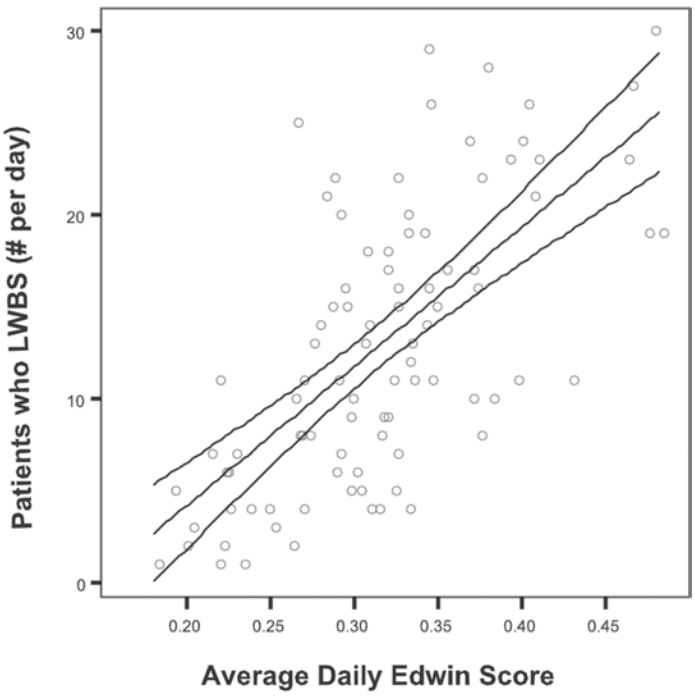

Figure 2. Correlation between daily number of patients who left without being seen (LWBS) and average daily emergency department work index (EDWIN) score.

to arrival in the ED from the waiting room by month was 72 minutes, 94 minutes, and 95 minutes, respectively. Finally, the average time to disposition was 233 minutes, 259 minutes, and 256 minutes, respectively.

Correlations

The daily number of patients who LWBS showed a positive correlation with both the average daily occupancy rate (Spearman's *rho* = 0.771, $p = .01$), Figure 1, and the average daily EDWIN score (Spearman's *rho* = 0.67, $p < .001$), Figure 2. The correlation between EDWIN score and occupancy rate was strong (Spearman's rho = 0.85, $p < .001$). By defining an adverse outcome as the presence of greater than two patients in one day who LWBS, the area under the ROC curve for occupancy rate was 0.97 (95% CI 0.93 to 1.0) and for EDWIN score was 0.94 (95% CI 0.89 to 1.0), Figure 3. Using data points from our ROC curves, an occupancy rate of greater than 95% provides a sensitivity of 93% and a specificity of 83% for the likelihood of more than 2 patients in one day who LWBS. Likewise, an EDWIN score of 0.22 provides a sensitivity of 93% but a specificity of only 67% for the likelihood of more than two patients in one day who LWBS.

DISCUSSION

We found a strong correlation between the two crowding metrics investigated and the number of patients who LWBS in our community ED, further supporting the associations seen in university-based academic medical centers. Because there are many important operational differences between community hospitals and university-based medical centers, the persistence of this association in our hospital setting, although likely, was not certain. For example, many of our patients have their own private physicians and, when they present to the ED, may anticipate admission under their own physician, which may induce them to wait longer than they would otherwise before leaving the waiting room. Conversely, because the majority of

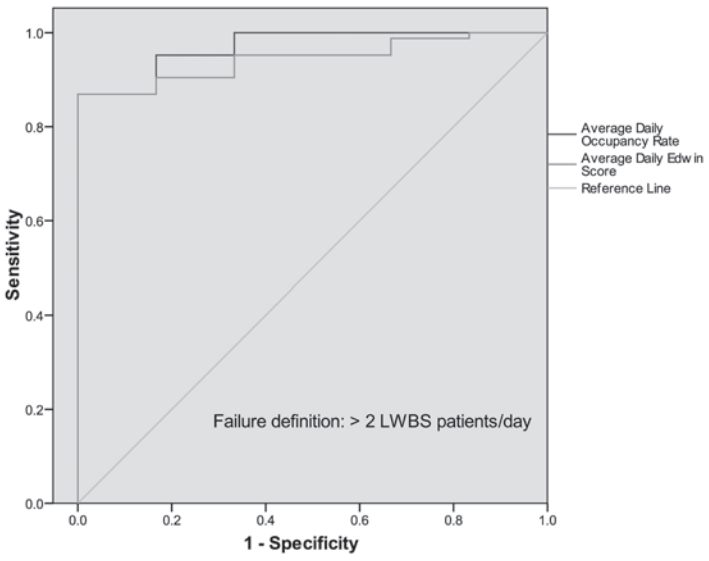

Figure 3. Receiver operating characteristic curves for average daily occupancy rate and emergency department work index (EDWIN) score with outcome defined as greater than two patients who left without being seen (LWBS) per day.

patients admitted do not have inpatient resident physician coverage, additional time spent waiting for their primary care physician to perform further inpatient workup may pose delays in hospital throughput not seen in university-based settings.

Prior studies in university-affiliated EDs have found markedly increased numbers of patients who LWBS when ED volume increased beyond a certain threshold, in contrast to the more linear relationship apparent in our ED. This difference suggests that additional operational or external factors may influence patient decisions.[12] For example, a recent study found that many patients in a level II trauma center and community teaching hospital who LWBS had a primary care physician and were able to obtain care elsewhere.[29] Another study found that implementation of a rapid triage and treatment protocol, which allowed initiation of patient treatment at triage, reduced the number of patients who LWBS.[30] A retrospective analysis suggests that more frequent communication to patients of expected wait times and the provision of more rapid temporary treatment of symptoms might reduce the LWBS rate.[31] Nevertheless, it seems likely that our findings might potentially provide individual EDs with a starting point from which to address their LWBS rate. For example, at a certain occupancy rate threshold (which may vary between individual EDs), additional contingency plans might be activated that call in additional staff to use areas outside of the ED (such as post-anesthesia care units not being used after-hours) to help reduce the total ED occupancy rate.

We chose a cutoff value of two patients per day who LWBS as a level above which would be considered a "failure" for an ROC analysis. This figure is based on prior recommendations that LWBS rates of 1% or less should be the target rate for EDs.[9] Given the risks associated with leaving the ED prior to treatment, this rate appears reasonable; however, an even lower rate should perhaps be considered as a future goal. Our findings, which we believe are likely to be seen in other community hospital EDs, further add to the growing list of adverse associations with ED crowding. Although we used both occupancy rate and EDWIN score as our crowding metrics, the easy calculation of the occupancy rate, combined with a likely broader generalizability of this metric, suggests that it may be the more useful metric, as suggested by others.[16]

LIMITATIONS

Our data are consistent with previous reports from university-based EDs, but because they were obtained from a single hospital ED they may not generalize to other community hospitals. Our correlations are based on EDWIN scores and occupancy rates averaged over a 24-hour period, limiting the ability to observe more detailed relationships that might surface if we used a more restricted time frame. Although we assumed a linear relation between crowding and the number of patients who LWBS, this relationship may instead be more accurately modeled using a non-linear approach. We were unable to confirm that patients did not LWBS only to return the same, or on a later, day, and therefore patients leaving from and returning to the ED within a 24-hour period would have been counted as separate patients. Finally, although the LWBS rate is considered an important measure by hospitals for a number of reasons, the association of this rate with patient outcomes remains uncertain.[32]

CONCLUSION

Average daily occupancy rates and EDWIN scores both correlate positively with, and have excellent discriminatory power for, the number of patients who LWBS in our ED; however, the scale of our EDWIN scores differs from that obtained at other institutions. For studies of crowding, occupancy rate may be the more useful metric due to its ease of calculation.

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Learning to Use an Emergency Department Information System: Impact on Patient Length of Stay

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Objective: An electronic emergency department information system (EDIS) can monitor the progress of a patient visit, facilitate computerized physician order entry, display test results and generate an electronic medical record. Ideally, use of an EDIS will increase overall emergency department (ED) efficiency. However, in academic settings where new interns rotate through the ED monthly, the "learning curve" experienced by the new EDIS user may slow down patient care. In this study, we measured the impact of the "intern learning curve" on patient length of stay (LOS).

Methods: We retrospectively analyzed one year of patient care data, generated by a comprehensive EDIS in a single, urban, university-affiliated ED. Intern rotations began on the 23rd of each month and ended on the 22nd of the next month. Interns received a 1.5-hour orientation to the EDIS prior to starting their rotation; none had prior experience using the electronic system. Mean LOS (± standard error of the mean) for all patients treated by an intern were calculated for each day of the month. Values for similar numerical days from each month were combined and averaged over the year resulting in 31 discrete mean LOS values. The mean LOS on the first day of the intern rotation was compared with the mean LOS on the last day, using Student's t-test.

Results: During the study period 9,780 patients were cared for by interns; of these, 7,616 (78%) were discharged from the ED and 2,164 (22%) were admitted to the hospital. The mean LOS for all patients on all days was 267 ± 1.8 minutes. There was no difference between the LOS on the first day of the rotation (263±9 minutes) and the last day of the rotation (276 ± 11 minutes, $p > 0.9$). In a multiple linear regression model, the day of the intern rotation was not associated with patient LOS, even after adjusting for the number of patients treated by interns and total ED census ($\beta = -0.34$, $p = 0.11$).

Conclusion: In this academic ED, where there is complete intern "turnover" every month, there was no discernible impact of the EDIS "learning curve" on patient LOS. [West J Emerg Med. 2010; 11(4): 329-332.]

INTRODUCTION

A computer-based emergency department information system (EDIS) can monitor the progress of a patient visit, facilitate computerized physician order entry, display test results, and generate an electronic medical record. Ideally, EDIS use will increase emergency department (ED) efficiency, enhance communication among members of the healthcare team, minimize charting time, eliminate illegible notes and missing charts, improve patient safety, and ensure proper coding for reimbursement. Indeed, in 2006 the Institute of Medicine report on the future of emergency care suggested that electronic information systems could improve ED efficiency and overall patient care.[1]

Little is known about the impact of an electronic patient information system on patient length of stay (LOS). LOS is the result of many complex and interrelated facility, provider,

patient, system and resource-related variables.[2-4] It is not clear if the methods of patient charting, whether hand-written or electronic, play a significant role in determining ED patient LOS since few studies have examined this issue.[5, 6] Comprehensive electronic patient charting and information systems are of special interest. On one hand, they promise greater accuracy and efficiency in documenting the reasons for a patient's visit and the results of his or her care in the ED. On the other hand, successful implementation of an EDIS requires physician and staff training, experience, and fluency with the specific electronic application.

In academic settings where new interns from multiple clinical services rotate through the ED monthly, there is concern that the "learning curve" experienced by new EDIS users may slow down patient care. In this study conducted in an academic, teaching hospital-based ED, we sought to measure the impact of the interns' EDIS "learning curve" on patient LOS.

METHODS

In this retrospective study, we examined the LOS for all ED patients seen by rotating interns over a one year period. To assess the impact of learning to use the EDIS, we compared the LOS for patients seen by interns on the first day of their one-month ED rotation with the LOS for patients seen on the last day of their rotation. This study was approved by the institutional review board.

We analyzed one year of patient care data generated by our EDIS (PICIS PulseCheck, Wakefield, MA). The study was conducted in an urban, university-affiliated ED with an annual volume of 36,000 patients. The hospital is a Level II trauma center with a 24-hour cardiac catheterization lab, regional burn center, multiple transplant services and other regional specialty centers. Data were gathered from March 1, 2005 to February 28, 2006.

Intern rotations began on the 23rd of each month and ended on the 22nd of the next month. These first year house officers were from emergency medicine, internal medicine, family medicine and surgery residency programs associated with the University of Colorado Denver School of Medicine and the Denver Health Residency in Emergency Medicine. On average there were five interns per 24-hour day who worked 10 hour shifts with an equal distribution of days, evenings, nights and weekends.

Interns received a 1.5-hour training session in the use of the EDIS prior to starting their ED rotation. None had prior experience using the EDIS. No interns repeated rotations in the ED during the study period. All orientations were taught by one of two emergency medicine faculty members and were unchanged in content or format during the course of the year. Both worked from the same orientation outline to ensure all relevant material was covered. Training included both didactic and hands-on practice using the EDIS; interns were taught to navigate the patient locater screens, generate orders (including medications, diagnostic studies and nursing and admission orders), document the medical evaluation and treatment for the patient visit, and produce discharge prescriptions and instructions. In general, the first 15 minutes of each orientation session was dedicated to navigation of the patient tracking screen; the next 45 minutes focused on order entry and charting the history and physical examination and procedures performed; and the final 30 minutes was devoted to hands-on practice in charting, order entry, and writing prescriptions and discharge instructions.

LOS was defined as the time from patient arrival to discharge from the ED, when the patient's name was removed from the patient-tracking screen. LOS data for all ED patients who were cared for by interns and who completed visits to discharge from the ED were included. Excluded from data analysis were patients who left without being seen, left before their visit was complete, or were triaged to other areas of the hospital, such as the obstetrics labor and delivery area. An attending physician supervised all care provided by interns.

Total numbers of patient visits (ED census), numbers of patients seen by interns (intern census) and mean LOS (± standard error of the mean) for all patients treated by interns were calculated for each day of the month. Values for similar numerical days from each month were combined, resulting in 31 discrete LOS, ED census and intern census values. The mean daily patient LOS on the first day of the intern rotation (23rd) was compared with the last day of the rotation (22nd) using Student's t-test. A linear regression analysis to determine whether the day of the month was associated with LOS after adjusting for the effects of intern census and total ED census for that day of the month.

RESULTS

During the study period 30,357 patients were included in the data analysis; interns provided care to 9,780 patients. Of these patients7,616 (78%) were discharged from the ED and 2,164 (22%) were admitted to the hospital. The mean LOS for all patients treated by interns on all days was 267 ± 1.8 minutes. There was no significant difference in LOS between the first day of the rotation (the 23rd) and the last day of the rotation (22nd) (263 ± 9 minutes vs. 276 ± 11 minutes, $p > 0.9$). Among all ED patients treated by interns, the shortest LOS occurred on the 24th day of the month (236 ± 8 minutes), the second day of the interns' rotation; the longest LOS (300 ± 11 minutes) occurred on the seventh of the month, midway through the rotation. In the multiple linear regression model, the day of the month was not associated with intern patient LOS, even after adjusting for intern census and total ED census ($\beta = -0.34$, $p = 0.11$).

DISCUSSION

In this academic ED where there is complete intern turnover every month, the EDIS learning curve had no discernable impact on patient LOS. Our results include more

than 9,000 patient visits over a one-year period. Following a brief orientation, practice and skill session, new interns were able to use the EDIS to track patients, order tests and medications, retrieve test results, complete the electronic medical record and issue discharge prescriptions and instructions without a measurable effect on patient LOS. The number of patients seen per day by interns was not significantly different on most days of the month and was not related to time elapsed since EDIS training.

While much has been written about the advantages and potential costs and hazards of electronic medical records and patient information systems,[7-11] there is scant information regarding the impact of these systems in academic settings and none that specifically assesses academic EDs. Retchin and Wenzel recognized several years ago that "training programs of academic health centers are optimal environments for testing and implementing EMR [electronic medical record] systems. Academic health centers have the expertise to resolve remaining software issues, the components necessary for integrated delivery, a culture for innovation in clinical practice, and a generation of future providers that can be acclimated to the requisites for computerized records." [12]

LOS is an important measure of the efficiency of ED care and a determinant of patient satisfaction.[13-15] Hospital administrators, physicians, nurses and patient care advocates may be encouraged by the finding in this study that LOS did not rise when new users were asked to learn and use a complex, comprehensive computer-based electronic information system.

There are several limitations to the current study. First, our interns were generally web and software savvy and seemed to learn EDIS skills easily. Our results may not be transferable to new users who do not have a high comfort level with web-based software. Second, our LOS were quite high (mean LOS 267 ± 1.8 minutes), and the effect of the EDIS might be different in EDs with much shorter or much longer LOS. Third, efficient use of the EDIS depends on "on the job training." Our physician and nursing staff were frequently called upon to help the new clinicians learn the subtleties of software navigation and advanced techniques to enhance speed and accuracy. In this investigation, we did not attempt to standardize or analyze the individual components of the intern "learning curve." We recognize that proficiency depends on many aspects of learning, including the orientation program, independent practice and experience with similar applications. Fourth, we did not study LOS for patients cared for by other trainees, including medical students or higher level residents.

There are two additional important limitations. We tested for an association between the day of the intern rotation and patient LOS. However, we did not attempt to measure the quality or content of charting performed by interns. Finally, we did not study a number of other important covariates that may affect patient LOS. Our results were unchanged when we controlled for individual intern patient load and overall ED patient volume; however, we did not consider intern specialty, their progress in learning clinical or procedural skills, supervising physician efficiency, ED staffing, patient severity of illness, test ordering behaviors, laboratory turnaround time, inpatient bed availability, waiting room volumes or other factors that affect LOS.[2, 16-20] At the same time, one of the strengths of our study design is the comparison of LOS across days of the month. It is unlikely that any of the above factors will vary systematically by day of the month, except for interns' experience in the ED. Future studies are needed to reach a more comprehensive understanding of the impact of the EDIS on patient "throughput," quality of care and the practice of emergency medicine.

CONCLUSION

In this academic ED where there is complete intern turnover every month, the EDIS "learning curve" had no discernable impact on patient LOS.

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Impact of Resident Physicians on Emergency Department Throughput

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Objective: Evaluate the impact of adding emergency medicine residents to a medium-size urban hospital by comparing emergency department (ED) admission rate, total census, length of stay (LOS), and proportion of patients who left without being seen (LWBS).

Methods: Using the student t-test, the study compared commonly used ED metrics for a mid-sized urban hospital (annual census 43,000) for the four-month period prior to (March-June 2006) and after (March-June 2007) residents began providing 24-hour coverage at the institution.

Results: There was no significant difference in the number of patients seen (NPS) in the two time periods, 14,471 and 14,699 patients respectively (p=0.507). Analysis of the NPS and LWBS was not statistically significant. The percentage of patients who LWBS decreased with the presence of residents (6.5% to 5.8%, p=0.531), and the overall ED LOS was similar (210 min vs. 219 min, p=0.56). Admission rate data demonstrated that residents had a similar admission rate (17.5% vs. 18%, p =0.332).

Conclusion: ED flow depends on a number of variables with complex interactions. When comparing two similar time periods in consecutive years, the presence of resident physicians in the ED had no effect on the number of patients seen, patient LOS in the ED, or LWBS, thus supporting the conclusion that residents did not adversely affect the patient flow within the ED. [West J Emerg Med. 2010; 11(4):333-335.]

INTRODUCTION

Over the past decade numerous studies have been published concerning physician shortages in the United States, including a shortage of emergency medicine (EM) physicians in rural areas.[1] Cheng et al. concluded that EM is the least-represented of all residency-trained physicians in rural areas.[1] The shortage of emergency physicians (EP) supports the need for expansion of EM residencies to increase the availability of residency-trained EPs.[2] The study by Branney et al. suggests that employing EM residency-trained physicians provides benefits, as residency-trained EPs have lower average malpractice claims.[3] The hospital that employs EPs trained by EM residency programs may also benefit from lower malpractice cases. Although there are potential advantages for hospitals to assume training of EM residents, the associated costs and the concern that residents will have a negative effect on patient flow can impact establishing training programs.

The creation of a new residency program, along with the incorporation of 16 residents over a single year, allowed us to measure the impact an EM residency on department function. The residents represented a class of eight postgraduate year one (PGY-1) and eight postgraduate year two (PGY-2) residents. The classes consisted of four newly matriculated and 12 transfer residents (four interns, eight PGY-2 residents) from a recently closed EM program. This study seeks to evaluate the effect of residents upon patient flow, admission rate, and time patients spent in the emergency department (ED) before disposition (either admission or discharge).

METHODS

The study took place at an urban tertiary referral hospital that is a level II trauma center. Annual census is 43,000. The ED is divided into an acute care area and a designated urgent care area. Prior to March 2007, there were 36 hours of attending coverage in the acute care area and 20 hours of mid-level coverage in urgent care. In March 2007, a supervising physician and two residents provided 24 hours of coverage daily in the acute care area with the additional 12 hours of attending coverage added to the 20 hours of mid-level coverage in the urgent care area. Two residents, a PGY-1 and a PGY-2, were the primary providers in the acute care area and would evaluate, treat, and give disposition of the patients. The institution also has a family practice residency that infrequently rotates residents through the ED.

The Meditech Health Care Information System used by the hospital is an electronic patient management system that tracks ED patient metrics. We obtained patient census data from March – June 2006, which represents the patients seen only by attending physicians and physician extenders. The same census data was obtained for March through – June 2007, a time period representing assumption of patient care duties by EM residents. We compared data from the same time period each year to reduce bias from seasonal fluctuations in the ED census.

We obtained year-to-year interrupted time series data, which included: total number of visits, average length of stay (LOS), the percentage of patients LWBS and the percentage of total patients admitted to the hospital. We compared pre- and post-residency data with the student t-test, and we used SPSS inc version 16, Chicago Il to analyze the data.

RESULTS

The number of patients seen prior to the start of the residency was 14,471, with 14,699 seen for the same period after resident coverage began in the ED, p=0.507. The census increased by only 1.6%, representing minimal change in census between the periods, supporting the comparison of similar patient groups. The number of patients LWBS did decrease from 6.5% to 5.8%, (950 vs. 856, p=0.531). The patients' total LOS increased by 9.4 minutes, which represents an increased average LOS of 4 %, (210.2 min vs. 219.6 min, p=0.56). The percentage of admissions increased from 17.5% without residents to 18.5 %, (p=0.332) Overall, none of the metrics showed a significant change.

Table 1: Summary of Emergency Department Metrics Pre- and Post-Resident Addition

	Pre-Residents	Post-Residents	t-Test
Number of Patients Seen	14471	14699	p=0.50
Left Without Being Seen (%)	6.5% (950)	5.8% (856)	p=0.23
Mean Length of Stay	210 Minutes	219 Minutes	p=0.56
Admission Rate (%)	17.5% (2534)	18% (2676)	P=0.06

DISCUSSION

The physician shortage in the United States continues for various reasons, among them the Congressional Balanced Budget act of 1997 that froze the available graduate medical education residency training spots supported by Medicare Part A.[4] Freezing the number of Medicare-supported resident positions makes continued federally funded expansion of the physician work force through graduate medical education programs difficult. While residents generally do not bill for their services, they provide a significant amount of patient care under the supervision of an attending physician, including a large percentage of indigent care.[5] Without the support of the federal government, individual states and health institutions must decide if there is benefit to paying the cost of training additional residents.

The impact of EM residents upon patient throughput in an ED can be difficult to quantify, and the available literature is limited. Lammers et al. evaluated the effect of the presence of EM residents over time by looking at patient LOS.[6] A before-and-after observational study was conducted one year prior and for the three years after the start of the EM residency. An additional year of data was collected during the fifth year after the residency started. A weak positive correlation was found between the ED patient LOS and the presence of postgraduate year three (PGY-3) EM residents, suggesting that residents took longer to provide a disposition for patients.[6] French et al. studied quality indicators in the ED when residents were present and absent during the study period and found no measurable difference for most of the quality indicators studied, although faculty physicians without residents were less efficient in admitting patients.[7] Our study represents the impact residents have over a much shorter period with immediate complete resident coverage within the acute care area of the ED due to filling a PGY-1 and a PGY-2 class in a newly established resident program. This decreases the impact of hospital census variables, minimizes other staffing effects, and limits bias. Our results confirm earlier studies that residents have a neutral effect upon ED efficiency.

LIMITATIONS

The study was limited in that only four months of resident coverage were included at a single institution with PGY-1 and PGY-2 residents. The residents' potential impact could change over time as the staff and residents become more familiar with the residency training system, as well as the hospital functions. The presence of PGY-3 residents could also affect patient throughput. The study addressed general trends and does not attempt to demonstrate causality.

CONCLUSION

The presence of an EM training program at the institution did not adversely affect patient flow within the ED. The previous physician and mid-level staffing was unchanged after residents began to staff the ED acute care area, so there was no change from previous staffing expenses and thus little opportunity for increased income based on the addition of residents. Training residents is not offset by an increased number of patient evaluations, and therefore is unlikely to provide increased income to support the administration of an EM residency.

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Emergency Department Frequent User: Pilot Study of Intensive Case Management to Reduce Visits and Computed Tomography

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Objective: Emergency department (ED) frequent users account for a large number of annual ED visits and often receive radiological studies as a part of their evaluation. We report a pilot study of a case management program for ED frequent users to reduce ED usage and radiation exposure.

Methods: This observational retrospective study was performed at a community hospital ED. Between May 2006 and April 2008, 96 patients were enrolled in a case management program and were followed through November 2008. The case management program consisted of a multi-disciplinary team of physicians, nurses, social services and specialists in pain management and behavioral health. Patients were enrolled if they had five or more visits to the ED in the previous month, if a concern about a patient's ED use was raised by staff, or if they were identified by the California prescription monitoring program. Case management addressed specific patient issues and assisted with receiving consistent outpatient care. The number of ED visits per patient and the number of radiological studies at each of these visits was recorded. When reviewing data for analysis, we used the number of total images in all computed tomography (CT) scans during the given time period.

Results: In the six months prior to enrollment, patients averaged 2.3 ED visits per patient per month. In the six months after enrollment, patients averaged 0.6 ED visits per patient per month ($P<0.0001$), and all visits after enrollment up to November 2008 averaged 0.4 visits per patient per month ($P<0.0001$). In the six months prior to enrollment, these patients averaged 25.6 CT images per patient per month. In the six months after enrollment, patients averaged 10.2 CT images per patient per month ($P=0.001$), and all CT images after enrollment up to November 2008 averaged 8.1 CT images per patient per month ($P=0.0001$). This represents a decrease in ED use by 83% and a decrease in radiation exposure by 67%.

Conclusion: Case management can significantly reduce ED use by frequent users, and can also decrease radiation exposure from diagnostic imaging. [West J Emerg Med. 2010; 11(4): 336-343].

INTRODUCTION

With emergency department (ED) use always on the rise and waiting room times ever increasing, management of ED frequent users is becoming a very important issue. Recent literature has defined frequent use as four or more ED visits per year, [1-3]These patients tend to have more psychiatric problems, substance abuse issues, chronic medical conditions, and psychosocial stressors than other ED patients.[1-16] Given the resources needed to manage these patients, several methods have been evaluated to decrease their use. Intensive

case management and the use of narcotics protocols have been shown to significantly decrease use, [11-12, 17-21] while other efforts have been ineffective in keeping frequent users out of the ED.[22-23]

Radiation exposure from diagnostic imaging is another issue that emergency physicians (EP) must consider when pursuing a diagnosis. EPs rely increasingly on computed tomography (CT) scans as they provide a rapid way to confirm a diagnosis, prevent misdiagnosis, and pick up incidental pathology that would otherwise be missed.[24-28] However, there can be significant radiation exposure from even a single CT scan. An abdominal CT provides on average an effective dose of 10 mSv, which is associated with a 0.05% risk of cancer. For patients receiving more than one CT in a single visit or multiple CT scans over time, the risk of cancer increases significantly.[29-32]

Although the threshold for frequent use has previously been defined as only four visits per year,[1-3] many patients seek emergency care significantly more than this. Several studies have identified large groups of patients who use ED services on average 20 times or more per month.[15, 22, 34] These patients consume large amounts of healthcare resources and worsen ED crowding.[12] Additionally, given how often these patients seek care and the major role that CT plays in patient evaluation in the ED, frequent users may be at an increased risk of radiation exposure by choosing to seek ED care.

Malignancy secondary to radiation exposure from CT scans is an issue that has received attention from both medical and patient audiences. Both patients and providers alike often choose not to use CT scans in ED diagnostic evaluations, citing the risk of malignancy. With this in mind, we chose to examine radiation exposure from CT scans as part of our investigation.

The purpose of this study was to evaluate a pilot program consisting of intensive case-management for frequent users at a community hospital to determine if case management is an effective means of decreasing both frequency of ED use and radiation exposure in frequent users.

METHODS

This observational retrospective study was performed at a 205-bed community hospital in central California with approximately 45,000 visits to the ED each year. This study was granted IRB exemption by the hospital committee on research.

A case management pilot program was developed by the ED staff to adequately meet the needs and improve the overall care of patients recurrently seeking care in the ED for chronic medical problems, including narcotic or benzodiazepine addiction. The program is chaired and operated by an ED nurse, who oversees a committee consisting of ED physicians, a chemical dependency physician, hospitalist physicians, pain management clinicians, behavioral health physicians and nurses, as well as social service providers. Patients were enrolled in the case management program if they were identified as having five or more visits to the ED in the month prior to enrollment. Patients could also be enrolled if nursing staff or physicians requested a case management evaluation for a particular patient based on patient pattern uses. Additionally, patients could be enrolled if one of the ED physicians received a letter from the California prescription monitoring program regarding a patient. The case management team met once a month for 90 minutes to discuss both patients currently being managed and patients newly identified as needing case management.

