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Emergency Department Chief Complaint and Diagnosis Data to Detect Influenza-Like Illness with an Electronic Medical Record

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Background: The purpose of syndromic surveillance is early detection of a disease outbreak. Such systems rely on the earliest data, usually chief complaint. The growing use of electronic medical records (EMR) raises the possibility that other data, such as emergency department (ED) diagnosis, may provide more specific information without significant delay, and might be more effective in detecting outbreaks if mechanisms are in place to monitor and report these data.

Objective: The purpose of this study is to characterize the added value of the primary ICD-9 diagnosis assigned at the time of ED disposition compared to the chief complaint for patients with influenza-like illness (ILI).

Methods: The study was a retrospective analysis of the EMR of a single urban, academic ED with an annual census of over 60, 000 patients per year from June 2005 through May 2006. We evaluate the objective in two ways. First, we characterize the proportion of patients whose ED diagnosis is inconsistent with their chief complaint and the variation by complaint. Second, by comparing time series and applying syndromic detection algorithms, we determine which complaints and diagnoses are the best indicators for the start of the influenza season when compared to the Centers for Disease Control regional data for Influenza-Like Illness for the 2005 to 2006 influenza season using three syndromic surveillance algorithms: univariate cumulative sum (CUSUM), exponentially weighted CUSUM, and multivariate CUSUM.

Results: In the first analysis, 29% of patients had a different diagnosis at the time of disposition than suggested by their chief complaint. In the second analysis, complaints and diagnoses consistent with pneumonia, viral illness and upper respiratory infection were together found to be good indicators of the start of the influenza season based on temporal comparison with regional data. In all examples, the diagnosis data outperformed the chief-complaint data.

Conclusion: Both analyses suggest the ED diagnosis contains useful information for detection of ILI. Where an EMR is available, the short time lag between complaint and diagnosis may be a price worth paying for additional information despite the brief potential delay in detection, especially considering that detection usually occurs over days rather than hours. [West J Emerg Med. 2010; 11(1):1-9].

INTRODUCTION

Many emerging infectious diseases, as well as influenza, originally present as nonspecific "flu-like illness." As a result, a sudden unexpected increase in the number of individuals with nonspecific complaints, such as headache, fever, or vomiting, could be the first sign of an outbreak. While emergency departments (EDs) present an excellent opportunity to observe emerging outbreaks and other disease entities, it is beyond the ability of any single physician in one ED on one shift to be able to do this effectively; therefore, systems are necessary for detection. Syndromic surveillance provides earlier detection of an event by collecting and analyzing non-traditional health indicators or pre-diagnostic data to detect aberrant patterns compared to expected rates of these groupings.[1] Since the primary purpose of many syndromic surveillance systems is the earliest possible detection of a bioterrorist attack or natural disease outbreak, many rely on the earliest available data. To do otherwise, it would seem, would limit the timeliness of the detection system. Following this logic, many ED systems analyze patient chief complaints, which are potentially available for analysis as soon as the ED patient is triaged. However, other data, such as ED discharge diagnosis, may provide more accurate or specific patient diagnoses. If the delay in making the more accurate data available is not too great, they could potentially be more effective in detecting disease outbreaks. The growing use of electronic medical record (EMR) systems in EDs makes this a possibility worth investigating.

Prior studies have found that a combination of complaint and diagnostic codes demonstrated the best accuracy and sensitivity for detection of the flu season.[2] Similarly, a retrospective analysis of over 500,000 patients found that for most syndromes, the chief-complaint classification system alone could identify only about half of patients with relevant syndromic presentations.[3] Other studies have found good agreement between different syndrome coding schemes; however, agreement between individual syndromes varied substantially.[4] Nonetheless, a study of the National Capitol Region's ED Syndromic Surveillance System found overall good agreement between chief complaint and diagnosis data, which was highest for respiratory and gastrointestinal syndromes.[5]

Purpose of this investigation

The purpose of this study is to characterize the added value of the primary ICD-9 diagnosis assigned at the time of ED disposition ("ED diagnosis") compared to the chief complaint assigned at the time of presentation ("chief complaint") for ED patients with influenza-like illness (ILI). We address this question in two ways. First, presuming that the ED diagnosis is more accurate, we determine the proportion of patients whose apparent diagnosis differs in the two data systems, how this proportion varies according to chief complaint, and the most common types of changes that occur. Second, by comparing time series and applying standard syndromic detection algorithms, we determine whether chief complaint, ED diagnosis, or both are the best indicators for the start of the influenza season.

Importance

ED diagnosis may contain more accurate and thus useful information than chief complaint for detection of outbreaks of ILI. Using an ED EMR in which diagnoses are assigned within several hours of patient presentation could mitigate concerns about the timeliness issue while providing more specific information.

METHODS

Study Protocol

Relationship Between Chief Complaint and Diagnosis

We conducted a retrospective search of the ED EMR data from June 2005 to May 2006 and analyzed data to ascertain the relationship between chief complaint and final diagnosis for the following categories: respiratory, gastrointestinal and viral illness. The study was conducted at a single urban, academic emergency department with a four-year emergency medicine residency and approved by the local Institutional Review Board.

The ED is staffed by board-certified emergency physicians, physician assistants, EM residents and rotating residents (mainly PGY-1s) from other departments (surgery, internal medicine, and OBGYN). Pediatric patients under age 18