When a patient was first presented to the case management team, the chair provided a tally of his or her recent ED visits, with a listing for each of the visits of the chief complaint, studies performed, ED treatments provided, and prescriptions given. Also included were a record of the patient's admissions from the ED and medical problems including regular medications. Based on this information, the case management team determined the chronic problem or problems underlying the frequent use of the ED and then developed a plan to manage these problems in the outpatient setting. Patient care plans consisted of referral to outpatient resources for the management of patients' chronic problems outside of the ED. Such resources included chemical dependency treatment for addiction, pain management for chronic pain, psychiatric services for untreated anxiety or depression, and primary care for those without a primary care provider. Patients without insurance could also be referred to social services for assistance in getting Medi-cal/Medicaid insurance. Additionally, to prevent repeat use for the same chronic problems, the team created recommendations regarding what treatments could be given in the ED. For example, the team recommended that patients with chronic pain not receive narcotics for their chronic pain; rather, the patient's primary care physician (PMD) or pain management physician would be contacted. Similarly, recommendations for patients with opiate or benzodiazepine addiction often involved not using opiates or benzodiazepines except in case of new and acute issues, such as trauma. Patients received letters at their listed mailing addresses informing them of their enrollment in the case management program and the specifics of their plan.

For patients already enrolled in the program, the case management team periodically reviewed all of the patient's visits to the ED, including those since enrollment. In the case of a significant reduction in the frequency of ED use and adherence by the ED staff to the case management plan, the patient's plan would be continued and reassessed at a later meeting. For patients with minimal decreases in ED use, the case management team reassessed the patient's problems to develop a new plan to implement.

Once patients were enrolled, documents regarding their case management plan were placed into the patient's medical record, allowing EPs and other physicians treating the patient

Table 1. Baseline patient demographics (n=85)

		Number	Percent
Gender			
	Female	57	67.1
	Male	28	32.9
Ethnicity			
	White	57	67.1
	Black	17	20.0
	Latino	5	5.9
	Other	5	5.9
	Asian	1	1.2
Age			
	Average age		42.4

Table 2. Patient care plans

Patient Care Plans	Number	Percent
Limited or no narcotic use	80	94.1
Chemical dependency evaluation	29	34.1
Limited or no benzodiazepine use	22	25.9
Referral to pain management	18	21.2
Behavioral health evaluation	11	12.9
Social services/Medicaid referral	5	5.9
Referral to primary care	3	3.5
Referral to physical therapy	3	3.5
Limited or no antibiotic use	1	1.2
Referral to alcoholics anonymous	1	1.2
Referral to neurology	1	1.2

to have easy access to the care plan. Furthermore, to improve adherence to the plan, patients in case management were identified upon arrival to the ED and a note was placed on the ED status board in the comments section to alert treating physicians and nursing staff of the patient's enrollment in the case management program.

In analyzing data for our study, we used the hospital's medical record system to obtain data regarding the frequency of patients' visits, chief complaints at each visit, nature of their care plan, basic demographic information about each patient, referrals attended, and the number of CT scans received. We recorded the total number of CT scan images at each visit to compare radiation exposure from CT scans before and after program enrollment.

Our study had two primary outcome measures. The first was the number of visits per patient per month to the ED, and the second was the number of CT scans per patient per month. We recorded the number of patient visits per month and number of CT scans received per month for the six months prior to enrollment in the program and the six months after enrollment. To assess the efficacy of the case management over a longer time period, all enrolled patients were followed through November 2008, when our study data collection ended. Patient visits per month and the number of CT scans per month were recorded for this time period.

Our study also had three secondary outcome measures. We compared admission rates before and after enrollment in the program as a method of discerning if the case management program was preventing people from seeking care when needing admission. We also evaluated the rate of attendance of our major referrals for the program to determine if patients were receiving the care recommended to them. Of the patients who were referred to obtain insurance, obtained a PMD, received care from the pain management service, received a chemical dependency evaluation, or received an evaluation and care from the psychiatry service, we examined the percentage of our patients successfully receiving these services. Finally, for each patient we determined the most common chief complaints that brought them to the ED for care both before and after enrollment as a means of assessing whether or not the patient's chronic problems were being adequately addressed. In case a patient presented frequently for two separate issues, both of these were recorded as their most common chief complaint.

We analyzed data with Microsoft Excel 2007, using a paired, two-tailed t-test to generate p values in comparing ED visits per patient per month and CT images per patient per month in the six months prior to enrollment to both the six months after enrollment as well as to the time period from enrollment through November 2008.

RESULTS

Between May 2006 and April 2008, 96 patients were enrolled in the case management program, and all were followed through November 2008. Eighty-nine patients were enrolled because of the frequency of their visits or staff concerns, and seven were enrolled after notification by the California prescription monitoring program. Of these 96 patients, four had plans that, for unclear reasons, were consistently not followed by ED staff, five had plans that did not address the patient's underlying problem, and two had medical records could not be found. These three groups were excluded from data analysis; thus, we included 85 patients in the case management program in the analysis. Baseline patient demographics of the 85 patients enrolled can be found in Table 1. Only one of the 85 patients (1.2%) included in the analysis died after enrollment.

In the six months prior to enrollment in the program, patients averaged 2.3 ED visits per patient per month. In the six months after enrollment, patients averaged 0.6 ED visits per patient per month ($P<0.0001$), and all visits to the ED after enrollment up to November 2008 averaged 0.4 visits per patient per month ($P<0.0001$).

Table 3. Primary Care Physician (PMD) and insurance status

PMD Status	Number	Percent
Prior to enrollment		
Had PMD	75	88.2
Did not have PMD	10	11.8
After enrollment		
Had PMD	79	92.9
Did not have PMD	6	7.1
Insurance Status		
Prior to enrollment		
Medi-Cal/Medicaid	29	34.1
Medicare	19	22.4
Commercial	16	18.8
HMO	1	1.2
Hospital sponsored	2	2.4
Workman's compensation	3	3.5
Military	4	4.7
None	11	12.9
After enrollment		
Medi-Cal/Medicaid	33	38.8
Medicare	19	22.4
Commercial	16	18.8
HMO	1	1.2
Hospital sponsored	2	2.4
Workman's compensation	3	3.5
Military	4	4.7
None	7	8.2

Table 4. Most common chief complaints

Chief Complaints	Number	Percent
Prior to Enrollment		
Headache	30	27.8
Back pain	24	22.2
Abdominal pain	17	15.7
Extremity pain	10	9.3
Chest pain	6	5.6
Medication refill	5	4.6
Substance abuse	3	2.8
Psychiatric complaint	3	2.8
Other complaints	10	7.3
After Enrollment		
Abdominal pain	15	18.1
Headache	12	14.5
Extremity pain	12	14.5
Nausea, vomiting	6	7.2
Chest pain	5	6.0
Back pain	5	6.0
Substance abuse	4	4.8
Shortness of breath	4	4.8
Medication refill	3	3.6
Psychiatric complaint	3	3.6
Neck pain	3	3.6
Other complaints	11	10.9

In the six months prior to enrollment in the case management program, these patients averaged 25.6 CT studies per patient per month. In the six months after enrollment, these patients averaged 10.2 CT studies per patient per month (P=0.001), and all CT studies after enrollment up to November 2008 averaged 8.1 CT scans per patient per month (P=0.0001).

The specific interventions of the patient care plans as a part of the case management program are outlined in Table 2. The admission rate, measured as admissions per ED visits, during the six months prior to enrollment in the program was 11%. In the six months after admission, the admission rate was 8.5% (P=0.43), while the admission rate for all visits after enrollment through November 2008 was 7.9% (P=0.19).

As far as the efficacy of our referrals, the primary physician status and insurance status for all patients before and after enrollment in the program is outlined in Table 3. Notably, of the three patients who did not have a PMD prior to enrollment and were referred to get one, all three (100%) received a PMD. Additionally, of the five patients that did not have insurance prior to enrollment and were referred to social services to obtain insurance, four of these patients (80.0%) received Medi-Cal/Medicaid after enrollment. Of the 29 patients who were referred to the chemical dependency service, three (10.3%) attended their referral. Of the 18 patients sent to the pain management service, six (33.3%) attended their referral. Finally, of the 11 patients referred to psychiatry, five (45.4%) attended the referral given to them. Of the 66 referrals given for these five services, only 21 referrals were successfully attended (31.8%).

Finally, the most common chief complaints for ED visits both before and after enrollment are outlined in Table 4. The most common chief complaint was the same prior to and after enrollment in 31 of the 85 enrolled patients (36.5%).

DISCUSSION

Prior to discussing the results of our intensive case management program, it is important to point out that much of the previous literature on frequent users of ED services focuses on those patients that are homeless.[10-12,15,21] Of the patient population in our case management program, only one of the 85 patients (1.2%) was homeless. Thus, our study likely represents a much different group of patients than previously studied.

Frequency of use

Literature on frequent users has demonstrated numerous reasons as to why patients choose to repeatedly seek care in the ED. Patients have reported that they prefer ED care because they anticipate that their regular physician will not be able to take care of them, the ED is easy to get to, and emergency services are conveniently available 24 hours per day.[35-36] Chronic pain and the desire for narcotics and other psychoactive drugs are two additional, common reasons why patients may choose to frequent the ED, with some estimates of drug-seeking patients accounting for as high as one-fourth of ED visits.[8-9,15-16,18,37] Furthermore, one prior study of case management for frequent users found that approximately two-thirds of ED frequent users required interventions involving restriction of narcotics prescriptions.[22] With 94% of the patients in our case management program requiring interventions involving restriction or limitation of narcotics, chronic pain and chemical, dependency must be regarded as important issues in frequent users. The restriction of narcotics in frequent users, both in our data as well as in other studies, markedly decreased ED usage.[18, 22]

Nearly 90% of patients in our program had a PMD prior to enrollment in case management, and nearly 90% had health insurance prior to enrollment. These figures strongly suggest that lack of access to care was not an underlying reason for repeated ED usage in our group of patients, but rather patients were either not being adequately treated for their chronic medical conditions by their regular physicians or were choosing to seek ED care in an attempt to obtain prescription medications for underlying substance abuse problems.

Regardless of why patients choose to come to the ED for care, crowding is an increasingly common problem that is only made worse by frequent users.[12,38] Case management has been previously documented as an effective means of reducing ED use by frequent users,[11-12,17-21] which we also found to be the case with our case management program. Between May 2006 and April 2008, the frequent users who eventually enrolled in the program averaged 2.3 visits per patient per month, which accounted for 1,173 visits in the six months prior to their enrollment. Should this have continued without intervention, this group of 85 patients would have accounted for 2,346 visits per year, which would make up approximately 5% of all visits to our ED. After enrollment in the program, these patients averaged 0.6 visits per patient per month for the first six months, which accounted for only 290 visits in the six months after their enrollment, a decrease in the number of visits by 75%. Following the patients for longer than the six months after their enrollment demonstrated that these patients only averaged 0.4 visits per patient per month, or just 398 visits per year. Thus, our case management program has decreased the number of visits by frequent users by 83%, and has saved the department 1,948 visits per year. As mentioned above, one of the limitations of the study was that patients were not always identified as being in case management upon arrival to the ED. With changes in patient tracking and recognition, we may be able to ensure that patient plans are followed more closely. Thus, further reductions in use beyond what we have already accomplished may be possible.

Frequent users are known to have conflicts with staff, tend to be heavy users of healthcare resources, and are often dissatisfied with their healthcare.[1,2,4] Given that frequent users tend to have more psychological, substance abuse, and chronic medical issues than other ED patients,[1-16] it becomes clear that their evaluation and treatment is time-consuming. It is difficult to estimate how much time and effort was saved by eliminating these visits, but it may well represent more time saved than elimination of visits by other ED patients.

One final point to consider on the topic of the frequency of ED use by the patients in our program is the cost associated with their care. Although we did not perform a formal financial analysis of our program, we can estimate the effect of our program on healthcare costs with reasonable accuracy. The average ED visit bills approximately $1,000.[15] Considering that our program decreased visits by about 2,000 visits per year, this likely represents nearly two million dollars annual savings to patients and insurance companies. Because many of our patients have Medicare or Medicaid/Medi-Cal insurance, this represents significant savings to overburdened government insurance plans. This finding is supported by additional research showing that case management programs effectively reduce costs associated with care of frequent users.[12,21] Furthermore, nearly 60% of the patients in our program had Medicare or Medicaid/Medi-Cal insurance. With declining reimbursements for ED visits by these two plans,[14] a significant decrease in the number of visits per year by patients with Medicare or Medicaid/Medi-Cal insurance may also represent a reduction in the number of non-profitable visits for the department. For EDs that serve a large population of homeless and/or uninsured patients, such a reduction in use by these patients would markedly reduce the number of uncompensated visits as well.

Efficacy of the program in meeting patient needs

Although we did not have any direct means of assessing patient satisfaction with the program, we recorded several data points for each patient that gives us a more thorough understanding of our case management program efficacy. First, in examining the patients' most common chief complaints, only 31 out of 85 patients (36.5%) had the same common chief complaint before and after admission in the program. We interpret this to mean that the underlying chronic problem was managed well enough in 63.5% of patients that they were less inclined to seek recurrent ED treatment. An alternative explanation is that patients with narcotic addiction issues, once informed that they would no longer receive narcotics except in the case of acute medical illness, chose to change their chief complaint in an attempt to bypass any restrictions placed on them so as to receive narcotics.

A second measure of success of our case management program is the efficacy of our referrals. The overall attendance rate of our five major referrals (PMD, insurance, chemical dependency, pain management, and psychiatry) was 31.8%. An initial look at this number may suggest that our program was ineffective in treating our patients. Previous evidence has shown that frequent users are notoriously poor at keeping appointments, and the low success rate of our referrals supports this claim.[16, 21] However, individual examination of each of the referrals reveals an interesting trend. The two referrals with the highest success rate were to obtain a primary physician and insurance, at 100% and 80.0%, respectively. These are services that patients may view as important and are thus more motivated to attend. Our referrals to psychiatry had an intermediate success rate of 45.4%. Furthermore, one referred patient died of cardiopulmonary disease shortly after his referral to psychiatry, so our success rate may actually be as high as 50.0%. Our interpretation of this intermediate success rate is that our patients with psychiatric needs often have limited insight into their problem, and it is likely that only patients with adequate insight and judgment actually attended their appointments. Finally, our success rate of referrals to pain management and chemical dependency were very low, at 33.3% and 10.3%, respectively. We feel that these low success rates are the direct result of the large number of patients in our program having narcotic addiction problems. Rather than wanting treatment for their addiction or receiving opiate narcotics on a set schedule by a pain management physician, we believe that these patients were only interested in obtaining more narcotics. Our experience is that only a small number of our narcotic addiction patients have the motivation and insight to seek treatment and improve their condition.

Radiation exposure

Risks associated with diagnostic imaging are an important issue that EPs must consider when evaluating patients in the ED.[24, 25] EP, both in an effort to rule out life threatening disease and to ensure that no pathology is missed, have become increasingly reliant on diagnostic imaging. Needless to say, frequent users appear to be at an increased risk of radiation exposure given their repeat ED evaluations. Prior to enrollment in the case management program, our group of patients averaged 25.6 CT scans per patient per month, which corresponds to approximately 300 CT studies per patient per year. When followed from the time of their enrollment to the end of the study in November 2008, patients in the case management program averaged 8.1 CT scans per patient per month, which corresponds to approximately 100 CT studies per patient per year. Our case management program thus reduced radiation exposure from CT scans by two-thirds. The reduction in the number of CT studies by 200 per patient per year roughly corresponds to each patient saving about one abdominal CT scan per year. Literature has shown that the average abdominal CT exam has an effective dose of radiation of about 10 mSv, [32] and that the corresponding risk of cancer associated with this dose of radiation is 0.05%, or 1 in 2000.[30,32] Although we reduced radiation exposure by two-third in those patients in our case management program, the number needed to treat (NNT) to prevent one cancer per year is 2,000 patients. However, this NNT is only for one year. Should these same patients remain in the case management program and maintain similar ED use patterns, it is likely that one case of cancer due to diagnostic imaging will be prevented in this group of 85 patients over the next 24 years. Our case management program is ongoing, adding new patients every month. As the number of patients' increases, the number of years needed to prevent one cancer will decrease. Additionally, should a similar case management model be used in other EDs, the number of patients that benefit from reduced radiation exposure will continue to rise.

LIMITATIONS

Our study had several limitations. First, it is limited by a relatively small number of patients enrolled in the program. Second, our retrospective observational study design has inherent limitations. The patients in our study represented the group using emergency services the most, and without randomization it is difficult to exclude regression towards the mean as an explanation for our findings. Third, our selection of patients may have been biased towards those with narcotic use issues, as patients could be enrolled in the case management program simply if staff expressed concerns about a patient. Those with chronic pain or those seeking narcotics are often very difficult to manage, and thus may have been disproportionally enrolled in the program, based upon staff concern. This effect may have been compounded by the fact that inclusion criteria also included notification by the California prescription drug monitoring program.

An additional weakness is that the original program design depended on all patients in case management to be immediately identified upon arrival to the ED to rapidly implement their case management plan. Due to limitations in status board software and staff recognition of patients in the program, patients were not always identified upon presentation. Thus, on rare occasions, patients in case management were not identified at all and given treatment conflicting with their care plan. Similarly, on rare occasions the recognition of patients was delayed until after they had already been given treatment in conflict with their care plan. Such lapses in the case management plan may have encouraged patients to attempt to resume higher frequency of use in the attempt to obtain restricted treatments. However, it is our experience that high frequency use patterns are maintained in only those patients whose case management plans are *consistently* ignored by treating staff. It is for this reason that only the four patients whose plans were repeatedly disregarded were excluded from the analysis.

Finally, as much as we attempted to determine whether or not our program was successful in actually treating patients' chronic problems by comparing chief complaints before and after enrollment, we have no direct measure of patient satisfaction with the program and no measure of the quality of life of our patients before or after enrollment. Many of our patients chose to never return to the department for care or only seek care in the department when emergent conditions arose, which makes their assessment rather difficult. Similarly, our IRB approval was only for a retrospective chart analysis.

DIRECTIONS FOR FUTURE STUDY

While our data shows that the patients in our case management program markedly decreased use of our ED, it is not clear how their use of other healthcare sites changed after enrollment in the program. There are two other community hospitals and one small county hospital within 35 miles of our study site. To improve care of the patients in our community, we plan to work with the surrounding hospitals to both assess frequent use patterns at the surrounding hospitals and create a group case management program. Additionally, our current data do not measure to what extent patient use of primary care resources changed before and after enrollment. We also plan to work more closely with the PMD in the community to assess how our case management program affects the use of primary care resources.

Additionally, our study was limited by the small number of patients enrolled, the inherent limitations of a retrospective analysis, and our lack of assessment of patient satisfaction and quality of life. Given our success with this pilot study, we plan further and more methodologically sound research to better study our frequent users program.

Finally, one of the most important lessons that we have learned in the operation of the case management program is that its success is contingent upon staff compliance with patient plans. As mentioned previously, there were instances in which patients whose plans involved the restriction of narcotics were not recognized, and they were able to obtain narcotics. In these cases, patients returned to the ED multiple times in the following days, ostensibly in hope of obtaining narcotics again. The biggest obstacle we face to improve compliance with case management plans is that our status board software does not display whether or not patients have case management plans. Case management status is only currently listed if a patient is recognized by staff and a note is placed in the comments section under that patient's name. We have been discussing this issue with our software provider in an attempt to resolve this issue and look forward to creating a system in which case management patients are readily identified by all staff in the department.

CONCLUSION

Case management for frequent users of the ED is an effective way to reduce repeat use of emergency services and to reduce radiation exposure from repetitive diagnostic imaging. Furthermore, chronic pain and substance abuse are prevalent issues in ED frequent users and should be considered in the evaluation of these patients.

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Eliminating Amylase Testing from the Evaluation of Pancreatitis in the Emergency Department

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Background: Alterations in serum biomarkers have been used to evaluate for pancreatitis in the emergency department (ED). Studies have shown lipase to be as sensitive and more specific than amylase in diagnosing pancreatitis and that amylase plus lipase does not improve accuracy over lipase alone.

Objective: To determine effects of interventions to decrease ordering of amylase in the evaluation of pancreatitis.

Methods: We conducted a pre- and post-cohort study. The number of amylase and lipase tests ordered in the ED was recorded prior to intervention to establish a baseline. We introduced an educational intervention to order lipase without amylase. A second intervention involved removing amylase from bedside order entry forms. We introduced a third intervention that included deleting amylase from trauma order forms, and decoupling amylase and lipase in the computer ordering system. We recorded the number of lipase and amylase tests in weekly aggregates for comparison to the baseline. Data analysis using students t-test, standard deviation and p values are reported.

Results: Before interventions 93% of patients had both tests ordered. Educational interventions resulted in a decrease to 91% (p=0.06) of co-ordering. Further interventions decreased the percentage of patients evaluated with both tests to 14.3%. This translates into a decrease in patient charges of approximately $350,000 a year.

Conclusion: Using simple structured interventions in the ED can reduce amylase ordering. Educational programming alone was not effective in significantly decreasing amylase ordering; however, education plus system-based interventions decreased amylase ordering. [West J Emerg Med. 2010; 11(4):344-347.]

INTRODUCTION

In the evaluation of abdominal pain in the Emergency Department (ED) serum amylase and lipase levels have historically been measured to evaluate for the diagnosis of pancreatitis. Multiple studies have compared the specificity of amylase and lipase to determine the best biomarker to diagnose pancreatitis.[1,2,3] Lipase has been shown to be as sensitive and more specific than amylase in the evaluation of acute pancreatitis.[4,5,6] Further studies have shown that amylase testing in addition to lipase adds no diagnostic value over lipase alone.[7,8] Despite these findings many physicians continue to order both amylase and lipase in the work up of pancreatitis in the ED. This study attempted to determine the effects of interventions including educational initiatives and

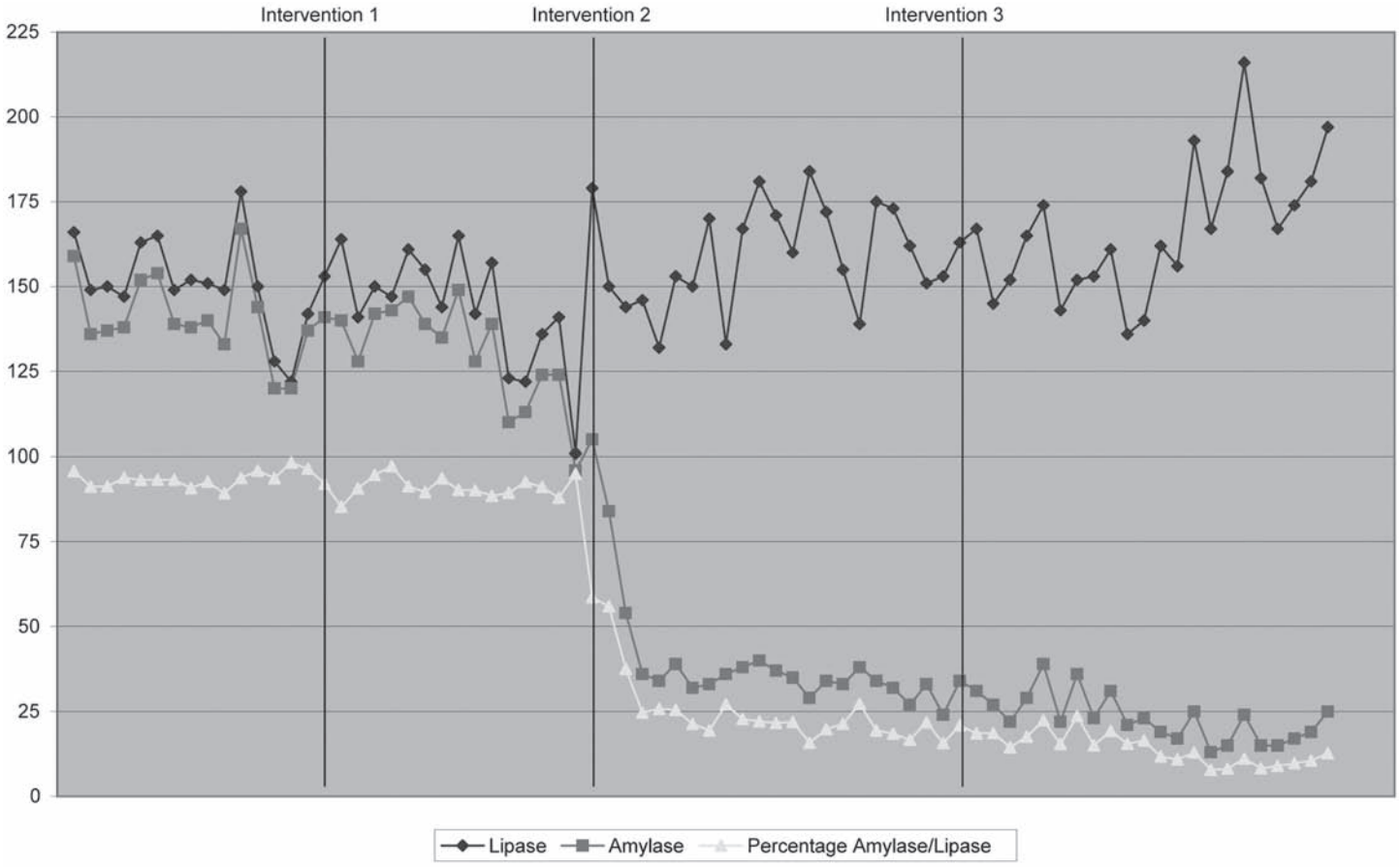

Figure 1. Amylase and lipase in the emergency department.

system changes to decrease unnecessary testing of amylase in the evaluation of pancreatitis in the Emergency Medicine (EM) clinical practice.

METHODS

Study design

A pre- and post-cohort study.

Study setting and population

We conducted the study at an urban academic Level 1 trauma center with over 55,000 annual visits. The hospital is the primary site for an EM residency with 12 residents per year. In addition, residents from medicine as well as interns from obstetrics and surgery rotate through the ED.

Study protocol

Prior to any intervention, we recorded lipase and amylase tests in weekly aggregates over a 15-week period to identify a baseline. An intervention was introduced that included didactic education at weekly mandatory morbidity and mortality conference, as well as at faculty meetings, with instructions to physicians to order only lipase and not amylase in the evaluation of pancreatitis. After 16 weeks we implemented a second intervention that involved removing amylase from bedside paper order-entry forms. Amylase could still be ordered as a write-in laboratory request or added on through a computer order-entry system. After 22 weeks we implemented a third intervention that included deleting amylase from bedside trauma order-entry forms. These are separate order sheets used for patients who arrive to the ED as trauma activations. At the same time we decoupled amylase from lipase in the computer order-entry system, which is used in the ED to add on additional laboratory tests after initial tests are ordered. IRB approval was obtained for this study.

Measurements

After each intervention, we recorded the number of lipase and amylase tests ordered in weekly aggregates and calculated hospital charges of amylase and lipase to determine the savings to the patient.

Data analysis

We analyzed data with students t-test, standard deviation and p values as appropriate. Stata software (StataCorp. 2007. College Station, TX: Stata Corporation) was used.

RESULTS

An average of 150±14 lipase tests and 141±13 amylase tests were ordered per week during the baseline period. An average of 144±17 lipase tests and 131±15 amylase tests

were ordered after the first intervention. After the second intervention an average of 159±17 lipase tests and 40±19 amylase tests were ordered. After the third set of interventions an average of 167±20 lipase tests and 24±7 amylase tests were ordered. The interventions resulted in a statistically significant drop in the number of amylase tests. After the educational intervention, the percentage of lipase tests ordered with amylase fell from 93% to 91%; this was not statistically significant (p=0.06). After the removal of amylase from bedside order forms the percentage of lipase with amylase fell to 25% (p <0.001). Further interventions of removing amylase from trauma bedside order forms and decoupling from electronic forms resulted in a further drop to 14% (p<0.001) (Figure 1). Patients were charged $70 per lipase test and $58 per amylase test with the average charge per patient of amylase and lipase testing $124 before any intervention, $123 after the first set of interventions, and $85 after the second set of interventions. After all interventions, the average charge of pancreatitis lab tests per patient fell to $78, for a reduction of $46 per patient. With approximately 150 of these tests ordered a week this translates into a yearly reduction of charges of over $350,000.

DISCUSSION

Research has demonstrated the difficulty in transferring evidence-based recommendations into clinical practice.[9] In this study we show that it is possible to use simple structured interventions in the ED to decrease unnecessary ordering of amylase in the evaluation of pancreatitis. These simple interventions were instituted with very little cost to the department. Notably we found systems-based inventions (specifically removal of amylase from order-entry forms and decoupling amylase from lipase in a computer order-entry system), in addition to educational initiatives to be more efficacious than educational programming alone. This suggests that physicians are only moderately influenced by educational initiatives that seek to change the ordering of amylase and lipase tests. This is consistent with a review of behavioral interventions by Oxman et al., which demonstrated that dissemination-only strategies, such as conferences, demonstrated little or no changes in health professional behaviors when used alone.[10]

Often initial lab tests are ordered by nursing staff. Although attempts at educational efforts were extended to the nursing staff these were more limited in scope and hampered by the fact that many of the nurses work on a per diem basis or are travelers; therefore, they may not have been exposed to the information, which would be a consistent difficulty in implementing changes in the ED. This could be avoided by system-based approaches similar to our second stage invention. This initiative focused on making the ordering of the test no longer as automatic as it used to be. By removing the amylase box from the order sheet it was no longer possible to simply check down the column of "belly labs" when submitting an order. Amylase could still be written in if it was desired. This second intervention met with much greater success. Based on this success we decided on seeking other order modalities where the amylase was still being ordered to try to further reduce the rate. The test could still be ordered if desired. It simply required a conscious effort. After all interventions, the average cost of pancreatitis lab tests per patient fell from $124 to $78. The total yearly reduction of charges of over $350,000 was achieved with a simple set of interventions that were of little cost and did not place an additional burden on providers.

LIMITATIONS

Our initial intervention was educational and aimed at changing practice patterns by providing physicians and nurses with evidence-based information. The results from this intervention in our study were minimal and we were unable to show a statistically significant change in ordering patterns. There are multiple potential explanations for the ineffectiveness of the educational interventions. A number of off-service rotators work in our ED, and these persons may have been less responsive to the information disseminated, as they would not be present at weekly didactics or morbidity and mortality conferences. In practice educating physicians outside EM rotating through the ED would be a consistent problem in implementing new clinical practices at an academic center.

Our system-based intervention avoids this problem as outside rotators now use the new order-entry sheets that no longer include amylase. This also demonstrates a benefit of systems change as it affects every physician in the ED, while educational efforts will miss physicians who are rotating through the department for a short period of time, on vacation, newly hired, etc.

Further investigations are warranted to determine if our results from this specific intervention can be generalized across other changes in clinical practice. Cost savings may differ at other sites based on different practice patterns and patient population. Implications of this study may include using simple structured and cost effective systems- based interventions to alter clinical practice to become more consistent with evidence-based recommendations in ED evaluations.

CONCLUSION

We conclude that system-based changes, in addition to educational information, are more effective than educational-based initiatives alone in changing clinical practice and can result in significant savings to the system. Systems-based interventions at our institution included oral instructions, deleting amylase from bedside order forms and separating amylase from lipase on the computer order-entry program; however, for this study to be applicable across EDs, interventions should be specific to each ED's protocol for ordering laboratory tests.

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Use of Health Information Technology to Manage Frequently Presenting Emergency Department Patients

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Objective: To determine if the effective use of Health Information Technologies (HIT) and the Electronic Medical Record (EMR) affects emergency department (ED) usage in a complicated frequently presenting patient population.

Methods: A retrospective, observational study of 45 patients enrolled in our Frequent User Program called Community Resources for Emergency Department Overuse (CREDO) between June 2005 and July 2007. The study was conducted at an urban hospital with greater than 95,000 annual visits. Patients served as their own historical controls. In this pre-post study, the pre-intervention control period was determined by the number of months the patient had been enrolled in the program. The pre- and post-intervention time periods were the same for each patient but varied between patients. The intervention included using HIT to identify the most frequently presenting patients and creating individualized care plans for those patients. The care plans were made available through the EMR to all healthcare providers. Study variables in this study intervention included ED charges, lab studies ordered, number of ED visits, length of stay (LOS), and Total Emergency Department Contact Time (TEDCT), which is the product of the number of visits and the LOS. We analyzed these variables using paired T-tests. This study was approved by the institutional review board.

Results: Forty-five patients were enrolled, but nine were excluded for no post enrollment visits; thus, statistical analysis was conducted with n=36. The ED charges decreased by 24% from $64,721 to $49,208 (p=0.049). The number of lab studies ordered decreased by 28% from 1847 to 1328 (p=0.04). The average number of ED visits/patient decreased by 25% from 67.4 to 50.5 (p=0.046). The TEDCT decreased by 39% from 443.7 hours to 270.6 hours (p=0.003).

Conclusion: In this pre-post analysis of an intervention targeting ED frequent users, the use of HIT and the EMR to identify patients and store easily accessible care plans significantly reduced ED charges, labs ordered, number of ED visits, and the TEDCT. [West J Emerg Med 2010; 11(4):348-353.]

INTRODUCTION

The effective and efficient management of frequently presenting emergency department (ED) patients is a challenge for many EDs.[1-12] This group of patients is among the most complicated as they generally have complex medical and social maladies.[1,3-5,7,10,11,13-21] Frequently presenting ED patients have higher incidences of chronic medical conditions, higher overall mortality rates, incur higher healthcare costs, and are admitted more frequently than the overall ED population.[5,6,9,11,14,15,21-25] An extreme example is a report of nine frequently presenting ED patients in Texas who accounted for approximately 2700 emergency room visits and $9,000,000 in healthcare charges over a six-year period.[26] As ED volumes rise and the national debate on healthcare reform

continues, appropriate and efficient care of the frequently presenting ED patient has become a priority.[11,21,27-30]

Previous care models include intensive case management [1,4,11] and care plan implementation strategies.[7,12,19,30,31] These models have demonstrated varying degrees of improved patient care and have varied greatly in terms of staff time and support needed for program success. The effective use of Health Information Technologies (HIT) and Electronic Medical Record (EMR) systems provide EDs new opportunities for more consistent identification and management of frequently presenting patients.[32]

Our approach to this problem was the development of a multidisciplinary, volunteer group. The Community Resources for Emergency Department Overuse (CREDO) committee consisted of an ED attending physician, ED medical social worker, ED mental health social worker, ED psychologist, ED resident, ED clinical nurse specialists, and a student healthcare volunteer. The CREDO team met twice per month to review current and potential patients to refine and create their care plans. CREDO expanded previous care management models by incorporating HIT into the program. Once created and refined, care plans were uploaded into the EMR, allowing universal 24/7 access and guidance for all healthcare providers treating CREDO patients. CREDO patients were "flagged" in the ED Information System (EDIS) to enable immediate implementation of their care plan.

The American Recovery and Reinvestment Act of 2009 (ARRA) has described expectations for increased HIT use throughout healthcare practice. Additionally, the ARRA has called for "multidisciplinary research on system challenges to healthcare delivery" with emphasis on "the measurement of the impact of HIT on the quality and productivity of healthcare".[33] Previous adaptation of HIT has demonstrated improved healthcare quality and productivity.[5, 23, 34-36] Frequent ED users present a healthcare delivery challenge, and because of their mixed medical and social problems, require the input of a multidisciplinary team. Although much more money is spent on these patients, the quality of care they receive may not be optimal. Use of HIT for this patient population is not only directly in line with the goals of the ARRA but also may be the only way to effectively manage this population. By using HIT for our CREDO program, we avoided the use of antiquated paper charts. Problems associated with paper charts include a lack of universal access, a potential for lost information, difficulties in updating, poor security of information, and inconsistent recognition that a plan exists for particular patients. HIT can overcome all these problems, as it has a centralized location, multi-user functionality, immediate access, consistent and easy updating, and can be password protected. Additionally, use of HIT allowed consistency in a large volume (>95,000 visits) urban ED setting. The CREDO initiative, similar to other case management models, relied on care plans devised to manage the needs of frequently presenting ED patients. Through the use of HIT and the EMR, this small committee was unique in that it was able to provide quality, cost-effective care on a more consistent basis than previous models. Our project focused on the rapid identification and availability of their care plan in the EMR. This paper describes our experience using this program and provides outcome measures to reflect its efficacy.

Automated Clinical Practice Guidelines
ER
CREDO BRIEF

MRN:
Patient Name:
Date/Time:

DEMOGRAPHIC
Other MRN(s):
Last Update: 04/7/07
PCP: Unassigned
Insurance: Medicaid (pnd according to careplus)
Has this patient been evaluated by SNAP? No

PAST HISTORY
54 yr old w/ hx of 1) CVA, 2) HTN, 3) GOUTY ARTHRITIS/ PSEUDOGOUT L KNEE. Pt has tested positive for opiates and heroin, cocaine.

CURRENT MEDICAL PROBLEMS
Frequent visits to ER with complaints of Back and knee pain, last knee xray in Feb. 2007 showing tricompartmental osteoarthritis.

MEDICATIONS
Atenolol 50mg
Indomethacin 25mg
Prednisone 10mg
Tylenol #3

ALLERGIES
NKDA

KEY FINDINGS/ LABS/ XRAYS
Multiple knee xrays in 2006 showing tricompartmental osteoarthritis, chondracalcinosis, and suprapatella joint effusion. Normal labs 12/06 including Creatinine 0.7 Joint aspiration revealed calcium pyrophosphate crystals 08/06

TREATMENT PLAN
Medical screening exam by administrative physician. AVOID NARCOTICS Pt needs social work evaluation. PT needs a primary care doctor and need to determine where else patient receives care

SOCIAL ISSUES/ OTHER
Pt given clinic list on visit for 1/17, needs f/u. Pt has not followed up. Pt needs to f/u at Community Health, contact SANP or SW for assistance.

CONSULTANT
Psychiatry: No
Social Work: No
Neurology: No

Figure 1. Sample Community Resources for Emergency Department Overuse (CREDO) note

METHODS

This study of 45 patients enrolled in the CREDO program between June 2005 and July 2007 was conducted at an urban, inner city hospital ED with greater than 95,000 annual visits. It was approved by the hospital Institutional Review Board. We determined patient selection through a quarterly query of the EDIS, EmSTAT (Allscripts, Chicago, IL). The query noted the 100 patients with the most ED visits. Patients older than 18 years old and with the highest number of visits were considered appropriate for enrollment in CREDO. We excluded frequent users with sickle cell anemia since they were managed in a separate and distinct program.

After a patient was selected for the program, a member of the CREDO committee created the CREDO brief. This was a summary of pertinent past medical and social history, including significant laboratory and testing results. It also included individualized specific treatment guidelines as to how to best care for this unique patient. The CREDO brief was then uploaded into the patient's EMR (CarePlus, HFHS) and made available to all patient care providers. All patients in CREDO were reviewed at least monthly (more frequently if necessary) and their CREDO brief was updated. All CREDO patients were "flagged" in the EDIS to communicate this status to providers in the ED.

The study was a retrospective, observational study of ED use. The intervention was the enrollment in CREDO, which included "flagging" patient in the EDIS and creating a CREDO brief in the EMR. Patients who were enrolled in the program served as their own historical controls.

The pre- and post-intervention time period was the same for each patient but varied between patients. The pre-intervention control period was determined by the number of months the patient had been enrolled in the program as of July 2007. For example, a patient enrolled in January 2007 had six months of CREDO activity. The pre-intervention control time period for this patient included the six months prior to enrollment, i.e. July-December 2006.

Demographic data, as well as key medical and social history, were obtained through retrospective chart review. For each patient the pre- and post-intervention end points analyzed were total ED charges, the number of laboratory studies ordered, average length of stay (LOS), total number of visits, and total emergency department contact time (TEDCT). The TEDCT is the product of the number of visits and the LOS. It represents the total amount of time that each patient was in the ED.

We analyzed pre- and post-intervention data using paired t-tests with a p value of <0.05 considered significant. Ninety-five percent confidence intervals (CI) are reported.

RESULTS

Forty-five patients were enrolled in the CREDO program between June 2006 and July 2007. Nine patients with no post-enrollment visits were excluded from the pre- and post-intervention analysis. The demographic data, as well as key medical and social history, were reported for the 36 patient in the final analysis.

Table 1. Characteristics of Community Resources for Emergency Department Overuse (CREDO) patients

Age	18-29	3%(1)
	30-59	86% (31)
	60 +	11% (4)
Sex	Male	75 % (27)
	Female	25 % (9)
Race	African American	89% (32)
	Caucasian	8% (3)
	Other	3% (1)
Marital Status	Single	80% (29)
	Married	3% (1)
	Divorced	8% (3)
	Widowed	6% (2)
	Unknown	3% (1)
Insurance	Medicaid	53 % (19)
	Medicare	33% (12)
	Uninsured	14% (5)
Substance abuse	Yes	89% (32)
	No	11% (4)

Demographic data is presented for these patients in Table 1. The patients in this study were predominantly male, African-American, and single. Most of the patients (84%) had some type of insurance, with only 16% uninsured. The mean age was 48 years with a range 21 to 71 years. The majority had substance abuse problems (89%). Mental illnesses, including depression, schizophrenia, and/or bipolar disorder, were present in 72%. The patients also had a variety of medical co-morbidities including asthma/COPD (44%), diabetes (25%), seizures (28%), and hypertension (64%).

Length of enrollment in CREDO ranged from three to 23 months with an average of 13.0 ± 7.4 months. The results of the CREDO enrollment on the selected endpoints are depicted in Table 2. Using ED charges (not reimbursement) as an indicator, enrollment in the program decreased the costs associated with these patients. There was a statistically significant reduction of $15,513 in the ED charges per patient before and after enrollment (p=0.049, 95% CI -$30943 to -$83). Also shown in Table 2, the number of laboratory studies ordered on each patient decreased from a mean of 1847/patient to 1328/patient after enrollment in the program (p=0.04, 95% CI -1252 to -26).

Although the mean LOS prior to enrollment was 388 minutes and decreased by 46 minutes to 342 minutes after enrollment, this decrease did not achieve statistical significance (p=0.08, 95% CI -98 to 6 minutes). The mean number of ED visits/patients decreased from 67.4 to 50.5 after enrollment in the program (p=0.046, 95% CI -33 to -0.3)

Table 2. Outcomes of Community Resources for Emergency Department Overuse (CREDO) intervention

	Pre-CREDO	Post-CREDO	P value / 95% Confidence Intervals
Total ED Charges	$64, 721 +/- $52,448	$49, 208 +/- $49,239	0.049 (-$30,943 To -$83)
Laboratory Studies Ordered*	1847 +/- 1826	1328 +/- 1191	0.04 (-1252 to -26)
Average Number of ED visits	67.4 +/- 47.4	50.5 +/- 49.0	0.046 (-33 to -0.3)
ED Length of Stay (Minutes)	388 +/- 186	342 +/- 180	0.08 (-98 to 6)
TEDCT (hours)	443.7 +/- 381.7	270.6 +/- 245.8	0.003 (-17072 to -3701)

TEDCT, total emergency department contact time
**The number of lab tests ordered is inflated since each individual lab result reported was counted as an individual laboratory study ordered. For example, the commonly obtained "electrolyte profile" (sodium, potassium, chloride, bicarbonate, blood urea nitrogen, creatinine, and glucose) while ordered as one test was counted in the analysis as seven laboratory studies ordered.*

The mean TEDCT pre-enrollment was 443.7 hours and decreased 39% to 270.6 hours (p=0.003, 95% CI -17072 to -3701). The mean decrease in TEDCT represents 173.1 hours or a mean of 7.21 days less in the ED.

DISCUSSION

The demographic characteristics, medical histories, and social problems of patients enrolled in this study are similar to those previously reported for frequently presenting patients.[1, 5, 11, 14-17, 21] We used a multidisciplinary team approach to create individualized care plans that were readily available in an EMR. Previous studies have used a similar approach but most have lacked the benefit of using the EMR and the EDIS to identify, facilitate, and manage these patients. This approach had a positive effect on the use of ED resources. Together these interventions resulted in a 24% reduction in ED charges, a 28% reduction in labs ordered, and a 25% reduction in the number of ED visits by this group of patients. The 12% reduction in ED LOS did not reach statistical significance. Of particular note was the 39% reduction in TEDCT.

TEDCT represents the total amount of contact time that ED providers have with a patient and thus to some extent reflects the efficiency of care. ED overcrowding leads to resource and supply mismatch and has been recognized as having a negative impact on patient care in the ED.[17,27,32,37-42] Since all patients in the ED are consuming resources to a variable extent, decreasing the TEDCT increases the amount of resources that can be used for other patients. Frequent users can be demanding and difficult to manage and are disproportionate consumers of ED resources.[32] In addition, "flagging" patients at time of registration via the electronic triage system allows the ED staff more consistency in the delivery of care as they can immediately identify these patients as frequent users who have care plans, and then find the care plans in the EMR.[12] The easy identification and accessibility of the CREDO brief led to prompt, efficient care of these patients.

Selection bias has been intrinsic to some previously published reports of frequent user programs.[1,4,7,11,23] In these studies, patients were "referred" to programs in a less objective and more subjective (physician/RN referral) method. Because our program chose patients solely based on number of visits as indicated by the EDIS, selection bias by ED staff is prevented. This also affords a better understanding of the multiple patient issues of this group, as opposed to focusing on problematic patients thought to be medication seeking, homeless etc. Several patients were referred by ED practitioners for inclusion into the program but were not included because they did not meet criteria. However, the use of the quarterly review of EDIS enabled the rapid identification and creation of care plans for patients who suddenly became eligible for the program.

Patient registries and individualized care plans have been used with success in the care of patients with a variety of medical conditions, including congestive heart failure and diabetes.[43,44] The use of such plans as part of the EMR and EDIS in the care of ED frequent users is unique and should be part of the future strategy to manage these patients.

LIMITATIONS AND FUTURE QUESTIONS

A major limitation to our study is the relatively small sample size. While 45 patients were initially enrolled, 20% had no post-enrollment visits. The data presented here are the result of our initial program attempts to combine HIT with managed care plans. The program has continued to expand with over 150 patients currently enrolled.

A second limitation of this study may be related to the natural tendency for ED frequent users to decrease their use over time regardless of intervention.[1,5,11,12,15,17,19,28] This may have contributed to our reduction in number of visits.

However, recent data from our institution indicates a certain subset of the frequent user population remain frequent users over a ten year period (G. Martin, M.D., personal communication, April 30, 2010). Future investigations may elucidate differences in ED use patterns within the group of frequent users.

A related issue is that definition of a frequent user varies across the literature. [3,5,6,9,14,16,19,21,45] While terms such as "super user" and "high frequency user" have been used in the past to describe ED patients, [8] there is no distinct cut-off point to define these categories. Recent studies have used >5 visits / year as criteria for a frequent user, and patients with > 20 visits/yr have been termed "super users" or high frequency users. A consistent approach to the identification of these patients using unbiased objective determinants will aid in their future study and management.

Another limitation is that we collected data only at a single ED, while frequent ED users have a tendency to use multiple EDs within their region.[3, 11,15,17,23] The decrease in number of visits to our institution may have led to increased visits to other institutions. A future goal of the CREDO program is to collaborate with neighboring hospitals to study our enrolled patients' use of other facilities.

The study demonstrated a decrease in ED charges for this group of patients for the study time period. We simply performed a rudimentary cost analysis of total ED charges, not accounting for any changes in supply cost or actual reimbursement. True cost savings cannot be ascertained at this time.

This paper presumes that shorter workups and less repetitive testing of frequent patients are cost effective and thus desirable outcomes. Most would agree with this reasoning. Since we did not follow up with outside institutions, there is a chance that diagnoses were missed due to truncated workups and shortened ED LOS. However, our patients were not only discussed in depth by our multidisciplinary group but also seen multiple times in our ED. As a result, we think the possibility that a significant diagnosis was missed is low.

A final limitation of our study is that the content of the CREDO brief in the EMR served as a treatment recommendation, not a mandate, for providers caring for CREDO patients. While the information was readily available and easily accessible to all providers, we cannot be certain how many providers referenced and followed the briefs' recommendations when caring for the CREDO patients. Future surveys from care providers regarding the use of the care plans may illuminate the reasons why recommendations were/were not followed.

CONCLUSIONS

In this pre-post analysis of an intervention targeting ED frequent users, the EMR allowed for easy efficient identification of frequent users and then provided the healthcare team with a pre-designed care plan for them to follow. The combination of HIT with managed care plans significantly reduced total ED charges, total labs ordered, total number of ED visits, and TEDCT for these patients. It did not have a significant change on ED LOS. The impact of our committee creating care plans on provider and patient satisfaction, or frequency of visits to neighboring ED, remains to be determined.

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Sgarbossa Criteria are Highly Specific for Acute Myocardial Infarction with Pacemakers

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Objective: In 1996 Sgarbossa reviewed 17 ventricular-paced electrocardiograms (ECGs) in acute myocardial infarction (AMI) for signs of ischemia. Several characteristics of the paced ECG were predictive of AMI. We sought to evaluate the criteria in ventricular-paced ECGs in an emergency department (ED) cohort.

Methods: Ventricular-paced ECGs in patients with elevated cardiac markers within 12 hours of the ED ECG and a diagnosis of AMI were identified retrospectively (n=57) and compared with a control group of patients with ventricular-paced ECGs and negative cardiac markers (n=99). A blinded board certified cardiologist reviewed all ECGs for Sgarbossa criteria. This study was approved by the institutional review board.

Results: Application of Sgarbossa's criteria to the paced ECGs revealed the following:
1) The sensitivity of "ST-segment elevation of 1 mm concordant with the QRS complex" was unable to be calculated as no ECG fit this criterion;
2) For "ST-segment depression of 1 mm in lead V1, V2, or V3," the sensitivity was 19% (95% CI 11-31%), specificity 81% (95% CI 72-87%), with a likelihood ratio of 1.06 (0.63-1.64);
3) For "ST-segment elevation >5mm discordant with the QRS complex," the sensitivity was 10% (95% CI 5-21%), specificity 99% (95% CI 93-99%), with a likelihood ratio of 5.2 (1.3 - 21).

Conclusion: In our review of ventricular-paced ECGs, the most clinically useful Sgarbossa criterion in identifying AMI was ST-segment elevation >5mm discordant with the QRS complex. This characteristic may prove helpful in identifying patients who may ultimately benefit from early aggressive AMI treatment strategies. [West J Emerg Med. 2010; 11(4):354-357.]

INTRODUCTION

Establishing the diagnosis of acute myocardial infarction (AMI) in the setting of a ventricular paced rhythm (VPR) is a difficult task and often results in delay of definitive treatment. In a 2001 retrospective cohort study, patients with a VPR were significantly less likely to receive emergent reperfusion and aspirin.[1] These paced patients were noted to have an increased long-term mortality rate when compared with non-paced controls, even after accounting for disease severity.

In the emergency department (ED), the diagnosis of AMI still relies primarily on history and the 12-lead electrocardiogram (ECG). Publications examining the utility of the ventricular paced ECG in the evaluation of acute chest pain have been limited to case reports, case series and review articles.[2-5] Occasionally, the intermittent presence of a native rhythm or progressive ECG changes may aid in the diagnosis of AMI.[6,7] The diagnostic accuracy of the ECG in the absence of these findings, however, has not been thoroughly evaluated.

In 1996 Sgarbossa published a retrospective review of 17 ventricular paced ECGs with AMI confirmed by cardiac biomarkers, compared with 17 ventricular-paced controls.[8] In

this study, several characteristics of the paced ECG were examined for findings that might be predictive of AMI.

Three findings appear to have low sensitivities, but potentially clinically useful specificities: 1) ST elevation >1mm in leads with a predominantly positive QRS (sensitivity 18%, specificity 94%); 2) ST segment elevation of >5mm in leads with predominantly negative QRS (sensitivity 55%, specificity 88%); 3) ST depression >1mm in v1, v2, v3 (sensitivity 29%, specificity 82%).

As this initial study had relatively small numbers (34 total patients), we sought to revisit the sensitivity and specificity calculations by reviewing a larger cohort of patients.

METHODS

This study is a chart review to identify a gold standard with de novo cardiology review of ECGs. The chart review identified existing patient records with paced ECGs who had an AMI. For this study, AMI is defined as a rise/and or fall of cardiac biomarker with at least one value above the most stringent manufacturer recommended cutoff or the suggestion of the hospital laboratory and a discharge International Disease Classification 9 (ICD-9) code of AMI (410.XX). This study was approved by the institutional review board.

The study reviewed records from two sites. Site A is a large tertiary care center with an ED volume of approximately 70,000 visits per year. Cardiologists' reads of ECGs are stored electronically and are searchable. ECGs of interest were identified by searching the text of the readings for "electronic pacemaker." These patients were then searched for a Troponin I greater than 0.8 Ng/ml (normal reference 0.000-0.080 Ng/ml before 2/1/08 and 0.000-0.120 after 2/1/08) within 12 hours of the ECG being performed. The cutoff of 0.8 Ng/ml was chosen as it is the most stringent manufacturer recommended criteria according to the American College of Emergency Physician clinical policies.[9] First, minimum and maximum Troponin I levels and times of the test were recorded. When available, cardiac catheterization information (at the minimum date and time of catheterization) was recorded as well. Controls for Site A were identified in a similar way to those with AMI, except that each control had at least one Troponin I performed, and all Troponin I's performed during that hospital stay were less than 0.080 Ng/ml.

Site B is a large community hospital with an ED volume of 100,000 visits per year. Unlike Site A, Site B does not store their ECG reads electronically. The search strategy for Site B consisted of identifying ED patients with a history of a permanent pacemaker by ICD-9 code (V45.01) recorded at that hospital. These were then searched for a Troponin I greater than 2 Ng/ml (reference range 0.0-0.3 Ng/ml before 5/1/04 and 0.0-0.1 Ng/ml after 5/1/04) within 12 hours of admission from the ED. A Troponin I of >2Ng/ml was defined as abnormal by the hospital laboratory from 8/16/98 onward. ED ECGs are routinely scanned into the medical information system with the ED chart with a unique, searchable code identifying them as ECGs. One abstracter searched all scanned ECGs to identify those whose machine interpretation was a paced rhythm. The abstracter then recorded the first value, minimum and maximum Troponin I values and times of the test.

Controls from Site B were identified in a similar way to those with AMI except that each control had at least one Troponin I performed and all Troponin I's performed during that hospital stay were less than 0.1 Ng/ml.

ECGs were de-identified and given a random number in a sequence. A blinded cardiologist reviewed these ECGs for signs of ischemia according to Sgarbossa criteria. When reproduction of the ECG changed the mV scale, the cardiologist adjusted appropriately (e.g., when the 10mm standard was measured at 8mm secondary to xeroxing adjustment, the 5mm discordance criteria was adjusted to 4mm).

Results were calculated using R (Vienna, Austria) version 2.7.2 with package DiagnosisMed version 0.0.2.[10,11] Microsoft Excel (Redmond, Washington) Version 11.5 was used for summary statistics.

RESULTS

For the ventricular-paced acute myocardial infarction (VPAMI) group, 72 paced ECGs with positive Troponin I were identified from Site A from December 1, 2002 to April 1, 2008. 39 were not coded as acute MI at hospital discharge. This left 33 ECGs from Site A. At Site B, 35 paced ECGs with positive Troponin I were identified from Site A from December 1, 2002 to April 1, 2008. Ten of these were not coded as AMI at hospital discharge. This left 25 ECGs from Site B, for a total of 58 ECGs in the VPAMI group.

For the control group, 101 ECGs with negative Troponin I were randomly selected. 100 was chosen as it was estimated there might be approximately 100 VPAMI ECGs.

When the cardiologist reviewed the ECGs, three were excluded (one control ECG and two ECGs from the VPAMI group) due to the presence of atrial pacers in two ECGs and missing information from lead V4 in an additional ECG. This left 57 ECGs from the VPAMI group and 99 control ECGs. The cardiologist also noted that seven ECGs (four potentially ischemic and three control) were recorded at one-half standard voltage; these were kept in the cohort, but 1/2 voltage Sgarbossa criteria were used. Only one ECG met more than one criteria (Score 3 and 2). This ECG was a control ECG and it was entered twice for data analysis.

The average age and sex distribution in the VPAMI group was 76.0 years with 63% male patients, while the control group averaged 73.8 years with 63% male patients.

Application of the Sgarbossa criteria to the ECGs found the following:

1) The sensitivity of ST-segment elevation 1 mm and concordant with QRS complex was unable to be calculated as none of the VPAMI ECGs fit this criteria.

2) For ST-segment depression 1 mm in lead V1, V2 or V3, the sensitivity was 19% (95% CI 11-31%), specificity 81% (95% CI 72-87%) and likelihood ratio 1.06 (0.63-1.64).
3) For ST-segment elevation >5mm and discordant with QRS complex, the sensitivity was 10% (95% CI 5-21%), specificity 99% (95% CI 93-99%) and a likelihood ratio of 5.2 (1.3 - 21).

DISCUSSION

We evaluated 57 ventricular-paced ECGs admitted and discharged with an elevated serum troponin and an ultimate diagnosis of AMI. This number represents to our knowledge the largest study population to date examining the diagnosis of AMI in the setting of a ventricular-paced ECG. We sought to evaluate the sensitivity and specificity analysis of Sgarbossa using 99 paced ECGs with normal serum troponins as the control group.

Using the criterion of ST segment elevation of 1mm with concordant QRS complex resulted in a sensitivity and specificity that could not be calculated as none of the VPAMI or control ECGs fit this criterion. It was noted to be the most specific finding in Sgarbossa's study (94% specificity) and was thus assigned the highest point value. In our study, the criteria of ST segment elevation >5mm and discordant with the QRS complex had the highest specificity (99%), but a low sensitivity (10%) when compared with Sgarbossa's study (specificity 88% with a sensitivity of 53%). The criteria of ST-segment depression in V1, V2 or V3 had similar test characteristics to Sgarbossa's study (sensitivity of 19%, specificity of 81% compared with a sensitivity of 29% and specificity of 82% in Sgarbossa's study). This criterion's test characteristics make it of limited value given its unacceptably high false positive and false negative rate.

The results of our study indicate that the ventricular-paced ECG is of little diagnostic value in ruling out the diagnosis of AMI using Sgarbossa criteria, but may be helpful in ruling in the diagnosis. Our key finding of applying Sgarbossa's criteria to paced ECGs, specifically the presence of ST segment elevation >5mm in leads with a discordant QRS, shows high specificity (99%) for the diagnosis of acute MI. The low sensitivity of ECG criteria for AMI in this study is consistent with a recent study by Kontos el al. They found that of 1641 patients with AMI, only 22% had diagnostic ST elevation on initial ECG..[12] As prior studies have suggested, possible benefit of early reperfusion with percutaneous intervention in patients with paced ECGs[13,14], the third Sgrabosssa criteria may be most useful in the ED setting to help rapidly identify patients to be considered for this intervention.

LIMITATIONS

Limitations of our study include the retrospective design and data collection. In addition, this study did not address in-hospital or long-term data regarding patient morbidity and mortality. ICD-9 codes and Troponin I values have inherent limitations in the diagnosis of AMI. Therefore, we chose to combine the two to ensure that the diagnosis was accurate. This likely excluded some ventricular- paced patients who had AMIs during the study time period.

Due to problems with reproduction, our sample included four ECGs that did not reproduce at the correct size. These were scaled by the reviewing cardiologist adjusting the criterion measured 10mm standard boxes. These measurements were not tested for inter-observer variability.

CONCLUSION

In our review of ventricular-paced ECGs, the most clinically useful Sgarbossa criterion in identifying AMI was ST-segment elevation >5mm discordant with the QRS complex. This criterion demonstrated a high specificity and low sensitivity suggesting that it may be helpful in identifying patients who could ultimately benefit from early, aggressive AMI treatment strategies. The clinical utility of the aggregate Sgarbossa criterion is questionable.

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Paget-Schroetter Syndrome: Review of Pathogenesis and Treatment of Effort Thrombosis

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Effort thrombosis, or Paget-Schroetter Syndrome, refers to axillary-subclavian vein thrombosis associated with strenuous and repetitive activity of the upper extremities. Anatomical abnormalities at the thoracic outlet and repetitive trauma to the endothelium of the subclavian vein are key factors in its initiation and progression. The role of hereditary and acquired thrombophilias is unclear. The pathogenesis of effort thrombosis is thus distinct from other venous thromboembolic disorders. Doppler ultrasonography is the preferred initial test, while contrast venography remains the gold standard for diagnosis. Computed tomographic venography and magnetic resonance venography are comparable to conventional venography and are being increasingly used. Conservative management with anticoagulation alone is inadequate and leads to significant residual disability. An aggressive multimodal treatment strategy consisting of catheter-directed thrombolysis, with or without early thoracic outlet decompression, is essential for optimizing outcomes. Despite excellent insights into its pathogenesis and advances in treatment, a significant number of patients with effort thrombosis continue to be treated suboptimally. Hence, there is an urgent need for increasing physician awareness about risk factors, etiology and the management of this unique and relatively infrequent disorder. [West J Emerg Med. 2010; 11(4):358-362.]

INTRODUCTION

Effort thrombosis refers to axillary-subclavian vein thrombosis (ASVT) associated with strenuous and repetitive activity of the upper extremities. The earliest description of spontaneous ASVT was by Cruveilhier in 1816, and the first elaborate account was provided by James Paget in 1875.[1,2] In 1894, von Schroetter was the first to identify vascular trauma from muscle strain as a potential etiologic factor.[3] In 1948, Hughes coined the term Paget-Schroetter Syndrome (PSS) and published the first review.[4, 5] PSS accounts for 30- 40 % of spontaneous ASVT and for 10-20 % of all upper extremity deep venous thrombosis (UEDVT). [6] Other important predisposing factors for UEDVT include indwelling hardware (central venous catheter, ports, and pacemakers), occult or overt malignancy and other thrombophilic states. [6-10]

PATHOGENESIS

Effort thrombosis usually follows sporting activities, such as wrestling, playing ball, gymnastics and swimming, which involve vigorous and sustained upper extremity movements.[11] It is believed that retroversion, hyperabduction and extension of the arm involved with these activities impose undue strain on the subclavian vein leading to microtrauma of the endothelium and activation of the coagulation cascade. Substantial evidence now supports the role of anatomical abnormalities involving the thoracic outlet (cervical rib, congenital bands, hypertrophy of scalenus tendons and abnormal insertion of the costoclavicular ligament) in the pathogenesis of effort thrombosis. [11, 12] (Figures 1 and 2 depict the normal/abnormal anatomy of the thoracic outlet.) The narrow costoclavicular space leads to compression of the vein

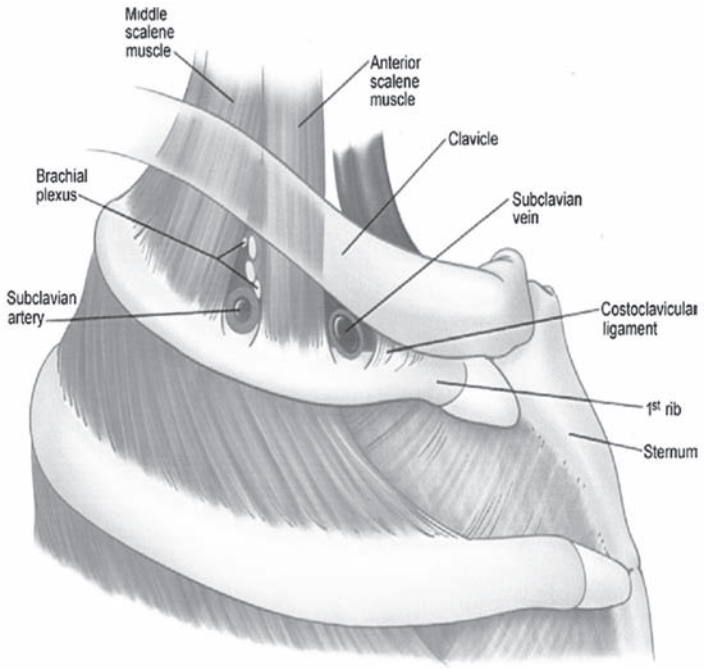

Figure 1. Normal anatomy of the thoracic outlet. *Foot note:* Reproduced with permission from Urschel et al, Ann Thorac Surg 2008;86:254-60 [12] Copyright Elsevier Inc, 2008.

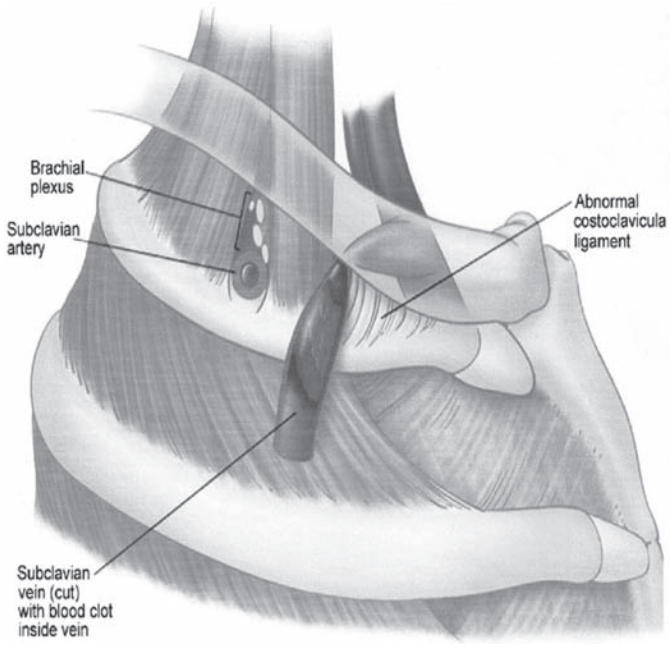

Figure 2. Abnormal lateral insertion of the costoclavicular ligament in Paget-Schroetter syndrome. *Foot note:* Reproduced with permission from Urschel et al, Ann Thorac Surg 2008;86:254-60 [12] Copyright Elsevier Inc, 2008.

and to stasis in the flow. More importantly, it restricts the mobility of the subclavian vein, making it more susceptible to trauma from arm use. These lead to a self-perpetuating cycle of endothelial trauma, thrombosis and recanalization. The repetitive endothelial trauma leads to intimal hyperplasia, inflammation and fibrosis, resulting in venous webs, extensive collateral formation and perivenular fibrosis. This in turn worsens the stasis and costoclavicular crowding. Effort thrombosis has therefore been rightfully categorized as a venous variant of thoracic outlet syndrome. [12, 13]

Some investigators have reported a higher frequency of factor V Leidin, Prothrombin gene mutation and other inherited thrombophilic states in patients with idiopathic UEDVT.[14-16] In fact, in one recent study, Cassada et al. demonstrated that approximately two-thirds of patients with PSS had concurrent thrombophilia. [17] In addition, they showed that concurrent thrombophilia led to increased postoperative complications following corrective surgery. However, others have refuted this association by demonstrating that the frequency of inherited thrombophilias in patients with effort thromboses was comparable to that of the general population. They found that the increased frequency of concurrent thrombophilic disorders was limited to patients with idiopathic UEDVT, which was not effort related.[18] Thus, unlike venous thromboses elsewhere (lower extremities and visceral), the role of inherited and acquired thrombophilic disorders in the development and progression of effort thrombosis is unclear. In summary, costoclavicular crowding due to anatomical abnormalities and repetitive endothelial trauma from muscular strain are the key pathogenic factors in the initiation and progression of effort thrombosis. Inflammation, by leading to perivenular fibrosis and adhesions, seems to play a contributory role in the perpetuation of obstruction. The role of inherited and acquired thrombophilic disorders remains unresolved and needs further investigation.

CLINICAL FEATURES

Not surprisingly, effort thrombosis is more common in young and otherwise healthy men. It preferentially involves the dominant arm. Unlike those with UEDVT secondary to central venous catheters, patients with effort thrombosis are usually symptomatic. Swelling and arm discomfort are the most frequent presenting problems.[12, 13, 19] Other symptoms include heaviness, redness of arm, cyanosis and dilated, visible veins across the shoulder and upper arm (Urschel's sign).[12] Symptom onset is usually acute or sub-acute but an occasional patient can present with chronic symptoms. Not infrequently, symptoms can be nonspecific and can even mimic a muscular strain.[20] A majority of patients report a discrete precipitating event, usually sports-related arm exertion. Occasionally, minor and relatively innocuous day-to-day activities can precipitate effort thrombosis.[11, 12] Complications include pulmonary embolism, post-thrombotic syndrome and recurrent thrombosis.[12, 13] While some investigators report a lower incidence of pulmonary embolism compared to patients with lower extremity DVT

and catheter related UEDVT, others have refuted this.[19, 21, 22] Irrespective of the relative risk, it is important to bear in mind that the risk of pulmonary embolism with effort thrombosis is real and significant. Post-thrombotic syndrome (characterized by pain, heaviness, and swelling), on the other hand, is more frequent in effort thrombosis, compared to secondary UEDVT, and is the major contributor to the morbidity associated with disease.[12, 13, 23, 24] In one recent review, it was shown that up to 45% (15% on average) with UEDVT develop post-thrombotic syndrome.[24] The fact that effort thrombosis preferentially affects young and active individuals makes even minor degrees of residual disability very relevant.

DIAGNOSIS

Notably, the symptoms and signs of UEDVT have poor specificity, and less than 50% of those with suggestive symptoms actually have deep venous thrombosis (DVT).[12, 13, 25] Confirmatory tests are therefore crucial following a presumptive clinical diagnosis.[23, 25] Compression ultrasonography with color Doppler by virtue of its ease, availability, portability and low cost is currently the preferred initial test in the evaluation of suspected UEDVT.[26] Contrast venography has traditionally been the gold standard for the diagnosis of UEDVT. However, invasive nature, high cost, and the accuracy of non-invasive tests have relegated venography to the background.[12, 13, 27, 28] Radionuclide, magnetic resonance and computed tomographic venography are superior to ultrasonography. Magnetic resonance venography has the highest sensitivity (100%) and specificity (97%) among all the non-invasive diagnostic modalities and has the potential to replace digital subtraction angiography as the gold standard.[27] However, the higher cost and limited availability limits the applicability of magnetic resonance venography.[12, 13, 22, 26-28] Conversely, computed tomographic venography is widely available but is associated with risks of radio contrast administration. These tests are therefore second line and reserved for patients with high clinical probability of effort thrombosis and negative ultrasound. Though venography is not necessary for diagnosis, it is almost always done as a part of multimodal treatment strategy to deliver catheter-directed thrombolysis and plan thoracic outlet decompression surgery.[12]

MANAGEMENT

Contemporary management of effort thrombosis varies widely, and there is no broad consensus as to what constitutes the best approach. The relative rarity of the disease, paucity of awareness and lack of large randomized trails are factors contributing to this confusion. For many years patients with effort thrombosis were managed conservatively with limb elevation and anticoagulation alone. However, subsequent long-term data demonstrated an unacceptably high incidence of residual symptoms, disability and recurrent thrombosis with this conservative strategy.[12, 29-31] This has prompted clinicians to devise and evaluate aggressive treatment strategies involving thrombolysis, thrombectomy, percutaneous and surgical venoplasty, venous bypass and stents.

Systemic fibrinolysis is superior to anticoagulation in achieving vein patency but is associated with higher rates of complications such as intracranial hemorrhage.[32] Local catheter-directed thrombolysis has the therapeutic value of systemic thrombolysis without significant systemic side effects and is currently recommended in all patients presenting early.[33] The precise time interval for defining early presentation is unclear. While some authors recommend using fibrinolytics only in patients presenting within two weeks of symptom onset, others have reported fair outcomes even with a delay of about four to six weeks.[12, 34-36] Of note, the success of thrombolysis diminishes as the time from symptom onset to treatment increases, underscoring the need for prompt recognition and treatment.[12] Newer fibrinolytics like alteplase and reteplase have replaced urokinase and streptokinase due to their better safety profile. The duration of treatment and dose of these agents is not standardized and therefore varies among various institutions. Most patients require prolonged infusion of the fibrinolytic agent for catheter directed thrombolysis; average durations varying between 24-48 hours.[33]

Therapy directed at thoracic outlet decompression (TOD) has become an integral part in the management of effort thrombosis with the recognition of the central role of thoracic outlet obstruction. TOD involves resection of the first rib, division of the scalenus muscles and the costoclavicular ligament using either a transaxillary or infraclavicular approach. Some investigators reserve TOD only for patients with persistent or recurrent symptoms following catheter-directed thrombolysis. Lee et al. used this restrictive strategy and reported that less than 25% of patients needed surgery after a mean follow up of 13 months.[37] However, others recommend routine and early TOD in all patients.[36, 38] Suboptimal results with delayed surgery vis-à-vis early surgery; in the form of higher incidence of residual symptoms, disability from post-thrombotic syndrome and recurrent thrombosis, argue in favor of early TOD.[34-36] Controversy remains regarding the best surgical approach to achieve TOD. Some suggest that the anterior, or sub-clavicular, approach is superior because it allows better exposure of the proximal subclavian and innominate veins, thereby ensuring more optimal vein repair.[36] However, others have reported excellent results with the relatively easier transaxillary approach.[12] Either approach can be associated with complications like pneumothorax, bleeding, nerve or arterial injury, underscoring the need for careful patient selection. Moreover, thoracic outlet decompression is a complicated surgery and should be undertaken only by experienced surgeons at centers with expertise in managing patients of effort thrombosis. The need for a detailed discussion with patients regarding

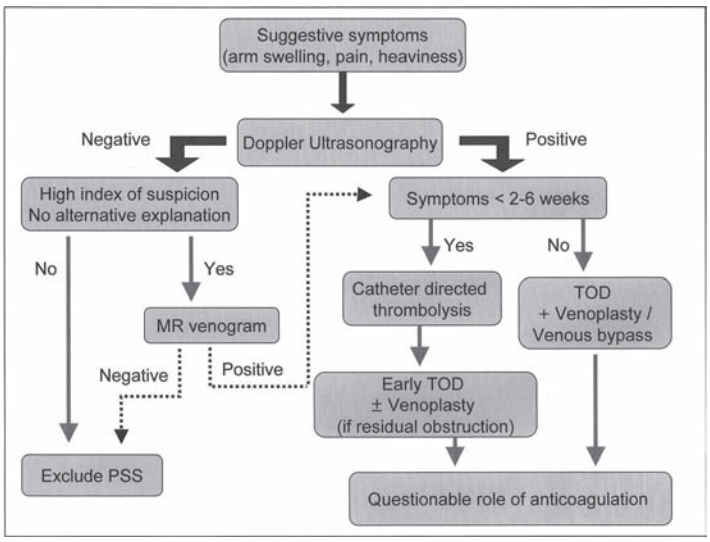

Figure 3. Diagnostic and management algorithm for patients with suspected effort thrombosis.
TOD, thoracic outlet decompression

the risks and benefits of surgery cannot be overstated. So far, definite markers predicting failure of thrombolysis and need for surgery have not been identified. Lee et al. reported that age < 28 years was a predictor of recurrent thrombosis following thrombolysis.[37] However, further validation is awaited. Surgical thrombectomy, balloon venoplasty and stenting have practically been abandoned due to the limited success, high procedural morbidity, and high rates of stent fracture.[12, 36-38] Patch venoplasty and venous bypass have been successfully used in some patients with residual stenosis after TOD.[35, 36] Based on our own experience and review of the literature, we suggest the algorithm in Figure 3 as a guide to the diagnosis and management of patients with suspected effort thrombosis. It is reasonable to seek early surgical (vascular and thoracic) consultation in all young patients with UEDVT especially, in the absence of obvious precipitating factors, such as a central venous line. Finally, the need for and the duration of anticoagulation in patients treated with a combination of catheter-directed thrombolyis and TOD remains unclear. While some authors recommend no anticoagulation when good surgical results are obtained, others prefer anticoagulation for at least two to three months[12, 36] As already mentioned, the role of inherited and acquired thrombophilic states in effort thrombosis is unclear. Nevertheless, it is reasonable to test at least selected patients for these abnormalities as they might help predict postoperative complications, recurrence rates and determine the need for long-term anticoagulation. It appears reasonable to recommend long-term anticoagulation in patients with coexistent thrombophilias and for those presenting late and having suboptimal surgical results. However, the efficacy of this strategy in preventing recurrent thrombosis and alleviating symptoms is unclear and needs further study.

CONCLUSION

In summary, effort thrombosis is a complex and relatively infrequent disorder with a distinct pathogenesis. Most physicians unfamiliar with effort thrombosis manage it similarly to classic lower extremity DVT. Instead, effort thrombosis is ideally managed using a multimodal approach consisting of routine catheter-directed thrombolysis, early TOD in appropriate patients and physical and occupational therapy. Long-term anticoagulation may be reasonable in patients with coexistent thrombophilia and suboptimal surgical results. Increasing awareness among primary care and emergency physicians will ensure early recognition, timely thrombolysis, and prompt referral to a thoracic or vascular surgeon. Future research should focus on defining the benefit of thrombolytic therapy in patients presenting late, identifying factors that predict failure of thrombolysis and need for surgery. Other avenues for research include assessment of the need for and duration of anticoagulation following TOD, and cost benefit analysis of the various treatment strategies.

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Emergency Department Activation of Interventional Cardiology to Reduce Door-to-Balloon Time

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Background: Despite American College of Cardiology (ACC) and American Heart Association (AHA) guidelines, many hospitals have door-to-balloon times in excess of 90 minutes. Emergency Department (ED) activation of interventional cardiology has been described as an important strategy to reduce door-to-balloon time. However, prior studies on ED activation have been in suburban hospitals with door-to-balloon times near the ACC/AHA targeted times.

Objective: To determine if ED activation of interventional cardiology could significantly improve reperfusion times and reach the ACC/AHA target of 90 minutes or less in a safety net hospital, a Level I trauma center and teaching hospital serving primarily uninsured and underinsured patient population with door-to-balloon times ranking in the lowest quartile of United States hospitals.

Methods: In this study, door-to balloon times before and after implementation of ED activation were compared by retrospective chart review.

Results: Eighty patients were included in the study, 48 before and 32 after ED activation of interventional cardiology. Median door-to-balloon time decreased from 163.5 minutes before to 130 minutes after ED activation, a significant difference of 33.5 minutes (p=0.028). Door-to-balloon time on nights, weekends and holidays decreased from a median of 165.5 minutes to 130 minutes, a reduction of 35.5 minutes, which also reached statistical significance (p=0.029).

Conclusion: ED activation of interventional cardiology produced a statistically significant reduction in door-to-balloon time. However, the reduction was not enough to achieve a door-to-balloon time of less than 90 minutes. Safety net hospitals with door-to-balloon times in the lowest quartile nationally may require multiple strategies to achieve targeted myocardial reperfusion times. [West J Emerg Med. 2010; 11(4):363-366.]

INTRODUCTION

Timely percutaneous coronary intervention (PCI) with balloon angioplasty reduces morbidity and mortality of patients with ST-elevation myocardial infarction (STEMI).[1,2] American College of Cardiology (ACC) and American Heart Association (AHA) guidelines recommend that a STEMI patient presenting to the Emergency Department (ED) have door-to-balloon times of 90 minutes or less.[3] The Joint Commission has identified door-to-balloon time of less than 90 minutes as a core measure of healthcare quality.

Despite ACC/AHA guidelines, many hospitals have median door to balloon times in excess of 90 minutes.[4-6] A recent study calculated door-to-balloon time for 365 United States hospitals and found a median door-to-balloon time of 100.4 minutes. More than 15% of hospitals in this study had median door-to-balloon times greater than 120 minutes.[5] An

observational study by the National Registry of Myocardial Infarction examined door-to-balloon times for 13,387 STEMI patients and found a mean time of 113 minutes.[7] Many hospitals have explored strategies to reduce door-to-balloon time, and the ACC/AHA has recently created a campaign for improving reperfusion times called "GAP-D2B: An Alliance for Quality." The goal of this initiative is to increase the percentage of patients in U.S. hospitals receiving PCI within 90 minutes from the current level of 35% to 75%.[8]

An effective yet infrequently used strategy to reduce door-to-balloon time is ED physician activation of interventional cardiology upon identification of a STEMI on electrocardiogram (ECG).[5, 9-14] Commonly, interventional cardiology teams are activated by a cardiology fellow or cardiologist after they have been consulted by the emergency physician (EP).[5] The process of consultation can be time consuming, particularly if the cardiologist is not in the hospital and must evaluate the patient in the ED prior to activating the interventional cardiology team. By allowing the EP to activate the cardiac catheterization laboratory, the time previously used for cardiology consultation is eliminated. Several recent retrospective studies and a survey of U.S. hospitals suggest that ED activation of the catheterization laboratory significantly reduces door-to-balloon time.[5, 9-14]

Several reports in the recent literature documenting improvements in door-to-balloon times due to ED activation of interventional cardiology were conducted in suburban hospitals, with initial reperfusion times at or below the ACC/AHA targets.[9-11] While ED activation has improved door-to-balloon times in these study settings, the results may not be generalizable to all practice environments. The effect of ED activation in hospitals caring for mostly uninsured or underinsured patients, the so-called safety net hospitals, is less clear. The purpose of this investigation was to determine the effect of ED activation of interventional cardiology in a safety net hospital with a ranking in the lowest quartile of U.S. hospitals for reperfusion times.[5]

METHODS

We retrospectively studied patients with STEMI or a new left bundle branch block, presenting to Louisianna State University Health Sciences Center Shreveport ED from November 2004 to May 2009. STEMI was defined by the ACC/AHA ECG criteria as an elevation of the ST segment greater than 1 mm in two or more contiguous leads.[3] The protocol compared door-to balloon times before and after implementation of a policy in October 2006, that allowed ED activation of interventional cardiology. This study was approved by the institutional review board of the sponsoring organization.

Louisianna State University Health Sciences Center Shreveport is a teaching hospital, Level I trauma center and tertiary care center serving a largely uninsured or underinsured patient population. PCI is available 24 hours a day. However, from 5:00 PM to 7:00 AM on weekdays, weekends and holidays (after-hours), the interventional cardiology team must be called from home. Prior to October 2006, the interventional cardiology team could only be activated by a cardiology fellow or cardiology attending physician.

Table 1. ST-elevation myocardial infarction (STEMI) patient demographics for each group, before and after emergency department (ED) activation of interventional cardiology.

Group	Before ED activation	After ED activation	p =
Age (mean)	51	54	0.20
Sex (percentage):			
Male	75%	77%	0.90
Female	25%	23%	
Race (percentage):			
Caucasian	58%	53%	0.70
African American	42%	43%	
Other	0	4%	

We conducted a chart review on each patient presenting to the ED with a STEMI during the 55-month study period. The data collected included a "door time," which was recorded on the nursing record. If a patient had no recorded door or balloon time, they were excluded from the study. Time intervals were calculated separately by two of the authors and any disagreement was settled by consensus.

We separated patient data into two groups, before and after ED activation of interventional cardiology. Patient characteristics, such as age, race, and gender, were compared between the two groups (using a t-test for age and nonparametric analysis for age and gender). We compared median door-to-balloon times in the two groups using nonparametric analysis with a Wilcoxon Mann-Whitney test. Patients were also separated into daytime (Monday-Friday; 7am-5pm) and after-hours subgroups (weeknights 5pm-7am, weekends and holidays) in both the before and after ED activation groups. Subgroup statistical analysis was conducted with nonparametric analysis. A p value of less than 0.05 was considered statistically significant. All statistical analysis was preformed with SPSS 11.0 (Chicago, Illinois) for windows.

RESULTS

During the 55-month study period, we identified 85 STEMI patients of which five were excluded for a missing door or balloon time. There were no subjects identified as receiving emergent catheterization for a new left bundle branch block. We performed data analysis on 80 patients, 48 prior to ED activation of interventional cardiology and 32 after. The two groups were similar in patient characteristics, such as race, age, and gender (Table 1). Median door-to-balloon time for the before and after groups was 163.5 minutes and 130 minutes respectively. Implementation of ED activation of interventional cardiology reduced median door-to-balloon time by 33.5 minutes, which reached statistical

Table 2. Median door-to-balloon times before and after emergency department (ED) activation of the interventional cardiology laboratory.

	Number of subjects	Door-to-balloon time before ED activation (median)	Door-to-balloon time after ED activation (median)	p =
Overall	80	163.5	130	0.028
Nights, weekends, and holidays	50	165.5	130	0.029

significance (p=0.028). Patients presenting during after hours had median door-to-balloon times of 165.5 minutes before and 130 minutes after ED activation of interventional cardiology. This represents a reduction of 35.5 minutes, a result that also reached statistical significance (p=0.029). Despite a significant decrease in median door-to-balloon time, ED activation failed to achieve the ACC/AHA target of 90 minutes or less. Results are summarized in Table 2.

DISCUSSION

EDs of Level I trauma centers and teaching hospitals, the nation's safety net hospitals, are some of the busiest and most crowded in the United States.[15] Moreover, ED crowding has been associated with adverse cardiovascular outcomes, such as delayed door-to-needle time in patients thrombolyzed in the ED for suspected acute myocardial infarction.[16] Thus, measures shown to reduce door-to-balloon time in suburban hospitals with reperfusion times approaching the Joint Commission and ACC/AHA target times may not be effective in all healthcare environments, particularly, safety net hospitals. The purpose of this study was to determine the effect of ED activation of interventional cardiology in a Level I trauma center and teaching hospital with door-to-balloon times in the lowest quartile of U.S. hospitals. Our results demonstrate that ED activation of interventional cardiology significantly reduced door-to-balloon times. However, it failed to reduce the median door-to-balloon time to the ACC/AHA and Joint Commission target of 90 minutes or less.

Failure to reduce door-to-balloon times below 90 minutes through ED activation of interventional cardiology is not unique to this study. Despite statistically significant results, three of six previous studies on ED activation failed to achieve door-to-balloon times of less than 90 minutes.[12-14] In fact, only two studies demonstrated reductions in door-to-balloon times to less than 90 minutes in institutions where reperfusion times were in excess of ACC/AHA recommendations.[10-11]

Accurately defining delays that occur in safety net hospitals may provide strategies to improve door-to-balloon times in similar hospitals nationwide. To achieve this goal it may be useful to separate door-to-balloon times into component intervals. Two important intervals that comprise total door-to-balloon time are door-to-activation time and activation-to-balloon time. EP activation of the interventional cardiology team is a strategy aimed at reducing door-to-activation time. Other steps described in the literature to reduce door-to-activation time include policies for decreasing door-to-ECG time. Unfortunately, these policies appear to have little effect on door-to-balloon time and may not be the best option to decrease reperfusion times in many healthcare environments.[5] Several studies have demonstrated reduction of door-to-balloon times by prehospital activation of the interventional cardiology team.[17]

Another important component of door-to-balloon time is the activation-to-balloon time interval. It has been demonstrated that significant transport delays are associated with a policy of having patients wait in the ED until the catheterization laboratory communicates readiness for patient transport. Hospitals that transport the patient at a set time interval following activation of the catheterization laboratory have significantly shorter door-to-balloon times.[5] Real-time feedback for ED and catheterization laboratory personnel was also recently reported as having a significant effect on overall door-to-balloon times.[5]

Door-to-balloon time in the current study appeared to be influenced by the time of patient presentation to the ED. When the interventional cardiology team is not in the hospital, potential delays may occur in team communication, in transit to the hospital, in setting up necessary equipment, and in patient transport to the catheterization laboratory. Expectations that the interventional cardiology team arrive in the catheterization laboratory within 20 minutes of team activation have been strongly associated with reduction in door-to-balloon times. Thus, further defining reasons for activation-to-balloon delays during after-hours may reduce overall door-to-balloon time in a variety of healthcare environments.

LIMITATIONS

There are several limitations of this study. For example, retrospective studies generally demonstrate associations rather than causation and therefore generate less meaningful results than prospective, randomized trials. Chart reviews are also limited by inaccurate or incomplete records. Most data points used in this study came from nursing notes or physician's documentation, which are subject to human error and bias. Bias can also be introduced as investigators interpret absent or conflicting data. The authors attempted to limit bias by using a standardized data collection method with uniform handling of missing or conflicting data and by having the authors independently review many of the same charts. Further, five patients were excluded from data analysis for missing door or balloon times. This study may also be limited by a small

number of patients enrolled. However, previous studies such as Jacoby et al.[11], Singer et al.[12] and Kraft et al.[14] were also small with only 44, 88 and 97 patients respectively. All three of these studies were able to demonstrate statistically significant reductions in door-to-balloon time despite their small patient enrollment.

CONCLUSION

The results of this study and review of the literature suggest that ED activation of the interventional cardiology team may not be sufficient to reduce door-to-balloon times below the ACC/AHA goal of 90 minutes in all healthcare environments. Although not proven in this study, it is possible the nation's safety net hospitals require other strategies in addition to ED activation of interventional cardiology to reduce overall door-to-balloon times and improve myocardial reperfusion.

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Therapeutic Hypothermia Protocol in a Community Emergency Department

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Objectives: Therapeutic hypothermia (TH) has been shown to improve survival and neurological outcome in patients resuscitated after out of hospital cardiac arrest (OHCA) from ventricular fibrillation/ventricular tachycardia (VF/VT). We evaluated the effects of using a TH protocol in a large community hospital emergency department (ED) for all patients with neurological impairment after resuscitated OHCA regardless of presenting rhythm. We hypothesized improved mortality and neurological outcomes without increased complication rates.

Methods: Our TH protocol entails cooling to 33°C for 24 hours with an endovascular catheter. We studied patients treated with this protocol from November 2006 to November 2008. All non-pregnant, unresponsive adult patients resuscitated from any initial rhythm were included. Exclusion criteria were initial hypotension or temperature less than 30°C, trauma, primary intracranial event, and coagulopathy. Control patients treated during the 12 months before the institution of our TH protocol met the same inclusion and exclusion criteria. We recorded survival to hospital discharge, neurological status at discharge, and rates of bleeding, sepsis, pneumonia, renal failure, and dysrhythmias in the first 72 hours of treatment.

Results: Mortality rates were 71.1% (95% CI, 56-86%) for 38 patients treated with TH and 72.3% (95% CI 59-86%) for 47 controls. In the TH group, 8% of patients (95% CI, 0-17%) had a good neurological outcome on discharge, compared to 0 (95% CI 0-8%) in the control group. In 17 patients with VF/VT treated with TH, mortality was 47% (95% CI 21-74%) and 18% (95% CI 0-38%) had good neurological outcome; in 9 control patients with VF/VT, mortality was 67% (95% CI 28-100%), and 0% (95% CI 0-30%) had good neurological outcome. The groups were well-matched with respect to sex and age. Complication rates were similar or favored the TH group.

Conclusion: Instituting a TH protocol for OHCA patients with any presenting rhythm appears safe in a community hospital ED. A trend towards improved neurological outcome in TH patients was seen, but did not reach significance. Patients with VF appeared to derive more benefit from TH than patients with other rhythms. [West J Emerg Med. 2010; 11(4):367-372.]

INTRODUCTION

In the United States, the incidence of out-of-hospital cardiac arrest (OHCA) is increasing, with approximately 166,200 patients suffering OHCA annually.[1] Survival among resuscitated patients remains low, and the majority of survivors have a poor neurological outcome. [2,3] Recently, aggressive post-resuscitation care has been recognized as an important link in the cardiac arrest chain of survival. Therapeutic hypothermia (TH) was used to treat patients resuscitated from cardiac arrest during the 1950s;[4] however, complications related to the depth of cooling led to this treatment being abandoned. Positive outcomes from animal studies in the 1990s, rekindled interest in this treatment modality.[5] TH is postulated to mitigate the effects of ischemia

and reperfusion injury by decreasing cerebral metabolism, suppressing the release of oxygen free radicals and excitatory neurotransmitters, and by decreasing the inflammatory response. [6,7] In 2002, two randomized controlled trials evaluated the effect of mild TH on comatose patients resuscitated after ventricular fibrillation OHCA and demonstrated improvements in survival and neurological outcome. [8, 9] Currently, both the International Liaison Committee on Resuscitation (ILCOR) and the American Heart Association (AHA) recommend the use of TH in the treatment of persistently comatose patients resuscitated after ventricular fibrillation OHCA. [10, 11]

A number of studies published since 2002 support the use of TH after cardiac arrest, but only one was conducted solely at a community hospital.[12-18] Also, few data have been published on patients treated with TH after presenting with rhythms other than non-perfusing ventricular fibrillation or ventricular tachycardia (VF/VT); consequently, firm conclusions cannot be drawn about the benefits of TH in these other populations.[9, 19-22]

In November 2006, we began to treat comatose patients resuscitated from OHCA with TH, regardless of their presenting rhythm. We hypothesized that establishing this protocol in our community hospital emergency department (ED) would decrease mortality and improve neurological outcome in these patients without increasing complication rates. The primary aim of our study was to assess the impact of our TH protocol on in-hospital mortality by comparing the mortality rates of treated patients with those of control patients from the preceding 12 months. Secondarily, we evaluated the neurological status upon hospital discharge and complication rates of both groups.

METHODS

Study Design

We conducted a retrospective, observational study of the mortality of patients resuscitated from OHCA in our ED from November 2006 through November 2008. The control group consisted of patients treated in our ED during the preceding 12 months, prior to the implementation of our TH protocol. This study was approved by the hospital's Institutional Review Board, with a waiver of informed consent.

Study Setting and Population

This study was conducted at a large tertiary care suburban community hospital with over 85,000 ED visits annually and nearly 700 inpatient beds.

Study Protocol

For our TH protocol we use an endovascular cooling catheter (ICY Catheter, IC-3893, Alsius, Irvine CA) with the goal to cool the patient to a target temperature of 33 °C within four hours. The Alsius ICY catheter is only intended for placement in the femoral vein. No patients were given cold intravenous saline. Our protocol advises using ice packs if the target temperature is not reached in four hours, but their use was not routinely noted in the medical record. Temperatures are monitored with a rectal or esophageal temperature probe. Patients are cooled for 24 hours from the onset of cooling, and then actively re-warmed at a rate of 0.5 °C/hour to a goal temperature of 36.5 °C using the endovascular catheter. Shivering is prevented with sedative medications, such as propofol, lorazepam and fentanyl; paralytics are added only if sedatives are ineffective. Vital signs are measured every 30 minutes until the goal temperature is reached and then every two hours. At the onset of cooling and at eight and 16 hours, blood tests and a 12-lead ECG is performed. The blood tests include a complete blood count, metabolic panels, coagulation studies, cardiac enzymes and arterial blood gas. Additionally, two sets of blood cultures are obtained at eight hours. Other testing and treatments are at the discretion of the treating physicians. Patients treated with TH are eligible for percutaneous coronary intervention (PCI) and anti-coagulation. Decisions regarding withdrawal of care are made by the primary physician or intensivist, usually in consult with a neurologist, but do not follow a standardized protocol. Study investigators are not involved in end-of-life decisions.

Patients were eligible for treatment with TH if they were 18 years of age or older and remained unresponsive to verbal stimuli following return of spontaneous circulation (ROSC) after cardiac arrest. Patients with any initial rhythm and with witnessed or unwitnessed arrest were eligible. Exclusion criteria were pregnancy, a systolic blood pressure less than 90mmHg despite the use of vasopressors, traumatic injuries, an initial temperature less than 30°C, a primary intracranial event determined by physician judgment, and known pre-existing coagulopathy. Eligible patients were treated with TH at the discretion of the treating physician.

We identified patients primarily by searching records from our ED automated medication and supply management machine for documentation that an endovascular cooling catheter had been dispensed. To ensure that we located all eligible patients, we also searched the diagnosis field of our ED's electronic medical record (EMR) using the key words: arrest, vfib, vtach, fibrillation, ventricular, asystole, and PEA (pulseless electrical activity).

We identified patients in our control group by searching our EMR diagnosis field for the same keywords. The charts extracted were reviewed to determine if the patients treated before the institution of our TH protocol met the same inclusion and exclusion criteria as our study group and survived to hospital admission.

Measurements

We created a standardized abstraction form for data collection prior to the start of the study. The data collected included patient demographics, hospital length of stay (LOS), survival to hospital discharge, initial recorded arrest rhythm,

Table 1. Summary of complications in the TH-treated patients.

	Therapeutic hypothermia		Control	
	% (n) or median	95% CI or IQR	% (n) or median	95% CI or IQR
Mortality	71.1% (27)	56% to 86%	72.3% (34)	59% to 86%
CPC 1 - 2 at discharge	8% (3)	0% to 17%	0 (0)	0% to 8%
Length of stay (days)	4.5	2 to 11.5	2	1 to 8
Mortality, VF/VT subgroup	47% (8)	21% to 74%	67% (6)	28% to 100%
CPC 1 - 2 at discharge, VF/VT subgroup	18% (3)	0% to 38%	0 (0)	0% to 30%
Complications				
Bleeding	16% (6)	4% to 28%	32% (15)	18% to 46%
Pneumonia	21% (8)	7% to 35%	26% (12)	13% to 38%
Sepsis	24% (9)	10% to 38%	40% (19)	26% to 55%
Renal failure	5% (2)	0% to 13%	6% (3)	0% to 14%
Pulmonary edema	24% (9)	10% to 38%	19% (9)	7% to 31%
Seizures	13% (5)	2% to 24%	17% (8)	6% to 28%
Arrhythmias	18% (7)	6% to 31%	49% (23)	34% to 64%

CPC, Cerebral Performance Category; *VF/VT*, ventricular fibrillation/ventricular tachycardia; *CI,* confidence interval; *IQR, interquartile range*

and neurological status at discharge using the Glasgow-Pittsburgh Cerebral Performance Category (CPC). We determined the CPC by chart review. Abstractors were not blinded to the patient's treatment group if it was specified in the inpatient chart. We also recorded complications during the first 72 hours, using pre-determined definitions. These included the rate of significant bleeding (requiring transfusion, or surgical or gastroenterological consultation), sepsis (meeting systemic inflammatory response syndrome criteria plus documented infection or positive culture), pneumonia (infiltrate on chest radiograph or clinical diagnosis recorded on chart), renal failure (new use of dialysis or continuous renal replacement therapy), and arrhythmias (requiring medical or electrical therapy) in the first 72 hours.

Chart abstractors met at the start of the study to define methods and were unaware of patient outcomes when abstracting data from ED records.

Our primary outcome was in-hospital mortality. Our secondary outcomes were neurological status on hospital discharge and complication rates.

Data Analysis

For the study group, our analysis of outcomes includes all patients for whom we initiated our TH protocol, regardless of whether the target temperature was reached, cooling was halted, or the patient died before hospital admission. We did not include patients who had ROSC during the study period but did not have TH initiated, even if they met inclusion and exclusion criteria. Demographic and clinical characteristics are described by means with 95% confidence intervals (CI) for normally distributed data and by medians with interquartile range (IQR) for non-normal data. We compared the mortality of each of the two groups with 95% CI, and compared the unadjusted mortality between the two cohorts with the $\chi 2$ test. We considered values of $p < 0.05$ to be statistically significant. Analyses were performed using SPSS version 15.0 (SPSS Inc., Chicago, IL).

RESULTS

Seventy-two patients with ROSC survived to hospital admission during our study period. Of these, 34 were eligible for TH but were not cooled for the following reasons: catheter could not be placed (n=7), co-existing infection (n=4), poor baseline health (n=4), deemed too unstable (n=3), do-not-resuscitate status (n=2), cooling unit in use for another patient (n=1), various (n=6) or unrecorded reasons (n=6). Reasons for catheter placement failure included the large size of the catheter, thrombus in the vein, contractures, skin breakdown and body habitus. Of the six patients with various reasons recorded, two had respiratory arrest followed by cardiac arrest, which likely was interpreted as a contraindication for TH; one had pulmonary embolism; one had suspected aortic dissection; one was transported for emergent PCI before the TH catheter was placed; and one patient was not treated due to "unknown baseline mental status."

The remaining 38 patients were treated with our TH protocol. We were unable to determine time-to-target temperature in 13 patients (34.2%), either because the patient's temperature was not recorded after the cooling catheter was placed or because the time of initiation of TH was not clearly documented. In the remaining 25 patients the median time to reach the target temperature was 240 minutes (IQR 115 min to 405 min).

Table 2. Baseline characteristics of patients.

	Control % (n) or median (IQR)	Therapeutic hypothermia % (n) or median (IQR)	*P* value
Gender (male)	57% (27)	55% (21)	0.840
Age (years)	75 (60 - 83)	74.5 (60 – 81)	0.521
Diabetes mellitus	42.6 % (20)	42.1% (16)	0.967
Hypertension	61.7 % (29)	63.2% (24)	0.890
Coronary artery disease	42.6% (20)	42.1% (16)	0.967
Prior CVA	14.9% (7)	13.2% (5)	0.819
Renal failure	8.5% (4)	15.8% (6)	0.300
Congestive heart failure	31.9% (15)	15.8% (6)	0.087
Cancer	19.1% (9)	5.3% (2)	0.058
On warfarin	21.3% (10)	13.2% (5)	0.329
Presenting rhythm			
VF/VT	19.2% (9)	44.7% (17)	0.008
Asystole	36.2% (17)	31.6% (12)	0.068
PEA	42.6% (20)	23.7% (9)	0.657
Other	2.1% (1)	0	0.366
Witnessed arrest	53.2% (25)	52.6% (20)	0.959

CVA, Cerebral Vascular Accident; *VF/VT*, ventricular fibrillation/ventricular tachycardia; *PEA*, pulseless electrical activity; *IQR,* interquartile range

For patients treated with TH, the mortality rate was 71.1% (95% CI 56% to 86%) with an odds ratio of 0.94 (95% CI 0.36 to 2.42). Eight percent (95% CI 0% to 17%) had a good neurological outcome (defined as a Glasgow-Pittsburgh CPC score of 1 or 2) on hospital discharge. The initial documented rhythms in this group were VF/VT in 44.7% (n=17), PEA in 31.6% (n=12), and asystole in 23.7% (n=9). The arrest was witnessed in 20 patients (52.6%). The median age was 74.5 (IQR 60 – 81) years; the median hospital LOS was 4.5 (IQR 2 – 11.5) days; and 55% were male (Tables 1 and 2). Five patients (13.2%) did not complete the protocol.

Complications in the TH-treated patients were as follows: bleeding in six [16% (95% CI 4% to 28%)]; pneumonia in eight [21% (95% CI 7% to 35%)]; sepsis in nine [24% (95% CI 10% to 38%)]; renal failure in two [5% (95% CI 0% to 13%)];arrhythmias in seven [18% (95% CI 6% to 31%)]; and seizures in five [13% (95% CI 2% to 24%)] (Table 1).

Our control group included 47 patients, with a mortality rate of 72.3% (95% CI 59% to 86%). None (95% CI 0% to 8%) had a good neurological outcome on hospital discharge. The presenting rhythms of the control group were VF/VT in 19.2% (n=9), PEA in 36.2% (n=17), asystole in 42.6% (n=20), and 2.1% documented as slow wide complex (n=1). Cardiac arrest was witnessed in 25 (53.2%) patients. The median age was 75 (IQR 60 to 83) years, the median hospital LOS was two (IQR 1 to 8) days, and 57% were male (Tables 1 and 2).

Complications in the control group were as follows: bleeding in 15 [32% (95% CI 18% to 46%)]; pneumonia in 12 [26% (95% CI 13% to 38%)]; sepsis in 19 [40% (95% CI 26% to 55%)]; renal failure in three [6% (95% CI 0% to 14%)]; arrhythmias in 23 [49% (95% CI 34% to 64%)]; and seizures in eight [17% (95% CI 6% to 28%)] (Table 1).

Of the 17 patients treated with TH whose initial documented rhythm was VF/VT, mortality was 47% (95% CI 21% to 74%). We observed good neurological outcome in 18% of these patients (95% CI 0% to 38%). Of the nine in the control group with an initial documented rhythm of VF/VT, mortality was 67% (95% CI 28% to 100%). Good neurological outcome was seen in none of these patients (95% CI 0% to 30%) (Table 1).

The mortality rate for all 72 patients who had ROSC and survived to hospital admission during the study period was 70.8% (95% CI 59% to 80%). The 34 patients who met the inclusion and exclusion criteria for TH but were not treated had a mortality rate of 70.6% (95% CI 17% to 46%). Four of these 34 patients who were eligible but not treated with TH had an initial documented rhythm of VF/VT.

DISCUSSION

The mortality rate of patients treated with our TH protocol was not significantly different from that of our control patients; however, we did find a non-statistically significant trend towards improved neurological outcomes in the TH group. Complication rates were also not significantly different between the two groups, although there was a trend towards more bleeding, sepsis and arrhythmias in the control group. In

patients with an initial rhythm of VF/VT, there was a trend towards improved mortality and neurological outcomes in the group treated with TH.

The number of published studies supporting the use of TH in the setting of resuscitated cardiac arrest continues to grow. [12-15, 16, 17] A recent review of studies of patients treated with TH after ROSC from any presenting rhythm concluded that its use improved survival and favorable neurological outcome with an odds ratio of 2.5 for both measures; of note**,** only one of the included studies was performed at a community hospital.[23] In other studies including all rhythms, much of the survival and neurological outcome benefit was limited to patients presenting with VF/VT cardiac arrest. [16, 17, 24] However, a recent study by Nielsen et al. reported a more dramatic effect of TH in non- VF/VT rhythms. Twenty-one percent of patients with an initial rhythm of asystole and 22% with PEA were discharged with good neurological outcome.[25]

Our overall survival rates and numbers of patients discharged with favourable outcomes were low compared to the landmark trials by Bernard and the HACA group.[8, 9] Unlike those trials, we included patients with any presenting rhythm as well as patients with unwitnessed cardiac arrest. In addition, the median age of our patients was 10-15 years greater. [8, 9] All of these factors would be expected to lower survival rates.

Some decrease in the rate of favourable outcomes is not uncommon when a therapy is initially studied in a community hospital setting. [24] The one other published study performed at a community hospital demonstrated a lower mortality rate (61%) and higher rate of discharge with good neurological outcome (33%).[18] Their study population was younger (mean age of 62 compared to a median age of 75); they did not specify presenting rhythms and used a different neurological outcome scale. These factors limit the ability to compare the outcomes between studies.

Although our study did not find a statistically significant benefit from TH, our sample size was small, increasing the likelihood of a type 2 error. The percentage of patients presenting with VF/VT was low in our study compared to others that included all rhythms, which may have depressed the expected treatment benefit.[16, 17, 24] In patients with VF/VT, where the evidence of benefit from TH is stronger, our point estimates show an improvement in the incidence of good neurological outcome from 0 to 18%. If this effect was borne out with a larger sample size, the use of a TH protocol would be justified. The published evidence of benefit for rhythms other than VF/VT is not as robust, and none was found in our study.

ILCOR and the AHA recommend the use of TH in unresponsive patients resuscitated after ventricular fibrillation OHCA. It is estimated that an additional 2,298 patients per year in the United States would have a good neurological outcome if TH was fully implemented in comatose survivors of OHCA. [26]Despite this recommendation, TH continues to be underused. In a 2005 survey of emergency physicians, cardiologists and critical care specialists involved in post-resuscitation care, 74% of United States respondents had never used TH.[27] Commonly cited reasons for not using TH included "not enough data", "not part of Advanced Cardiac Life Support Guidelines", "have not considered cooling therapy", and "too technically difficult to use."[27] In developing our TH protocol, we encountered these same barriers to implementation despite significant educational efforts for our physicians and nurses. In the present study, 14 of 34 potentially eligible patients were not treated with TH for reasons that were not clearly documented, and seven of the 34 were not cooled because placement of the endovascular catheter was unsuccessful.

LIMITATIONS

There are a number of limitations to our study, including its being limited to a single institution with a small sample size. We chose to evaluate in-hospital mortality and neurological outcome at the time of hospital discharge rather than longer-term survival and disability. We used the Glasgow-Pittsburgh CPC as our neurological outcome measure. The CPC has been criticized for being a relatively gross assessment tool;[28] however, it still is a standard outcome measure used in resuscitation research. Our protocol and study design designated the use of an endovascular catheter for cooling, thus limiting our ability to generalize our results to institutions using alternative cooling techniques. The 2005 AHA guidelines for emergency cardiovascular care were published before the period of our historical controls, and no other significant changes in ED resuscitation were implemented during our study. However, the medical and cardiac intensive care units (ICUs) at our hospital became closed units in June 2008, which may have impacted the care of TH patients in the ICU as compared with historical controls. Our hospital does not have a standardized protocol for comprehensive post-resuscitation care, although some protocols, including emergent PCI and maintenance of euglycemia, do exist.

Although our control and study groups did not differ statistically with regard to baseline characteristics, the control group did contain more patients with congestive heart failure and cancer. In addition, there were statistically fewer control patients who presented with VF/VT as opposed to other rhythms in comparison to the study population. Both factors likely favor the group treated with TH.

CONCLUSION

Although we demonstrated a trend towards improved neurologic outcomes in patients treated with TH as compared with historical controls, we found no overall difference in mortality. In patients with an initial rhythm of VF/VT, those treated with TH showed a trend towards improved mortality and neurologic outcomes. Our TH protocol appears safe,

as we found no significant difference in complication rates between patients treated with TH and historical controls. Large collaborative descriptive studies of TH are now needed especially involving non-university institutions and patients with presenting rhythms other than VF/VT.

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Systemic Inflammatory Response Syndrome Predicts Mortality in Acute Coronary Syndrome without Congestive Heart Failure

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Introduction: High levels of inflammatory biochemical markers are associated with an increased risk among patients with acute coronary syndrome (ACS). The objective of the current study was to evaluate the prognostic significance of the systemic inflammatory response syndrome (SIRS) among ACS patients with no clinical or radiological evidence of congestive heart failure (CHF).

Methods: Consecutive patients with ACS and no clinical or radiological evidence of CHF in the emergency department (ED) were included in the study. The endpoint was hospital mortality. Categorical variables were compared by calculating proportions with 95% confidence intervals (CIs) and by using the Fisher Exact test. Continuous variables were compared by using the Wilcoxon Rank Sum test. The association of the variables with hospital mortality was assessed by using the logistic regression analysis.

Results: The study included 196 patients (60 years; female 32.6 %). Six patients (3.1 %) died in hospital and 22 patients (11.2 %) had SIRS on admission to the ED. The following variables were predictors of hospital mortality: age with an odds ratio (OR) of 1.1 (95% CI, 1-1.2) for each one additional year ($p < 0.01$), systolic arterial pressure with an OR 0.9 (95% CI, 0.9-1), diastolic arterial pressure with an OR 0.9 (95% CI, 0.8-1) for each one additional mmHg ($p < 0.01$), respiratory rate with an OR 1.5 (95% CI, 1.2-1.9) for each one additional breath per minute ($p < 0.01$), and SIRS with an OR 9 (95% CI, 1.7-47.8) (p 0.02). Because of the small number of events, it was not possible to assess the independence of these risk factors.

Conclusion: SIRS was a marker of increased risk of hospital mortality among patients with ACS and no clinical or radiological evidence of CHF. [West J Emerg Med. 2010; 11(4):373-378.]

INTRODUCTION

There is increasing evidence supporting the pathogenic role of inflammation in acute coronary syndrome (ACS).[1-4] The local inflammatory process at the coronary artery plaque may cause the release of cytokines and other inflammatory acute-phase reactants into the circulation.[5] Indeed, some evidence suggests that an independent systemic inflammatory process, apart from the local one, may also be involved in the pathogenesis of ACS.[6] Clinical manifestation of systemic inflammation is known as systemic inflammatory response syndrome (SIRS), which may be seen in infections and a variety of other conditions.[7,8] The diagnosis of SIRS is based on heart rate, respiratory rate, body temperature, and leukocyte count.[7]

Effective triaging of ACS patients is one of the main subjects of investigation in emergency medicine. One investigation line focuses on the subjacent inflammatory process as a prognostic factor. It has been demonstrated that high plasma levels of inflammatory biochemical markers are associated with an increased risk of major cardiac events in

ACS patients.[5, 9–11] However, while these biochemical markers are not routinely available in the emergency department (ED), SIRS may be easily assessed in almost every ACS patient. We hypothesized that SIRS could be a prognostic marker among ACS patients. Since tachycardia and tachypnea, two of the diagnostic criteria of SIRS, are strongly associated with congestive heart failure (CHF),[12] we excluded ACS patients with clinical or radiological evidence of CHF.

The objective of the current study was to evaluate SIRS in the ED as a predictor of hospital mortality among ACS patients with no clinical or radiological signs of CHF.

METHODS

Study design

This prospective cohort study included ACS patients consecutively admitted to the ED between February 2003 and January 2004. The study was approved by the local Institutional Research Board. The outcome was hospital mortality.

Study setting and population

The study was conducted in an urban teaching hospital with 13 ED beds. The ED sees more than 86,000 patients per year. Consecutive patients aged more than 21 years old with confirmed diagnosis of ACS were enrolled in the study. All patients provided an informed consent. Patients with clinical or radiological signs of CHF were excluded from the study.

Study protocol

Medical history, physical exam, a 12-lead electrocardiogram, leukocyte count in peripheral blood and a chest radiograph were performed in every patient. The electrocardiogram was repeated in case of recurrent symptoms. Leukocytes were counted by using an automated cell counter as per standard laboratory techniques. Each patient had two or more determinations of plasma cardiac troponin I, one of them performed at least 12 hours after the onset of the symptoms. Cardiac troponin I concentrations were measured by chemiluminescence assay, using an ACS: 180 automated analyzer (Bayer Diagnostics™) with a detection limit of 0.1 ng/ml and a cut-off value for myocardial necrosis of 0.5 ng/ml. Other diagnostic procedure and therapeutic strategies were decided by the medical team in charge of the patient. Data collection forms included medical history, clinical examination on admission to the ED and complementary tests (laboratory assays, stress test, myocardial perfusion test or coronary angiography) performed during hospitalization.

SIRS was defined by the presence of at least two of the following criteria: 1) heart rate >90 beats/minute, 2) respiratory rate >20 breaths/minute, 3) body temperature >38°C or <36°C, and 4) leukocyte blood count >12 x 10^3/mm^3 or < 4 x 10^3/mm^3.

The final diagnosis of acute myocardial infarction (AMI), unstable angina (UA), and CHF were independently assigned by two cardiologists based on the following definitions.

A final diagnosis of AMI was confirmed in the presence of two or more measurements of plasma cardiac troponin I above the cut-off value for myocardial necrosis (>0.5 ng/ml).

A final diagnosis of UA was made in the presence of at least one of the following criteria: 1) two or more determinations of plasma cardiac troponin I within the range of myocardial injury (0.1 – 0.5 ng/ml), 2) ischemic abnormalities in at least two contiguous leads on the initial electrocardiogram (transient ST-segment depression ≥0.5 mm, transient ST-segment elevation ≥1 mm, or T-wave inversion ≥2 mm), or 3) any evidence of severe coronary artery disease on complementary studies performed during hospitalization (a positive exercise stress test or cardiac perfusion test, or a coronary angiography demonstrating any severe stenosis in a major branch).

The diagnosis of CHF was based on physical exam reports (jugular venous distension, third sound, or pulmonary rales) and initial chest radiography (pulmonary edema). Echocardiography was not available in the ED.

In case of disagreement, a third cardiologist determined the final diagnosis. Inter-rater agreement was not evaluated.

Data analysis

On the basis of a previous report,[13] 120 patients were required to detect a 2.9% (95% confidence interval [CI], 0-5.9%) of hospital mortality rate among ACS patients with no CHF on admission to the hospital.

Categorical variables were reported by using proportions and continuous variables by using medians and interquartile range (IR). Categorical variables were compared by calculating proportions with 95% CIs and by using the Fisher Exact test. Continuous variables were compared by using the Wilcoxon Rank Sum test. Abnormal values for body temperature and leukocyte count draw a U-shaped curve; therefore they were analyzed as dichotomized variables ("normal"/"abnormal"). The logistic regression analysis was used to determine how factors predicted hospital mortality. The odds ratios (ORs) for in-hospital mortality and the 95% CIs were derived by using the asymptotic standard error of the estimate. Software package Excel™ version 2000 (Microsoft™ Corporation, 1999) was used for data base management and Statistix™ version 7.0 (Analytical Software™) was used for all calculations.

RESULTS

Description of the population

During the study period 255 ACS patients were evaluated in the ED. 59 (23.1%) patients had clinical or radiological signs of CHF and were excluded. The study population comprised of 196 patients (76.9%). Population characteristics

are shown in Table 1. The final diagnosis was AMI in 73 patients (37.2%) and UA in 123 patients (62.8%).

Main results

Six patients (3.1%) died in hospital. The comparison between survivors and non-survivors is shown in Table 2. The variables age, systolic and diastolic blood pressure, ST-segment elevation, and SIRS demonstrated a statistically significant difference between survivors and non-survivors. Because of the small number of events, it was not possible to assess the independence of these risk factors.[14]

22 patients (11.2%) had SIRS. The mortality rate was 13.6% (95% CI, 0-28) among patients with SIRS and 1.7% (95% CI, 0-3.7) among patients without SIRS [risk ratio (RR) 7.9, 95% CI, 1.7-36.8] ($p < 0.01$). The AMI rate was not statistically different between both groups of patients: 40.9% (95% CI, 20.3-61.3) among patients with SIRS and 36.8% (95% CI, 29.6-43.9) among patients without SIRS (RR 1.1, 95% CI, 0.6-1.9) (p 0.7).

Table 1. Baseline characteristics of 196 patients with acute coronary syndrome and no clinical or radiological signs of congestive heart failure in the emergency department.

Continuous variables	Median	IRQ
Age (years)	60	51-70
Categorical variables	**N**	**%**
Demographic data		
Female	64	32.6
Medical history		
Hypertension	124	63.3
Diabetes mellitus	21	10.7
Cigarette smoking	118	60.2
Dyslipidemia	52	26.5
Coronary artery disease	84	42.9
Chronic stable angina	49	25.0
Myocardial infarction	41	20.9
Percutaneous coronary angioplasty	20	10.2
Coronary artery bypass surgery	13	6.60
Stroke	7	3.60
Peripheral artery disease	12	6.10
Previous treatment		
Aspirin	66	33.7
Beta-blockers	64	32.6
Calcium-channel-blockers	25	12.8
Angiotensin converting enzyme inhibitors	54	27.6
Nitrates	34	17.4
Statins	9	4.60
Diuretics	14	7.10

IRQ, interquartile range

DISCUSSION

In the current study, ACS patients with SIRS on admission to the ED were at an increased risk of hospital mortality, compared with ACS patients without SIRS. SIRS was a predictor of mortality along with traditional risk factors, such as age, blood pressure, or ST-segment elevation.

Inflammation plays a central role in the development of atherosclerosis and in the process of plaque rupture in ACS.[15] Acute phase reactants of inflammation may increase in plasma, which has been shown to provide prognostic information among ACS patients.[16]

SIRS may be caused by the activation of the immune system[8] in patients with an infectious disease;[17-19] however, SIRS can develop in other non-infectious conditions, including traumatic injuries,[20,21] critical surgeries,[22,23] burns,[20] or pancreatitis.[24] To our knowledge, the current study is the first to evaluate the prevalence and prognostic significance of SIRS among ACS patients. In a previous study, Rangel-Frausto et al[25] showed that the prevalence of SIRS in a general ED was 25 to 64%. In our study, only 11.2% of patients had SIRS. However, prevalence of SIRS in our study might have been higher if patients with CHF had not been excluded because tachycardia and tachypnea are common clinical manifestations in this condition.[12] Rangel-Frausto el al [25] reported that 32 to 64% of patients with SIRS developed sepsis during hospitalization. Patients in our study did not develop any infectious disease within 72 hours after admission to the hospital; therefore, infection did not appear to have been involved in the pathogenesis of SIRS among our patients. ACS patients with SIRS were at an increased risk for hospital mortality. This finding is consistent with the findings of previous studies, which showed that SIRS was a marker of increased risk of death among patients with intestinal bleeding,[18] critical surgeries[23] and acute pancreatitis.[24]

Two of the components of SIRS, tachycardia[26-30] and high leukocyte count,[31-33] are well-known markers of risk in ACS patients.

In summary, SIRS may contribute to stratify the risk of ACS patients with no clinical or radiological signs of CHF in the ED.

LIMITATIONS

This study has important limitations. First, the standard definition of SIRS is strict and excludes patients with mild distortion of the inflammatory parameters.[34] Moreover, the biochemical markers of inflammation other than leukocytes, such as C-reactive protein, fibrinogen, interleukin-6, tumor necrosis factor α may be more accurate for establishing an inflammatory state than the measurement of non-specific clinical parameters.[8] However, the objective of this study was to evaluate the prognostic significance of classical SIRS, which may be easily determined in the ED setting.

Second, it could be hypothesized that tachypnea and tachycardia had been subtle signs of CHF, [12, 35] a marker of increased risk among ACS patients.[13, 36-39] We could not strictly evaluate this hypothesis because other complementary studies, such as echocardiography or plasma B-type natriuretic factor,[39] were not available in the ED.

Table 2. Comparison of baseline characteristics, emergency department variables and final diagnosis between non-survivors (n=6 patients) and survivors (n=190 patients).

	Non-survivors (3.1%)	Survivors (96.9%)	OR	95% CI	P
Continuous variables (median [IQR])					
Demographic data					
Age (years)	76 (67-80)	59 (51-69)	1.1	1-1.2	<0.01
Physical exam					
Systolic pressure (mmHg)	104 (93-117)	130 (118-152)	0.9	0.9-1	<0.01
Diastolic pressure (mmHg)	60 (46-68)	80 (70-86)	0.9	0.8-1	<0.01
Heart rate (beats/minute)	73 (60-107)	71 (60-80)	1	1-1.1	0.6
Respiratory rate (breaths/minute)	23 (22-28)	20 (18-21)	1.5	1.2-1.9	<0.01
Temperature (ºC)	36.1 (36-36.2)	36.2 (36-36.5)	0.1	0-9.5	0.3
Laboratory					
Leukocyte count (x 10^3/mm^3)	10.3 (7.9-13.8)	8.5 (7-11.3)	1	1-1	0.2
Categorical variables (% [95% CI])					
Demographic data					
Female	50 (18.8-81.2)	32.1 (25.9-39.1)	2.1	0.4-10.8	0.4
Medical history					
Hypertension	66.7 (30-90.3)	63.2 (56.1-70)	1.2	0.2-6.5	1
Diabetes mellitus	0*	11.1 (7.3-16.3)	0	*	0.6
Cigarette smoking	50 (18.8-81.2)	60.5 (53.4-67.2)	0.7	0.1-3.3	0.7
Dyslipidemia	0*	27.4 (21.5-34.1)	0	*	0.2
Coronary artery disease	16.7 (3-56.4)	43.7 (36.8-50.8)	0.3	0-2.2	0.2
Chronic stable angina	16.7 (3-56.4)	25.3 (19.6-31.9)	0.6	0.1-5.2	0.6
Myocardial infarction	16.7 (3-56.4)	21.1 (15.9-27.4)	0.8	0.1-6.6	1
Percutaneous coronary angioplasty	0*	10.5 (6.9-15.7)	0	*	0.6
Coronary artery bypass surgery	0*	6.8 (4-11.4)	0	*	1
Stroke	0*	3.7 (1.8-7.4)	0	*	1
Peripheral artery disease	0*	6.3 (3.7-10.7)	0	*	1
Electrocardiogram					
Left bundle complete block	16.7 (3-56.4)	3.2 (1.5-6.7)	6.1	0.6-60.9	0.2
Q waves	66.7 (30-90.3)	41.1 (34.3-48.2)	2.9	0.5-16.1	0.4
Inverted T-waves	50 (18.8-81.2)	56.8 (49.7-63.9)	0.8	0.1-3.9	1
ST-segment depression	66.7 (30-90.3)	31.1 (24.9-38)	4.4	0.8-24.9	0.09
ST-segment elevation	83.3 (43.7-97)	33.2 (26.9-40.1)	10.1	1.2-88.1	0.02
Final diagnosis					
Acute myocardial infarction	83.3 (43.7-97)	35.8 (29.3-42.8)	9	1-78.4	0.03
Systemic inflammatory response					
Systemic inflammatory response syndrome	50 (18.8-81.2)	10 (6.5-15.1)	9	1.7-47.8	0.02
Increased heart rate	33.3 (9.7-70)	10.5 (6.9-15.7)	4.3	0.7-24.7	0.1
Increased respiratory rate	83.3 (43.7-97)	24.7 (19.2-31.3)	15.2	1.7-133	<0.01
Abnormal temperature	0*	0.5 (0.1-2.9)	0*	*	1
Abnormal leukocyte count	50 (18.8-81.2)	21.6 (16.3-28)	3.6	0.7-18.7	0.1

Continuous variables are reported by using medians and interquartile ranges (IQR) and compared by using the Wilcoxon Rank Sum test. Categorical variables are reported by using percentages and 95% confidence intervals (CI) and compared by using the Fisher Exact test. The odds ratios (ORs) were calculated by using bivariate logistic regression analyses.
*Exact confidence levels were not estimated because of zero count cells.

Third, the increase in heart or respiratory rate may have been associated with fear or anxiety, [40] which are frequently triggered by pain.[41] Consequently, it is possible to speculate that persistent chest pain, an ACS risk marker, [42] rather than inflammation was the cause of tachycardia and tachypnea in our study. However, in a clinical setting, Marco et al[43] did not identify any significant association between pain score and vital signs among more than 1000 ED patients, including 80 with AMI.

Fourth, the frequency of abnormal body temperature was low in our study (only one patient), despite the fact that fever has been described as a common finding after an AMI.[44] Previous studies[45-48] reported serial body temperature determinations among AMI patients, while our study reported

only the first determination in the ED among patients across all ACS subsets. Gabriel et al[49] attributed the fever to a systemic inflammatory response, a conclusion supported by the concomitant rise of acute phase reactants.

Finally, the independence of the risk factors could not be assessed because the number of events was small.[14]

CONCLUSION

The presence of SIRS on the admission to the ED was a marker of increased risk of hospital mortality among ACS patients with no clinical or radiological evidence of CHF.

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Echocardiography to Supplement Stress Electrocardiography in Emergency Department Chest Pain Patients

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Introduction: Chest pain (CP) patients in the Emergency Department (ED) present a diagnostic dilemma, with a low prevalence of coronary disease but grave consequences with misdiagnosis. A common diagnostic strategy involves ED cardiac monitoring while excluding myocardial necrosis, followed by stress testing. We sought to describe the use of stress echocardiography (echo) at our institution, to identify cardiac pathology compared with stress electrocardiography (ECG) alone.

Methods: Retrospective cohort study of 57 urban ED Chest Pain Unit (CPU) patients from 2002-2005 with stress testing suggesting ischemia. Our main descriptive outcome was proportion and type of discordant findings between stress ECG testing and stress echo. The secondary outcome was whether stress echo results appeared to change management.

Results: Thirty-four of 57 patients [59.7%, 95% confidence interval (CI) 46.9-72.4%] had stress echo results discordant with stress ECG results. The most common discordance was an abnormal stress ECG with a normal stress echo (n=17/57, 29.8%, CI 17.9-41.7%), followed by normal stress ECG but with reversible regional wall-motion abnormality on stress echo (n = 10/57, 17.5%, CI 7.7-27.4%). The remaining seven patients (12.3%, CI 3.8-20.8%) had non-diagnostic stress ECG due to sub-maximal effort. Stress echo showed reversible wall-motion abnormality in two, and five were normal. Twenty-five of the 34 patients (73.5%, CI 56.8-85.4%) with discordant results had a different diagnostic strategy than predicted from their stress ECG alone.

Conclusion: The addition of echo to stress ECG testing in ED CPU patients altered diagnosis in 34/57 (59.7%, CI 46.9-72.4%) patients, and appeared to change management in 25/57 (43.9%, CI 31.8-57.6%) patients. [West J Emerg Med. 2010; 11(4):379-383.]

INTRODUCTION

Chest pain (CP) is a common presenting symptom in emergency department (ED) patients, accounting for 5.4% of all ED visits.[1] These patients present a diagnostic dilemma, as the prevalence of coronary artery disease (CAD) is low but the consequence of misdiagnosis is high.[2] After history, physical examination, electrocardiogram (ECG) and cardiac markers, most patients are found to be low risk for acute coronary syndrome. Many EDs use stress ECG alone to further risk-stratify this group and determine which patients need coronary angiography (CA) or admission. Although CA is considered the criterion reference in CAD diagnosis, it is invasive and expensive.[3]

According to American Heart Association/American College of Cardiology guidelines, exercise ECG is the first test for evaluation of known or suspected CAD. Patients must reach greater than 85% of their maximum heart rate on a treadmill or exercise bicycle for optimal stress.[4] Stress ECG is considered positive with reversible, regional ST changes suggesting ischemia, but it has demonstrated sensitivity and

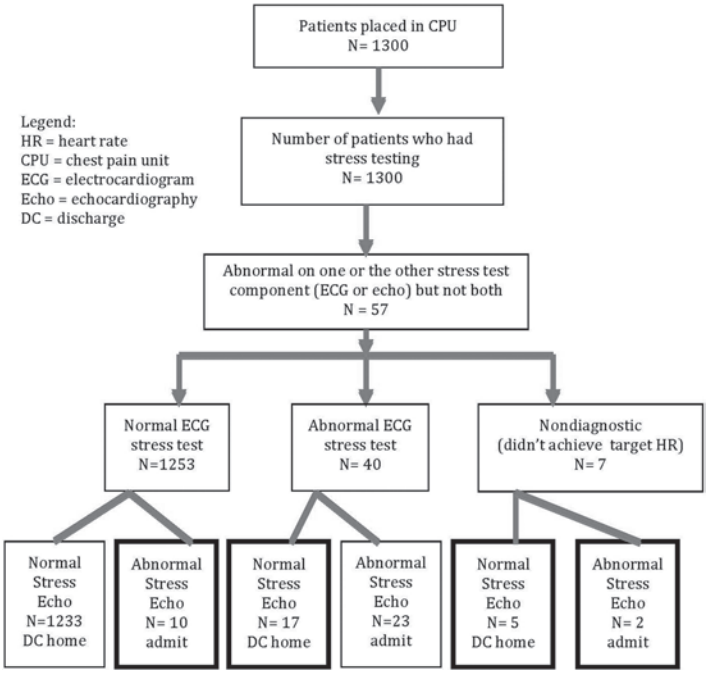

Figure 1. Flowchart of patients. All negative stress echocardiograph patients were discharged home, while those with positive stress test components were admitted. Patients with changes to expected disposition after stress ECG alone in **bold (n=34):**

specificity of 68% and 77%, respectively.[5] When applied to a CPU population with low prevalence of disease, stress ECG yields many false-positives.

The addition of echocardiograph (echo) to stress ECG testing may reveal cardiac pathology and potentially better inform the decision to perform CA. Stress echo shows left ventricular systolic and diastolic dysfunction, valvular problems, infarction and stress-induced ischemia.[4] It also discovers other cardiovascular diagnoses, such as pericardial effusion or aortic dissection. Reversible regional wall motion abnormalities indicate myocardial ischemia and last up to two minutes or until heart rate drops from maximal. The sensitivity and specificity of stress echo for CAD improves modestly to 79.1% and 87.1%, respectively, over stress ECG testing alone.[6]

Previous studies have compared stress ECG alone with the combination of stress ECG and echo, [7,8] but no study has compared the two in ED patients. We describe the use of stress echo, at our institution, to identify cardiac pathology compared with stress ECG, and its apparent effect on patient management.

METHODS

We conducted a retrospective cohort study of CP patients who also had an abnormal stress test result, either ECG stress test or stress echo and admitted to the CPU between January 1, 2002 and December 31, 2005. In the judgment of the attending emergency physician (EP), these patients' presentations warranted diagnostic testing for CAD (initial and six-hour ECG, initial chest radiography, and initial and six-hour creatine phosphokinase-MB fraction and Troponin I) but were all negative. We performed the study in a 35-bed tertiary care ED, with a census of 38,000 patients per year, supporting a postgraduate year 1-3 emergency medicine residency. The CPU protocol ended with a stress echo in all cases. Patients had a resting echo, followed immediately with stress by treadmill or, for those unable to walk or run, with intravenous dobutamine. We considered treadmill and dobutamine equivalent stressors. Finally, the echo was repeated immediately with rapid heart rate to assess tachycardia-induced regional wall motion. Nuclear studies were not part of the CPU protocol at our institution.

We included all patients with positive stress tests of either type during calendar years 2002-2005, drawn from the cardiology stress test database (n=57). The cardiac stress lab personnel searched the database for either abnormal stress test component. A positive stress ECG was defined as a ≥1 mm of horizontal or downsloping ST-segment depression or elevation for at least 60 to 80 milliseconds after the end of the QRS complex.[9] A positive stress echo was defined as normal resting wall motion but reversible hypokinesis or akinesis after exercise or dobutamine.[10] We did not include any patients with nuclear imaging as CPU patients all undergo stress echo testing, nor exclude any patients with either a positive stress ECG or positive stress echo.

Patients were aged 30-76 (mean = 54). Twenty-seven were female (47.3%). Ethnicity was 59.6% Caucasian (n = 34), 17.5% Hispanic (n = 10), 10.5% Asian (n = 6), 8.8% African-American (n = 5), and 3.5% other (n = 2).

A single investigator (EKW, a fourth-year medical student with research experience) abstracted ED and hospital charts and computerized ECG and stress echo repots directly into an Excel spreadsheet (Microsoft Corporation, Redmond, WA) with standardized data elements. We recorded patient demographics, disposition, stress ECG and stress echo findings. We searched computerized records for CA reports after stress testing on all patients through 2007; if absent, we presumed they were not done at our institution. We included data from only one CP evaluation per patient. We did not have access to stress test or CA results outside our institution.

A senior emergency medicine resident assisted the medical student in interpreting and categorizing the stress test reports based solely on the attending cardiologist's interpretation. Non-diagnostic stress tests were those where the patient did not achieve 85% of their predicted maximum heart rate for age. As the data gathered were primarily objective, we did not need to resolve any ambiguities in the medical record.

We conformed to most elements of optimum retrospective chart review. However, the chart abstracter was not blind to

the hypothesis. As there was only one data abstracter and the data were objective, we did not test intrarater agreement, nor periodically monitor the data abstracter. [11, 12]

We determined concordance between stress ECG and echo and whether the stress echo results provided evidence that would customarily lead to change in clinical management. Concordance was defined as both the ECG and echo components showing ischemic changes and reversible regional wall motion abnormality in similar coronary distributions. Stress echo results that identified reversible regional wall motion abnormality in the absence of ST segment ischemic changes were deemed discordant, as was a normal or abnormal stress echo in the face of suboptimal exercise level. Change in clinical management was defined as admission to the hospital from the CPU rather than customary discharge home or performance of CA. It was presumed that CPU patients would be discharged home if the stress echo were normal. Any admission or CA following the stress echo was therefore considered a change in clinical management. The local Institutional Review Board approved the study.

RESULTS

During calendar years 2002-2005, approximately 1,300 stress tests were done from the CPU, of which 57 (4.4%) had at least one component of stress testing that was abnormal, either an abnormal stress ECG, abnormal stress echo or both, and formed our study population. In 34/57 patients, the echo findings were discordant with stress ECG test results (59.7%, CI 46.9-72.4%), while in the remaining 23 CPU patients, the stress ECG and stress echo components were both abnormal.

The most common discordance was an abnormal stress ECG with a normal echo (n= 17/57, 29.8%, CI 17.9-41.7%), followed by normal stress ECG but with reversible regional wall-motion abnormality on stress echo (n= 10/57, 17.5%, CI 7.7-27.4%). The remaining seven patients (12.3%, CI 3.8-20.8%) had non-diagnostic stress ECG due to sub-maximal effort. Stress echo showed reversible wall-motion abnormality in two, and five were normal. Twenty-five of the 34 patients (73.5%, CI 56.8-85.4%) with discordant results had a different disposition than predicted from their stress ECG alone. Additionally, stress echo discovered moderate mitral regurgitation in two patients. No patient had CA based on the stress ECG component alone; all 57 patients got the echo component both before and after stress.

DISCUSSION

The addition of stress echo provided additional information about cardiac pathology in 34 of 57 patients (59.7%). It discovered reversible wall motion abnormalities in patients with normal stress ECG findings. The echo component seemed to provide sufficient reassurance for the EPs to feel comfortable discharging the patient home with no further non-invasive testing or CA.

Echo also found valvular pathology that cannot be assessed with ECG.

Two previous studies of non-ED patients made similar comparisons between stress echo and stress ECG tests.[7, 8] These studies of higher risk patients had CAD rates of 71.2% and 57.3%, respectively, far higher than our ED CPU population. Salustri et al. found a lower rate of discordance between the two tests (n= 7/35, 20%) than we did (59.7%), while Severi's published data preclude calculation of a discordance rate. However, at least 16.1% of his patients must have had discordance, while the true rate was likely much higher. Seven of our 34 discordant findings (20.6%) were equivocal stress ECG tests limited by exercise tolerance. Salustri reported no patients with equivocal stress ECG tests, while Severi reported 7.0%, both unrealistically low in our experience. Whether we consider all of our equivocal stress ECG tests as positives or negatives, our discordant rate is largely unchanged, 58.2% and 55.7%, respectively. Neither of these studies commented on additional anatomical findings with stress echo, while we found two patients with valvular disease.

Adding echo to standard ECG stress testing more than doubles the charges at our institution, from $1,103 to $2,299, including professional and technical fees. Despite this, stress echo is supported in the literature as cost-effective.[3] After studying 429 patients in 1994, Severi postulated that, while stress echo outperformed stress ECG as a diagnostic test, the latter would still remain first line for screening due to lower cost.[7] However, a 2008 economic analysis of strategies to diagnose CAD, including non-invasive ECG, echo, and nuclear imaging, as well as CA, found pharmacological stress echo to be the most cost-effective. Exercise stress echo was found to be 1.5 times the cost of pharmacological stress echo, while exercise stress ECG was 3.5 times higher, due to false-positives requiring CA. The same study found the cost of a primary CA strategy after history, physical, resting ECG, and cardiac markers, to be 56.3 times higher than pharmacological stress echo.[13]

Lewandowski, et al. reported an economic-analysis of diagnostic screening for CAD in 551 patients, beginning with baseline risk. CPU patients, who are already deemed low risk (<10% prevalence of CAD), can be further risk-stratified by gender, since at any age CAD is less common in women. Therefore, this approach recommends stress ECG in males (94% sensitivity, 27% specificity), but stress echo in females (79% sensitivity, 71% specificity) increases specificity and avoids pursuit of false-positive results.[3] This differential approach by gender increases the specificity in women from 16% with stress ECG to 71% with stress echo, without sacrificing sensitivity (91% vs. 79% respectively, p = NS)

In our study, 25/34 patients with discordant stress test results had a different clinical course than predicted from stress ECG results alone. We presumed that 17 positive stress

ECG tests would have required CA, but 16 did not when the echo component was negative. Five of seven with non-diagnostic ECG stress tests also would have customarily had CA to clarify pathology, but echo changed their management, as one had CA after positive stress echo, while four did not when the stress echo was normal. Of 10 more with normal stress ECG and abnormal stress echoes, four had CA. The other six should have had CA but did not at our institution. Therefore, routine stress echo in addition to stress ECG testing is supported by the bulk of previous literature, and is used at our institution to guide patient management. All CA for our patients was performed during the hospitalization following the abnormal stress echo test.

The addition of echo to stress ECG identified cardiac pathology in CPU patients and may have been used to avoid CA and hospital admission in our institution. This strategy appears to be cost-effective. However, a prospective study that compares both test components to a criterion reference of CA with clinical outcome is required to validate this approach.

LIMITATIONS

Our study had major limitations. As a retrospective review, the data in the computerized medical record was incomplete. Many of our patients did not undergo CA, even if the non-invasive testing indicated it. This, in turn, precluded determination of the test characteristics of stress testing for CAD. In addition, we could not determine the treating physicians' pre-test treatment plans. Hence, assertions that the stress echo changed management are speculative and based on our view of customary practice.

By searching the cardiology database to identify patients with abnormal stress test results, it is possible that we omitted some patients who should have been included. The Director of Cardiac Stress Testing laboratory is facile with the database, but there has been no validation of the search strategy to assure that it captures all appropriate patients.

While some exercise ECG stress tests were indeterminate due to failure to achieve the target heart rate, the same limitation would apply to the echo portion of these patients' tests, limiting the sensitivity to identify acute coronary syndrome at maximal load. That our cardiologists felt comfortable calling a stress echo negative short of the target heart rate has not been validated. Therefore, the disposition of five patients in the study with non-diagnostic stress ECGs appears unsupported by non-invasive testing.

As with all non-invasive testing to risk stratify CP patients, the approach in our institution leads to discharge of some patients with coronary disease. This is inherent in the limited sensitivity of diagnostic testing, whether for cardiac problems or otherwise. Hence, it is prudent to advise all discharged patients of the warning signs to return to the ED immediately and not to portray the diagnostic workup as "negative," but rather "very low risk."

The cardiologists reading stress echo tests were subject to incorporation bias, as they were aware of results of the stress ECG tests. We assumed that reversible regional wall motion abnormality on stress echo represented acute ischemia and suggested CAD. However, the echo findings may have been incidental, and reflected asymptomatic or chronic CAD.

Our study was too small to address which type of patient might benefit from the stress echo versus stress ECG alone. We did not, for example, stratify our patients by age, sex or beta-blocker use. This paper describes customary practice at one institution and should not be generalized.

CONCLUSION

In 59.7% of ED CPU patients in our institution, we found that stress echo testing was used to justify either patient discharge home or the need for admission or CA and to identify valvular pathology. Furthermore, stress echo appeared to alter disposition in 74% of patients who had discordant stress ECG and stress echo results. As this is a description of one institution's approach to risk stratification of CP patients, this report should not be construed to validate such an approach. We recommend a prospective study of a larger sample to answer the question whether the addition of echo to ECG stress testing provides accurate information and to assess the test characteristics of stress echo and stress ECG alone compared to a criterion reference of CA with clinical follow up.

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Coronary Disease in Emergency Department Chest Pain Patients with Recent Negative Stress Testing

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Background: Cardiac stress tests for diagnosis of coronary artery disease (CAD) are incompletely sensitive and specific.

Objective: We examined the frequency of significant CAD in patients presenting to the emergency department (ED) with chest pain who have had a recent negative or inconclusive (<85% of predicted maximum heart rate) cardiac stress test.

Methods: This was a retrospective chart review of patients identified from ED and cardiology registries at the study hospital. We included patients presenting to the ED with a chief complaint of chest pain, with a negative cardiac stress test in the past three years as the last cardiac test, and hospital admission. One-hundred sixty-four patients met the inclusion criteria. Their admission was reviewed for diagnosis of CAD by positive serum troponin, percutaneous coronary intervention, or positive stress test while an inpatient.

Results: Of 164 patients, 122 (74.4%, 95% CI 67.7, 81.1) had a negative stress test prior to the index admission, while 42 (25.6%, 95% CI 18.9, 32.3) had otherwise normal but inconclusive stress tests. Thirty-four (20.7%, 95% CI 14.4,27.0) of the included patients were determined to have CAD. Twenty-five of the 122 patients (20.5%, 95% CI 13.3, 27.7) had negative pre-admission stress tests and nine of 42 patients (21.4%, 95% CI 9.0, 33.8) had inclusive stress tests of CAD. A statistical comparison between these two proportions showed no significant difference (p = .973).

Conclusion: Due to inadequate sensitivity, negative non-invasive cardiac stress tests should not be used to rule out CAD. Patients with negative stress tests are just as likely to have CAD as patients with inconclusive stress tests. [West J Emerg Med 2010; 11(4):384-388.]

INTRODUCTION

In 2007 the Centers for Disease Control and Prevention (CDC) reported chest pain as the second most common reason for emergency department (ED) visits (5%) in the United States (U.S.). Almost six million patients presented to the ED in 2005 complaining of chest pain.[1] The CDC also reports that heart disease accounted for over four million admissions to U.S. hospitals in 2005.[2]

It can be difficult to determine whether or not a patient with chest pain needs hospital admission. Greater accuracy in identifying chest pain patients who can be safely discharged home might help to reduce hospital and ED crowding. Unfortunately, discharging chest pain patients carries risk. One large multicenter study by Pope found that 2.1% of acute myocardial infarctions (AMI) were mistakenly discharged home from the ED, as were another 2.3% of patients with proven unstable angina (USA).[3]

Disposition decisions can be more difficult in patients with a recent negative cardiac stress test. Cardiac stress tests for diagnosing coronary artery disease (CAD) range in

sensitivity from 67% to 85% and specificity from 70% to 95% depending on the study referenced and the type of stress test performed.[4] This sensitivity and specificity may not be sufficient to make disposition decisions on patients presenting to the ED with chest pain.

A few recent studies have further examined this clinical dilemma. Nerenberg et al found no difference between ED admission rates and 30-day cardiovascular event rates in patients with and without a prior normal stress test. Also, while patients with a prior abnormal stress test were admitted more frequently, there was no statistically significant difference in adverse outcomes among patients with a previous abnormal stress test, a previous normal stress test, or no previous stress test.[5] Smith et al studied the incidence of AMI, defined by an elevated troponin in patients presenting to the ED within three years after a documented normal stress test with subsequent admission and found that 4.8% of the patients had an AMI.[6]

The purpose of this study was to examine the frequency with which significant CAD is found in patients presenting to the ED with chest pain who have had a negative cardiac stress test within three years.

METHODS

This was an IRB-approved retrospective chart review of patients presenting to the ED with a chief complaint of chest pain and a negative cardiac stress test in the three years preceding presentation. This timeframe was chosen because consensus opinion of cardiologists at our institution viewed older stress test results as unreliable. We reviewed charts for adverse cardiac events in the 30 days after ED presentation as described below.

This study was conducted at a community teaching hospital with an ED census of 70,610 visits in 2007. Of these visits, 5,591 (7.9%, 95% CI 7.7, 8.1) were for chest pain. Of the 19,501 patients admitted from the ED in 2007, 17.5% (95% CI 17.0, 18.0) were for patients > 18 years who presented with a chief complaint of chest pain. From August 2005 through February 2008 (31 months), 2910 stress tests were performed locally. There was a single large cardiology group in our region, allowing data capture from all locally-performed stress tests (both in our hospital and outside the institution). The negative stress tests performed on the 164 patients included in the study represent 5.6% of the total stress tests performed. Included patients could have had a positive stress test at an outside institution, but this was felt unlikely because of the long distance to the nearest outside facilities that perform stress tests.

We used the hospital's cardiology registry, which began in August 2005, to obtain a list of patients to evaluate for inclusion. The database only recorded patients who had stress echocardiograms (both treadmill and pharmaceutical). No database for electrocardiogram (ECG)-only stress tests or nuclear stress tests was available. The stress test recorded in the study, however, was the most recent study on record, so some nuclear stress tests and ECG-only studies were included if the patients from the cardiology database had one of these types of stress tests closer to the ED encounter. For patients who had multiple past stress tests, we also collected data on the most recent stress test. Thus, for all patients in the study, only results from the most recent stress test on record prior to admission were used for analysis.

We then used an ED patient registry to obtain a second database of patients who were > 18 years old and presented to the ED during this same time frame with a recorded chief complaint of "chest pain," "CP," "chest tightness," or "chest pressure," and the patient was admitted to the hospital. If one of these patients presented multiple times during the time period with the above chief complaints, each visit was counted as a separate encounter, as each visit would represent the same disposition dilemma to the emergency physician.

The stress test database and ED database were then compared to identify study patients. We found that 337 patients >18 years old who presented to the ED with chest pain had undergone a stress test (regardless of result) prior to their ED visit and were admitted.

Each of the patient encounters in the final database underwent a thorough chart review by a single reviewer (MG). Patients were excluded if their most recent stress test within three years was positive, or if they had cardiac catheterization or coronary artery bypass grafting (CABG) between the stress test and their ED visit.

A positive stress test was defined as any positive individual aspect of the test, as reported by the interpreting cardiologist. This included clinically positive studies with chest pain, as well as ischemic changes on ECG, echocardiogram, or nuclear imaging. Official stress test reports provided at our institution include a summary statement of the cardiologist's interpretation of the test. Tests were considered positive for the purposes of this study if the cardiologist interpretation included a description of possible ischemic changes or other evidence of CAD. All other stress tests results were considered negative. Of note, those stress tests that did not meet any of the positive criteria but were considered inconclusive because they did not reach the 85% maximum heart rate target were included in the negative group, and analyzed as a separate subgroup.

For our patients, the type of stress test performed, the time between stress test and admission, and evidence of CAD within 30 days of admission were recorded using a standardized data collection sheet. We defined significant CAD within 30 days as a myocardial infarction identified by positive cardiac markers, subsequent positive stress test of any type, cardiac catheterization requiring intervention (angioplasty or medical management but no stent placed as reported on catherization report), CABG, or death due to medical cardiac arrest.

RESULTS

We reviewed 337 patient encounters; 173 patients were excluded due to positive stress test (111 patients), history of another previous positive cardiac stress test within three years of admission, or interval cardiac catheterization or CABG (62 patients). The remaining 164 met all inclusion criteria. The mean age was 55 years old (range of 27-93; SD 15). There were 82 males. Of the 164 patients included, 122 (74.4%, 95% CI 67.7, 81.1) had a prior negative stress test and the remaining 42 (25.6%, 95% CI 18.9,32.3, ±6.68%) had a prior inconclusive stress test. Table 1 provides a summary of this data.

The distribution of time between the most recent stress test and ED visit is shown in Figure 1. The majority of patients had a treadmill echocardiogram as their most recent stress test (83 patients, 50.6%, 95% CI 43.0, 58.3). Other types of stress tests included pharmacologic echocardiograms (59 patients, 35.9%, 95% CI 28.6, 43.2), pharmacologic nuclear studies (16 patients, 9.8%, 95% CI 5.3, 14.4), treadmill nuclear studies (5 patients, 3.0%, 95% CI 0.4, 5.6), and a treadmill ECG only study (1 patient, 0.6%, 95% CI -0.6, 1.8). [Figure 2]

Of the 164 patients, 34 (20.7%, 95% CI 14.4, 27.0) had significant CAD within 30 days of admission. Twenty-five (20.5%, 95% CI 13.3, 27.7) of the 122 s who had a negative stress test had CAD, while nine (21.4%, 95% CI 14.1, 28.7) of 42 who had an inconclusive stress test had CAD.

When examining the time between the most recent stress test and hospital admission for patients who had significant CAD, and of the 34 patients who developed CAD, eight (23.5%, 95% CI 9.3, 37.8) had their most recent stress test within one month of admission. Seven were (20.6%, 95% CI 7.0, 34.2) between one and three months, one (2.9%, 95% CI -2.7, 8.5) between three and six months, 11 (32.4%, 95% CI 16.7, 48.1) between six months and one year, and seven (20.6%, 95% CI 7.0, 34.2) within one to three years. [Figure 3]

Of patients with significant CAD, 20 (58.5%, 95% CI 41.9, 75.1) had a treadmill echocardiogram as their most recent stress test, 10 (29.4%, 95% CI 14.1, 44.7) had a pharmacologic echocardiogram, and four (11.8%, 95% CI 1.0, 22.6) had a pharmacologic nuclear study. None had a treadmill nuclear or treadmill ECG only study. [Figure 4]

Of the 164 patients with negative stress test prior to admission, 24 (14.6%, 95% CI 9.2,20.0) had a heart catheterization in which an intervention was performed, 13 (7.9%, 95% CI 3.8,12.0) had an AMI, nine (5.5%, 95% CI 2.0,9.0) had a positive stress test, one (0.6%, 95% CI -0.6,1.8) had a CABG and one (0.6%, 95% CI -0.6,1.8) died [Figure 5]. Some patients had more than one indicator of CAD. Table 2 shows the different combinations of CAD indicators found in the 34 patients with CAD.

DISCUSSION

The disposition of patients presenting to the ED with the chief complaint of chest pain is complex. When no definitive

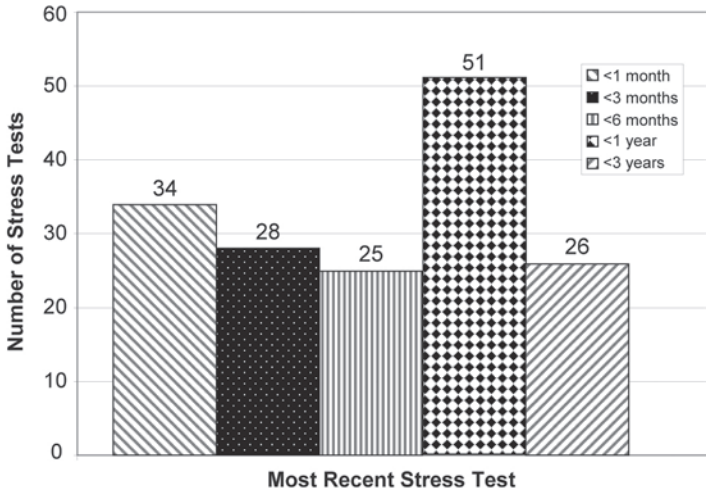

Figure 1. Timing of stress test prior to emergency department visit

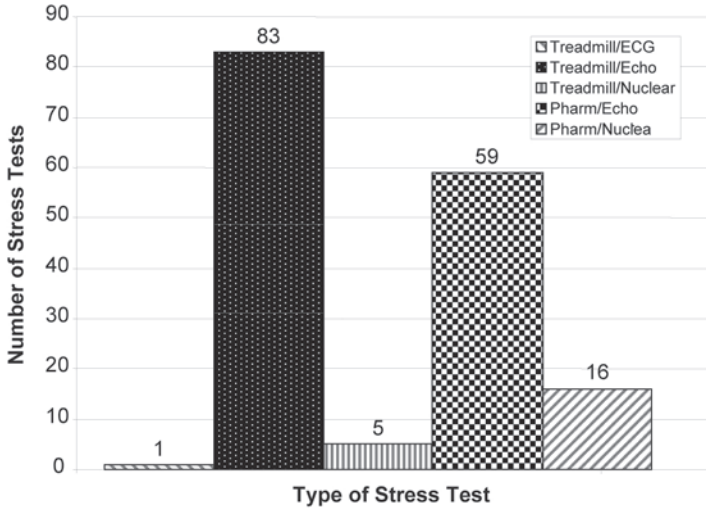

Figure 2. Type of stress test

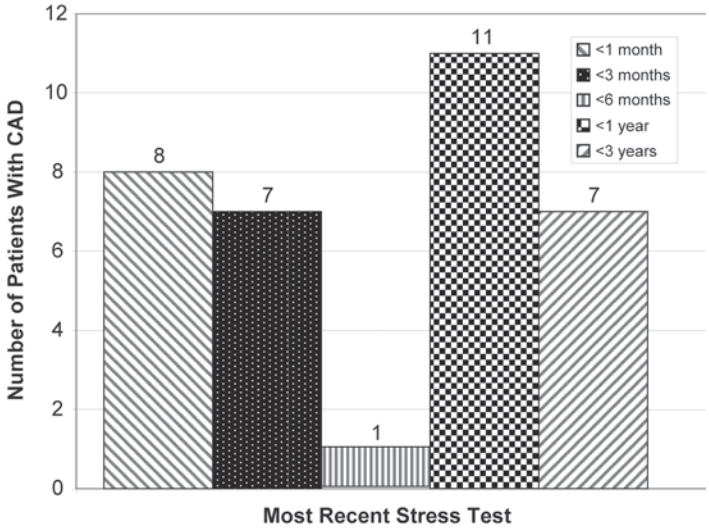

Figure 3. Timing of negative stress test in patients with coronary artery disease (CAD)

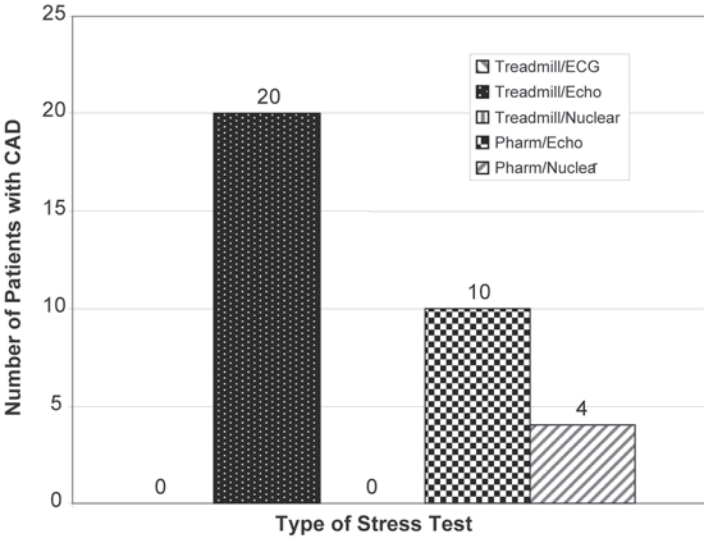

Figure 4. Number of patients that ruled in by type of stress test

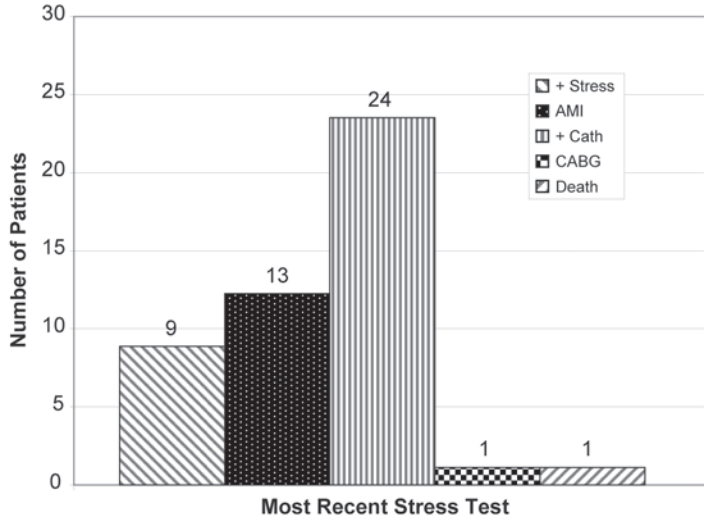

Figure 5. Thirty-day adverse cardiac events

diagnosis can be made, the decision to admit or discharge is often based on the physician's level of suspicion of acute coronary syndrome (ACS). One study found that 2.1% of patients with AMI and 2.3% with USA were inappropriately discharged home.[3] The goal of the emergency physician is to minimize the number of patients discharged home with ACS. At the same time, limited hospital resources may place pressure on physicians to minimize the number of patients admitted for possible ACS.

Cardiac stress testing is one modality used to screen patients for CAD. The goal of the stress test is to identify a fixed obstruction to coronary blood flow, such as in stable angina. However, in ACS including AMI and USA, the underlying pathophysiology is plaque rupture and thrombus formation. The lesion may not have been significant enough to be detected on stress testing.[5] Therefore, the use of a negative stress test to determine the disposition of ED chest pain patients is questionable.

In our study, 20.7% of patients presenting to the ED with a negative stress test within three years of presentation still had significant CAD. A fraction of these were technically inconclusive based on not achieving 85% of the maximum predicted heart rate for age (25.6%). However, there was no difference between patients whose stress test was negative compared to those whose tests were negative but technically inconclusive based on heart rate (20.5% vs. 21.4% respectively).

Our results suggest that a negative stress test is unreliable in ruling out CAD. In a similar study, Smith found that 4.8% of patients presenting to the ED within three years after a normal stress test had an AMI.[6] While there is some discrepancy between the total percentage of AMI found in Smith's study and ours (4.8% versus 7.9%), both studies call into question the use of prior negative stress test results in ED disposition of patients with chest pain.

In a cohort study Nerenberg evaluated the disposition decisions of ED physicians on1,853 patients presented to the ED with chest pain, 291 of whom had a negative prior stress test. A previous negative stress test did not significantly change the rate of admission to the hospital. The study also measured secondary outcomes of 30-day cardiac events in both admitted and discharged patients. There was no significant difference in adverse events between patients who had a positive stress test, a negative stress test, or no previous stress test; 5.2% of the patients who had a previous negative stress test had an adverse cardiac event. The study defined adverse cardiac events in similar terms as our study, including AMI, catheterization requiring intervention, CABG, or death.[4]

The most likely explanation for the difference in 30-day adverse events between the Nerenberg study (5.2%) and ours (20.7%) is that their study included both admitted and discharged patients, while ours only included patients admitted from the ED. Patients discharged from the ED would be expected to have a lower occurrence of adverse events than those admitted. Thus, our study would be expected to find more patients with indicators of significant CAD. Also, both studies were performed with data from a single institution in different geographic and economic areas, which could indicate different subsets of the population with different prevalence of CAD. Ultimately, however, both studies find significant numbers of patients with previous negative stress testing who were found to have CAD.

LIMITATIONS

The design of the study as a retrospective chart review from a single institution has inherent limitations. Unique characteristics of our patient population or our institutional standards in decision-making may not make our findings applicable to other settings. Because of the retrospective

nature of the study, only admitted patients could be assessed for adverse cardiac events, which likely introduces selection bias, as admitted patients would be expected to have a higher prevalence of CAD than those discharged home. Also, if a patient presented multiple times, we considered each visit separately. If the indicator of CAD was only found on the last visit, this could have slightly diluted the true frequency of CAD.

The relatively small sample size in our study produces additional limitations. We do not have enough samples in each group to determine statistically significant differences between the types of stress tests and between the various time frames from the most recent stress test and admission. It is possible that some types of stress tests may be better than others as a negative predictor of CAD. Likewise, the time between the last stress test and presentation to the ED could have a more significant role than our study would indicate. A much larger data sample is needed to detect significant differences in these subgroups.

Another limitation is that we used a positive stress test after admission as a marker of CAD. Since a positive stress test prior to admission was used as an exclusion criterion for the study, the use of a positive stress test as a marker of CAD after admission may be reasonable. However, it is possible that patients with a positive stress test after admission did not have CAD demonstrated by other means. A positive stress test, however, is almost always followed by further evaluation and possibly intervention.

We were limited by the data available. Our cardiology database of stress tests only dated back to August 2005 and only included exercise and pharmaceutical echocardiograms. This certainly reduced the number of included patient encounters in our study and may have been an unavoidable source of selection bias. Twenty-two of the 164 (13.4%) included patient encounters had a most recent stress test that was one other than a pharmaceutical or treadmill echocardiogram. Four of the 22 patients (18.8%) had CAD on admission (Figure 4), which is consistent with the overall incidence of the study. Therefore, it is uncertain how the results would be affected if more nuclear studies had been included.

Finally, abstractors were not blinded to the hypothesis of the study so we did not follow the guidelines set for by Worster et al.[13]

CONCLUSION

A previous negative stress test cannot be used alone to rule out CAD in patients presenting to the ED with chest pain. In this study, 20.7% of patients with negative stress tests within three years prior to presentation had significant CAD within 30 days of admission. Further studies are needed to determine the role that previous stress testing should play in determining the disposition of chest pain patients.

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Idiopathic Ventricular Tachycardia: Belhassen Type

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A healthy 26 year-old G3P2 12 weeks pregnant with twins presented to the emergency department after the abrupt onset of palpitations, dizziness, shortness of breath and chest pain. An initial electrocardiogram demonstrated frequent preventricular contractions, which progressed to runs of sustained ventricular tachycardia (VT) [Figure 1]. Further workup, including blood work, a computed tomography of the chest and an echocardiogram, was negative for electrolyte imbalance, pulmonary embolism and structural heart disease. The arrhythmia was eventually terminated with verapamil, and she was discharged symptom free five days later on oral metoprolol.

Of patients presenting with monomorphic VT, 90% of cases are secondary to structural heart disease, including ischemic heart disease, congenital heart disease, valvular dysfunction and myocardial dysfunction.[1,2] The remaining 10% are referred to as "idiopathic" VT, as they represent VT in the absence of identifiable structural disease.[1,2] Seventy-five to 90% of idiopathic VT originates in the right ventricle, while the remaining cases represent an ectopic focus within the left ventricle, especially the left posterior fascicle.[1] This rare arrhythmia of the left ventricle was first described as a unique electrophysiologic entity in 1981 by Belhassen et al. Commonly referred to as fascicular or intrafascicular tachycardia, verapamil sensitive VT or Belhassen VT, it is characterized by a right bundle branch block pattern and left axis deviation.[3] Patients are typically young and healthy with their first episode often occurring in adolescence.[2] Attacks may be precipitated by exercise, excitement, and infection.[2] Patients usually present with palpations, dizziness, fatigue, and shortness of breath but are typically hemodynamically stable.[1,2] The prognosis is excellent and the incidence of syncope and sudden death is rare.[1,2] Intravenous verapamil has proven efficacious for terminating VT in symptomatic

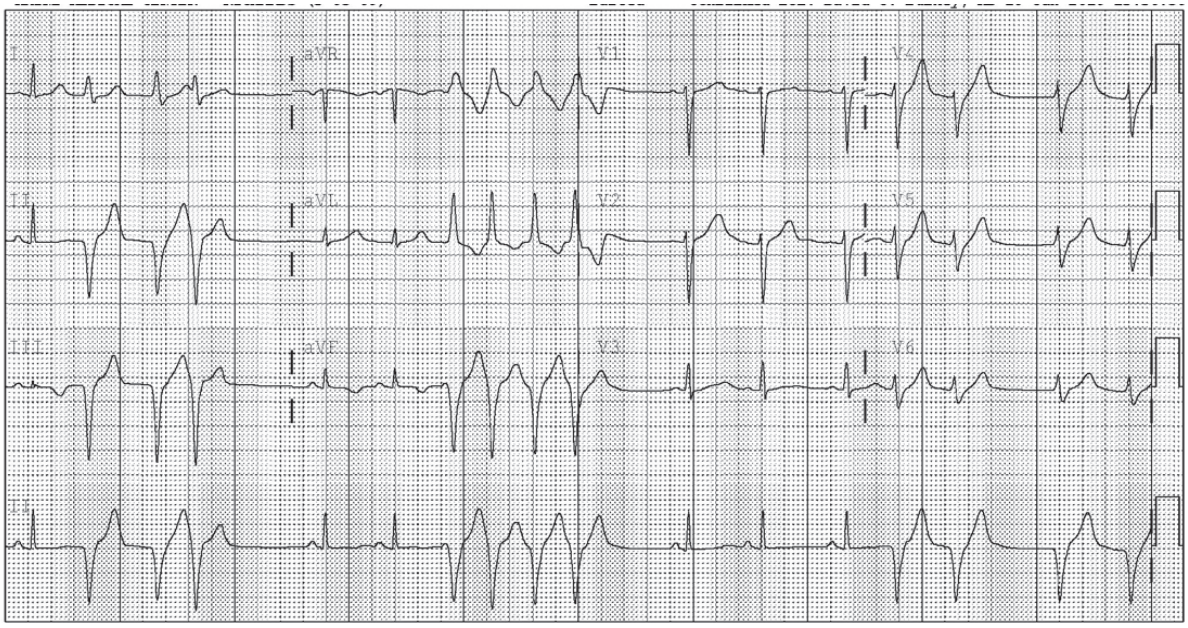

Figure 1. Initial electrocardiogram demonstrated frequent preventricular contractions which progressed to runs of sustained ventricular tachycardia.

patients.[3] Patients with recurrent refractory episodes of VT may be referred for radiofrequency ablation.[1,2]

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Intestinal Angioedema Misdiagnosed as Recurrent Episodes of Gastroenteritis

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Emergency physicians (EP) frequently encounter angioedema involving the lips and tongue. However, angioedema from Angiotensin Converting Enzyme inhibitors or hereditary angioedema (HAE) can present with gastrointestinal symptoms due to bowel wall involvement. EPs should begin to consider this clinical entity as a potential cause for abdominal pain and associated gastrointestinal symptoms given the common use of medications that can precipitate angioedema. We report a case of a 34-year-old woman who presented with abdominal cramping, vomiting and diarrhea due to an acute exacerbation of HAE. [West J Emerg Med. 2010; 11(4):391-394.]

INTRODUCTION

Intestinal angioedema is less commonly encountered by emergency physicians (EP) than angioedema of the lips and tongue and therefore may be unrecognized. Prompt detection and treatment of this rare disease can significantly improve patient outcome by minimizing morbidity from misdiagnosis or unnecessary operative interventions. EPs should be aware that hereditary angioedema (HAE) and medications, such as Angiotension Converting Enzyme (ACE) inhibitors, can cause intestinal angioedema and therefore may present with gastrointestinal complaints. In this case report, we will review the features that may help differentiate intestinal angioedema from other, more common, etiologies of abdominal pain with gastrointestinal symptoms. We also provide a review of the literature including therapy, which remains controversial in the emergency department (ED) setting.

A review of emergency medicine (EM) literature revealed no previously reported cases of isolated intestinal angioedema caused by HAE. A few such cases have been described in radiology and gastroenterology literature spanning several decades.[1-9] However, a case of ACE-inhibitor associated intestinal angioedema was recently described in the EM literature.[10]

CASE REPORT

A 34-year-old African-American female who denied any prior medical history presented to the ED complaining of a three-day history of diffuse, constant abdominal "cramping" with associated nausea, vomiting and blood-streaked diarrhea. She received two liters of crystalloid and 25 mg of promethazine intravenously in the triage area and reported resolution of her nausea at the time of the initial interview by the EP. She described four similar episodes in the preceding year, for which she had been seen in the ED, treated symptomatically with intravenous fluids and promethazine and discharged with a diagnosis of gastroenteritis. She did note, however, that no other relatives or personal contacts were suffering from these symptoms.

Physical examination revealed vital signs consisting of an oral temperature of 36.7°C (98.0°F); blood pressure 137/106 mm Hg; heart rate 114 beats/min; and a respiratory rate of 18 breaths/min. She appeared in no apparent distress, was alert, awake, and oriented. Pertinent physical examination findings included the presence of normoactive bowel sounds and tenderness to palpation in the bilateral lower abdominal quadrants. She exhibited some voluntary guarding but had no rebound tenderness, percussive tenderness, or involuntary guarding. There were no remarkable cutaneous lesions visualized, nor were any abnormalities noted on inspection of the oropharynx.

Mild abnormalities were detected on laboratory results, including: white blood cell count 10.38 K/μL; hemoglobin 17.8 g/dL; hematocrit 53.4; platelet count 468 K/μL; blood urea nitrogen 15 mg/dL; creatinine 1.0 mg/dL; lipase in the

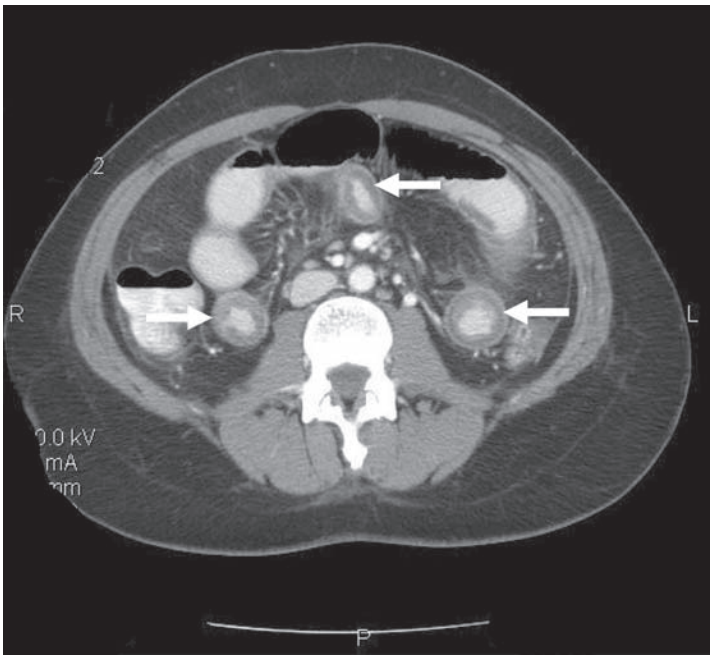

Figure 1. Computed tomography revealing small bowel mural thickening and submucosal edema (arrows).

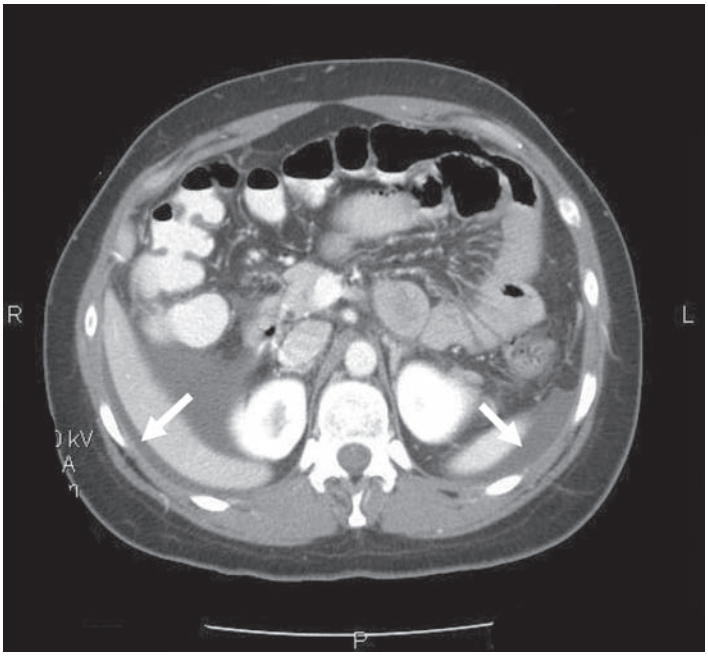

Figure 2. More cephalad section of the same computed tomography revealing areas of dependant ascites (arrows).

normal range and a negative urine pregnancy test. The patient's elevated hemoglobin and hematocrit within this clinical context was interpreted to be evidence of hemoconcentration and dehydration. Only yeast was detected on urinalysis.

Given the recurrent nature of her symptoms (four episodes within a year) and her abdominal exam findings, a computed tomography (CT) scan of the abdomen and pelvis with oral and intravenous contrast was obtained. The CT revealed dependant ascites in the abdominal and pelvic peritoneal cavities and discontinuous mural thickening in the proximal and middle small bowel suggestive of intestinal angioedema (Figures 1 and 2).

Upon review of the patient's archived medical records, it was noted that she had previously been seen in the allergy clinic in 2004 with complaints of hand, foot and facial swelling. Biochemical testing performed at that time revealed a decreased C1 esterase inhibitor protein level of 5 mg/dL, and she was diagnosed with HAE and prescribed Danazol for prophylaxis against future attacks. However, the patient did not fill the prescription and was lost to follow-up. She had never previously experienced gastrointestinal symptoms related to her disorder prior to the past year and had not made the connection between her current symptoms and her diagnosis of HAE.

The patient's allergist was called and notified of the patient's presentation to the ED. He agreed that the totality of symptoms and clinical findings supported a diagnosis of an acute exacerbation of HAE, and an appointment was set within one week for further evaluation, treatment and definitive therapy. The patient reported that her symptoms had completely abated upon re-evaluation, and she was discharged home with a prescription for promethazine and instructions to consume clear liquids and advance her diet as tolerated for symptomatic control of her nausea.

Table 1. Clinical Features of intestinal Hereditary Angioedema and ACE-inhibitor associated angioedema.

• Report of recent ACE-inhibitor use or prior diagnosis of HAE
• Colicky abdominal pain, nausea and vomiting and delayed watery diarrhea
• Vital signs and clinical findings suggestive of dehydration
• Concomitant angioedema of the face, pharynx, or extremities.

DISCUSSION

HAE is a rare autosomal dominant disease first described by Sir William Osler in 1888.[11] The disease is most commonly caused through a quantitative deficiency (type 1) or alternately due to a qualitative dysfunction (type 2) of the C1 esterase inhibitor protein in the plasma, which inhibits the action of vasodilators, such as kallikrein and bradykinin. Without inhibition from C1 esterase, bradykinin serves to increase vascular permeability resulting in angioedema that can occur at any mucosal or subcutaneous surface in the body.[1]

Although the patient in this case was suffering from a hereditary cause of her symptoms, the EP is more likely to encounter patients with angioedema due to ACE inhibitor use. However, angioedema from both etiologies presents similarly and share a common mechanism. ACE-inhibitors cause an excess of bradykinin by inhibiting its breakdown.[12] Patients sensitive to increased levels of bradykinin will often only

Table 2. Diagnosis and treatment of intestinal angioedema.

Diagnosis	Hereditary angioedema	ACE-inhibitor associated angioedema
Biochemical tests	• C1 esterase less than 21mg/dL • Reduced C2 and C4 levels	• None indicated
Ultrasound	• Bowel mucosal thickening • Ascites	
Computed tomography	• Massive small bowel or colonic edema • Prominent mesenteric vessels • Thickened omentum • Moderate ascites • Normal pericolic fat	
Treatment	• Maintain airway patency • Antihistamines • Steroids • IM Epinephrine 1:1000 • C1 inhibitor concentrate, fresh frozen plasma and/or DX-88 infusion	• Maintain airway patency • Antihistamines • Steroids • IM Epinephrine 1:1000 • Discontinue ACE-inhibitor

complain of a persistent, dry nagging cough, which resolves upon discontinuation of the offending medication, but in rare circumstances, bradykinin excess precipitates angioedema. The clinical findings and treatment of intestinal angioedema are summarized in Tables 1 and 2.

Classically, HAE and ACE-inhibitor associated angioedema is located in the pharynx, extremities, or face. However, the bowel wall may be involved concomitantly in up to 75% of cases. Rarely, as we present in this case, angioedema of the bowel mucosa may be the only site of angioedema.[2,13] The initial clinical presentation in patients with isolated gastrointestinal involvement may include colicky abdominal pain accompanied by nausea and vomiting that may easily be mistaken for appendicitis or biliary obstruction.[2] About a day into an acute attack, the patient may experience watery diarrhea secondary to extravasation of fluid into the intraluminal space.[2]

Imaging with ultrasound or CT confirms the diagnosis of intestinal angioedema. Ultrasonography often reveals mucosal thickening and free peritoneal fluid in dependant areas of the abdomen, such as Morrison's pouch.[4] The sonographer may also detect a compressible but edematous bowel wall with increased intraluminal fluid and decreased motility.[5] CT findings typically include massive edema of the small bowel or colon, prominent mesenteric vessels, thickened omentum, moderate ascites, and a normal appearance of the pericolic fat. Normal appearance of pericolic fat is useful for ruling out inflammatory changes seen in other diseases, such as appendicitis or diverticulitis.[6,7] Other findings may include increased contrast enhancement of the small bowel and mucosa with visualization of additional layers of the small bowel wall.[8] Such findings are usually transient and will resolve following an acute episode of HAE or ACE-inhibitor associated angioedema.[8,10] The appendix and gallbladder are usually well visualized, which may serve to effectively rule out some surgical etiologies if they are not involved.[6] The differential diagnosis suggested by the findings on a characteristic CT for angioedema involving the bowel can be rather narrow and include ischemia and intramural bleeding secondary to coagulopathy or trauma.[2]

ACE-inhibitor induced angioedema is a clinical diagnosis, but use of diagnostic tests to determine the cause of angioedema in the ED is limited. If HAE is suspected, the diagnosis can be confirmed with a C1 esterase inhibitor level, although this may not practical or available in the ED setting. If performed, the normal limits of C1 esterase typically range from 21-39 mg/dL. A low C1 esterase inhibitor level is consistent with a diagnosis of HAE. In addition reduced levels of C2 and C4, which are substrates of the C1 esterase enzyme, further enhance specificity.[1,2,3.]

The management of this rare disorder in the ED remains largely undefined. Intestinal angioedema may be a particular challenge due to its rarity and the broad differential associated with its presentation. Unrecognized and untreated cases of angioedema exacerbations as a whole carry a mortality rate of 30-56%.[5,13] Airway patency should be a priority in cases involving the oropharyngeal structures. When acute abdominal symptoms are present, surgical consultation may be prudent or required if there are doubts about the etiology of the clinical and radiologic findings, particularly when the patient is experiencing hemodynamic instability.[10] In terms of immediate management, administration of C1 inhibitor concentrate and fresh frozen plasma have been reported to be effective in rapid reversal of some attacks.[13-15] Cases related specifically to ACE-inhibitor associated angioedema are primarily treated through recognition and discontinuation

of the offending agent. Antihistamines, steroids and intramuscular epinephrine 1:1000 may be used as adjunct therapies in cases where edema threatens airway patency. However, their efficacy has not been tested in clinical trials and is based on anecdotal reports. Recently, infusion of DX-88, a synthetic, potent inhibitor of kallikrein, has been successfully applied to accelerate resolution of attacks.[9] Long term management for either etiology should include permanent discontinuation of ACE-inhibitors and close referral to an allergy and immunology specialist. For cases of HAE, androgen derivatives have been successful in terms of prophylaxis.[13,15] Danazol is perhaps the most commonly prescribed agent, and tranexamic acid has been reported to be effective in terms of symptomatic treatment of swelling in up to 70% of patients.[13,15]

CONCLUSION

Angioedema secondary to HAE or ACE-inhibitor use is classically associated with facial and tongue swelling. However, intestinal angioedema commonly occurs in combination with facial involvement and rarely may occur in isolation. EPs must remain mindful of this entity, particularly in patients on ACE inhibitors or with a history of HAE presenting with acute abdominal pain, vomiting, or diarrhea. Early diagnosis may prevent morbidity from unnecessary exploratory surgery. Treatment of ACE-inhibitor-associated angioedema consists mainly of cessation of the offending agent; the management of HAE is much more poorly defined and should at minimum consist of supportive care and consultation with an allergy and immunology specialist.

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Massive Empyema

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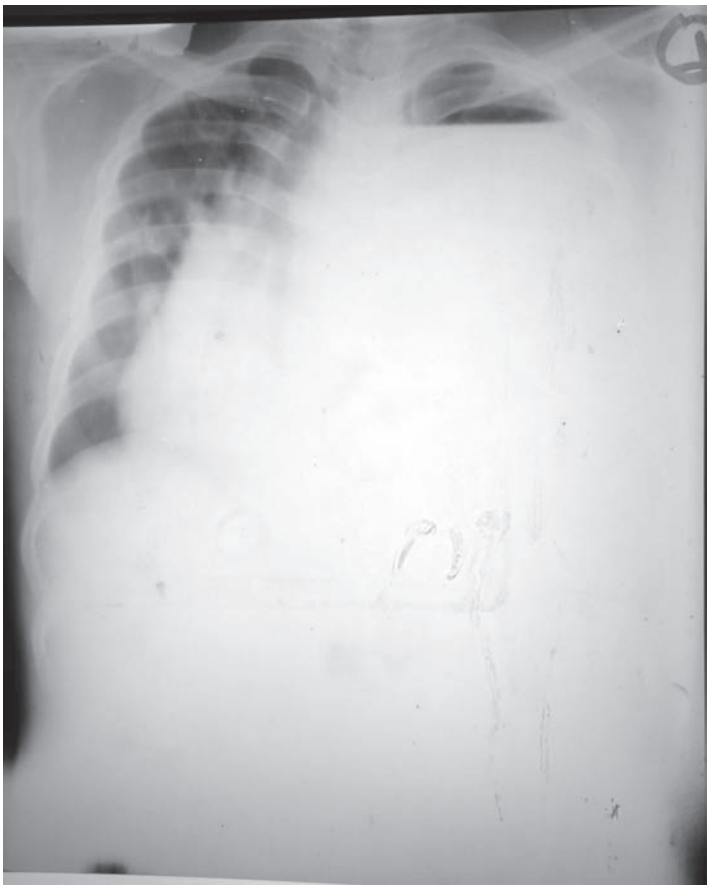

Figure 1. Chest radiograph of patient with progressive dyspnea

A 22-year-old man presented to a rural Ugandan clinic with three months of progressive dyspnea. He described a non-productive cough and subjective fevers and chills. He appears mildly dyspneic but is in no acute distress. His has a temperature of 37.7°C, pulse of 112 beats per minute, respiratory rate of 22 breaths per minute, blood pressure of 105/50 mmHg and an oxygen saturation of 93% on room air. Examination reveals absent breath sounds over the left chest. Chest radiograph demonstrates a massive fluid collection in his left hemi-thorax (Figure 1). Subsequent tube thoracostomy was productive of over three liters of purulent material (Figure 2). The patient tolerated the procedure without complication and was started on broad-spectrum antibiotics. AFB studies were eventually negative, but he was lost to follow-up.

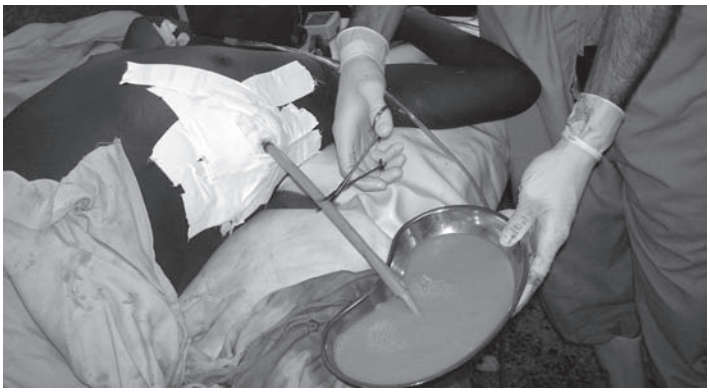

Figure 2. Outcome of chest tube thoracostomy

Patients with massive empyema, although uncommon in this country, are likely to be more frequently encountered as international medicine experiences increase. The early goals of empyema therapy include evacuation of the purulent collection, sterilization of the pleural cavity, and lung re-expansion.[1] Drainage requires aggressive management, such as large bore (at least 28 French) tube thoracostomy, with or without fibrinolytic therapy. The outer fibrin pleural peel of the empyema must be penetrated.

Complications from evacuating massive empyemas include re-expansion pulmonary edema (in adults from any cause and in children with malignant lymphoma), hemorrhage, secondary infection, pneumothorax and esophagopleural fistulas.[2,3] To prevent these complications, sterile technique is required and image guidance by computed tomography and/or ultrasound may be useful. It is recommended that no more than 1500 mL of fluid be drained at one time or that the drainage be limited to no more than 500 mL/hour.[4] Incomplete drainage may be attributed to pleural loculations or tube

clogging, kinking or malposition.[3] Debridement via video-assisted thoracoscopy or open thoracotomy may be required.[5]

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Acute Stroke from Air Embolism After Leg Sclerotherapy

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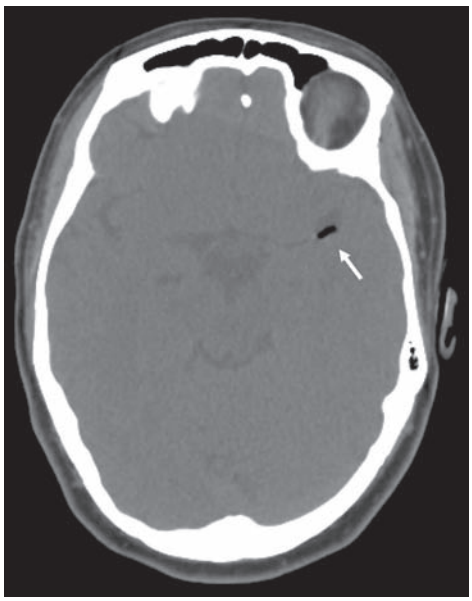

Figure 1. Computed tomography demonstrating an air embolism in the left middle cerebral artery distribution (arrow)

A previously healthy 38-year-old woman, with no significant past medical history, presented to the emergency department with acute onset of weakness after outpatient sclerotherapy. She had two milliliters of 0.5% foamed tetradecylsulfate injected into right lower extremity varicose veins. Twenty minutes after completion of the procedure, she had acute onset of right upper and lower extremity weakness. Computed tomography (CT) of the brain revealed gas within the distal left middle cerebral artery (Figure 1). She was treated with high flow oxygen via a non-rebreather facemask at 15 liters/minute. While transfer was being arranged to a facility with hyperbaric capabilities, her symptoms entirely resolved. Repeat neurologic examination 76 minutes after arrival revealed no residual deficits.

Complications from venous sclerotherapy involve pain at the site of injection, venous thromboembolism, improper injection into the arterial circulation and cutaneous necrosis.[1] While localized complications following sclerotherapy are well documented, the incidence of these complications is rare. Systemic complications, such as the CVA presented above, are even less common. Case reports by Forlee[1] and Hanisch[2] document stroke after foam injection. Morrison[3] examined a group of 21 patients with symptoms of visual disturbance or headache after foam sclerotherapy. Echocardiography identified foam particles in the right heart in all patients within 10 to 30 seconds of injection. Seven of those patients were found to have a patent foramen ovale and four had high-intensity signals in the middle cerebral artery, suggestive of paradoxical embolism. While a definitive relationship between the procedure and the complication cannot be documented in our patient, the occurrence of an air embolism immediately following venous sclerotherapy would suggest a causal association between the two events. Emergency physicians should consider the possibility of paradoxical embolization in the setting of new onset neurologic symptoms associated with venous foam sclerotherapy.

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Orbital Cellulitis and Abscess

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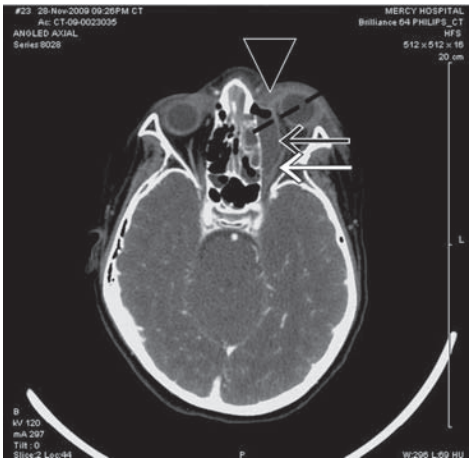

Figure 1. Axial view of contrast-enhanced CT scan demonstrating (black arrow) extraconal orbital subperiosteal abscess with air-fluid collection along the medial and anterior walls of the maxillary sinus with (white arrow) associated lateral displacement of the left medial and inferior recti, (arrowhead) left preseptal cellulitis with proptosis, (dotted line) left maxillary and ethmoid sinusitis.

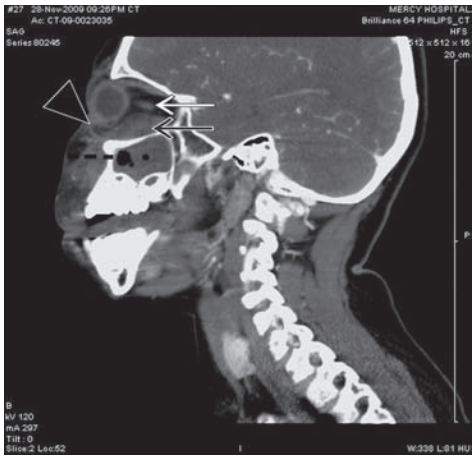

Figure 2. Sagittal view of contrast-enhanced CT scan demonstrating (black arrow) extraconal orbital subperiosteal abscess with air-fluid collection along the medial and anterior walls of the maxillary sinus with (white arrow) associated lateral displacement of the left medial and inferior recti, (arrowhead) left preseptal cellulitis with proptosis, (dotted line) left maxillary and ethmoid sinusitis.

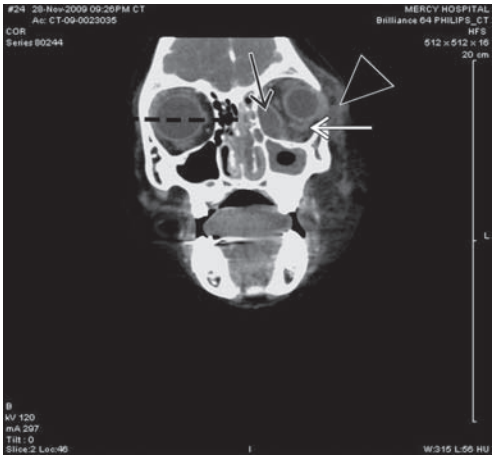

Figure 3. Coronal view of contrast-enhanced CT scan demonstrating (black arrow) extraconal orbital subperiosteal abscess with air-fluid collection along the medial and anterior walls of the maxillary sinus with (white arrow) associated lateral displacement of the left medial and inferior recti, (arrowhead) left preseptal cellulitis with proptosis, (dotted line) left maxillary and ethmoid sinusitis.

A seven-year-old male presented with fever, left-sided facial redness, swelling and proptosis over a 24-hour period. He had noted left-sided toothache and rhinorrhea over the preceding week. On presentation, he stated that he was unable to see "anything, including light" from his left eye. On physical examination, the patient was febrile with left periorbital swelling and significant left-sided proptosis, chemosis and loss of extra-ocular movements. As a part of the evaluation we obtained, a contrast-enhanced computed tomography (CT) scan, which demonstrated extraconal orbital subperiosteal abscess with air-fluid collection along the medial and anterior walls of the maxillary sinus with associated lateral displacement of the left medial and inferior recti, left preseptal cellulitis with proptosis, left maxillary and ethmoid sinusitis. We began intravenous Unasyn, and the patient underwent intraoperative drainage of the left orbital abscess, maxillary antrostomy, and total ethmoidectomy.

Orbital infections are posterior to the orbital septum and involve the orbit itself as compared to periorbital infections.[1] Given the make-up of its anatomical boundaries, the etiology of orbital cellulitis and abscess is often due to extensions of sinus infections.[1] Case reports from odontogenic sources have also been reported.[2] Physical exam differentiations between orbital infections from periorbital infections include proptosis, chemosis, and ophthalmoplegia.[1] CT scanning may assist in diagnostic differentiation, as well as in determining which patients will benefit from surgical intervention.[3,4] Common contrast-enhanced CT scan findings of orbital abscess include ring-enhanced lesion or an air-fluid level in the extraconal space, displacement of adjacent rectus muscle, marked

proptosis, and in advanced cases osteomyelitis of the orbital wall.[4] Causative organisms of orbital cellulitis and abscess include *S. pneumonia*, nontypable *Haemophilus influenzae*, *Moraxella catarrhalis*, group A *Streptococcuus*, *Staphylococcus aureus*, and anaerobes. Treatment involves intravenous antimicrobial therapy and in some cases surgical drainage.[1,5,6]

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Frail Patient with Abdominal Pain

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Volvulus is a frequent condition in patients presenting in the emergency department (ED) with abdominal pain. While cecal volvulus occurs more often in young patients, sigmoid volvulus is more common in elderly patients. [West J Emerg Med. 2010; 11(4):400-401.]

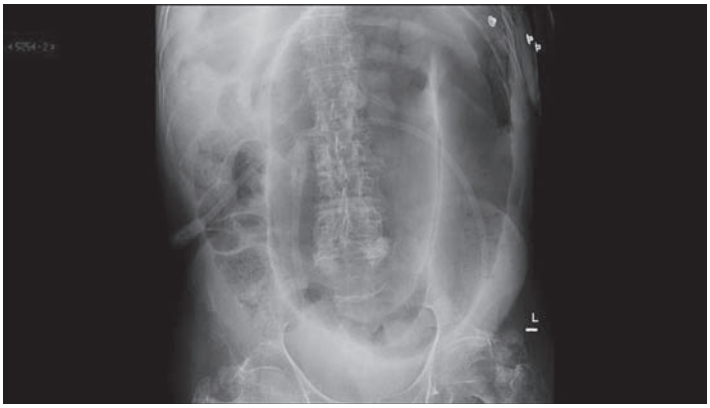

Figure 1. Abdominal radiograph

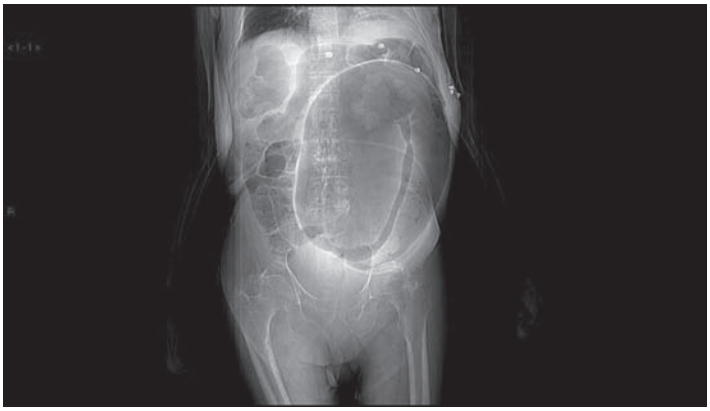

Figure 2. Anteroposterior scout film of computed tomography abdomen

A 76-year-old man presented with abdominal pain and constipation. A previous ischemic stroke and subsequent neurological complications had left him bedridden for six years. Surgical history included tracheotomy and gastrostomy tube. On admission he was normotensive and afebrile but mildly tachycardic. Abdominal examination revealed severe distension and tenderness in the left lower quadrant with localized peritonitis. Laboratory tests yielded leukocytosis. Abdominal radiographs and computed tomography (CT) revealed a markedly dilated sigmoid colon in the presence of distal volvulus. (Figures 1 and 2) With clinical and laboratory signs suggestive of gangrene, the patient underwent open laparotomy. Sigmoid volvulus with necrotic bowel was detected; reduction of the volvulus and sigmoid resection was performed. No surgical complication occurred, but he ultimately succumbed to pulmonary complications.

Volvulus is a common condition in patients presenting with abdominal pain. Cecal volvulus occurs more often in young patients, while sigmoid volvulus is more common in the elderly. Being bedridden, neuropsychiatric conditions and chronic constipation are common risk factors for sigmoid bowel involvement. Typical radiographs and CT findings include distended sigmoid loops with an inverted "U" shape and/or coffee-bean appearance (Figure 1 and 2). However, classic appearance is absent in one fourth of CT scans.[2] Treatment requires detorsion of sigmoid loops. Endoscopic reduction is effective in most cases; however, recurrence is common. Surgical approach is indicated in suspected gangrene, perforation and for patients with recurrent volvulus.

The increasing access of elderly and frail patients in emergency departments entails an increase in diagnosis of sigmoid volvulus, raising clinical and ethical questions about appropriate treatment.[3]

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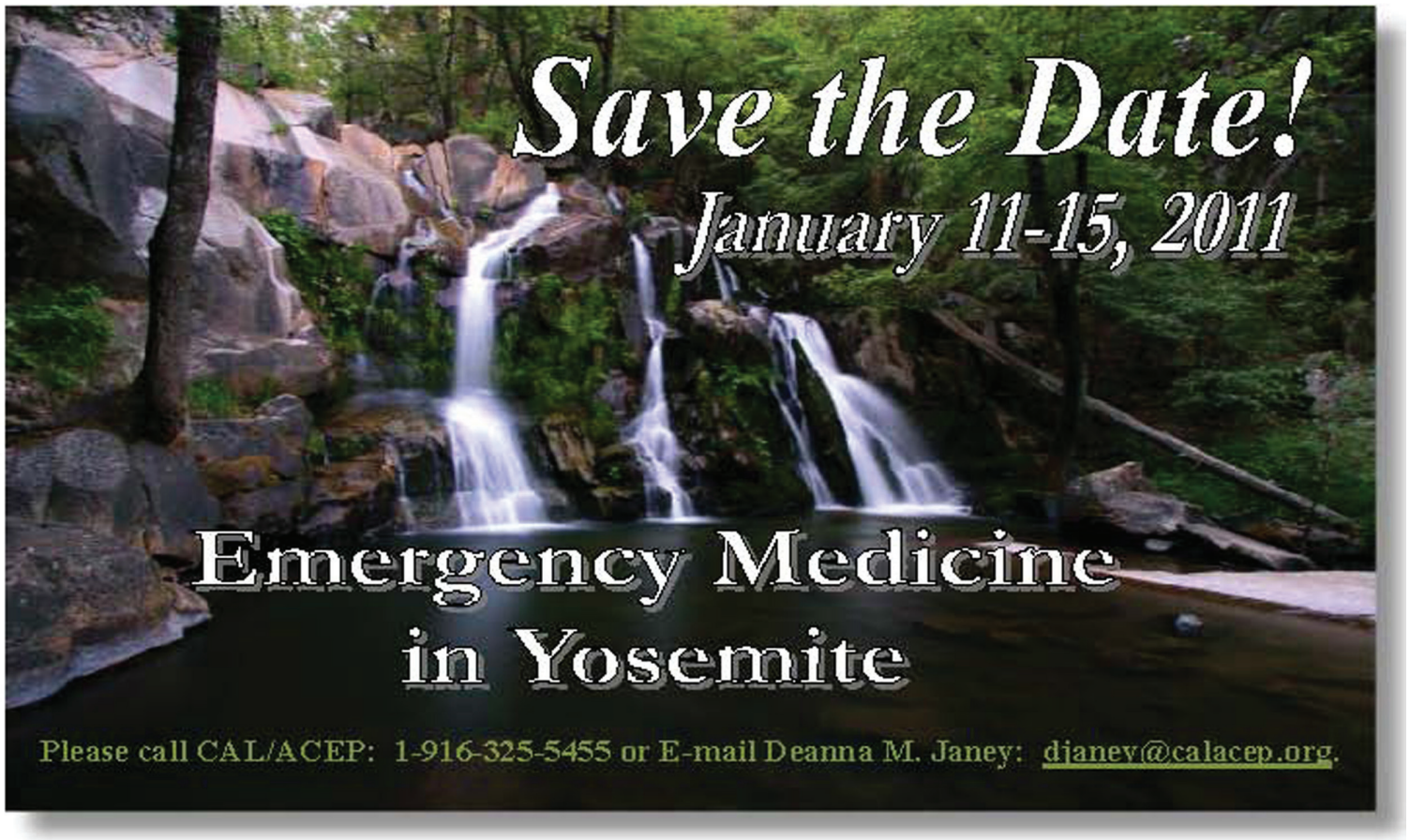

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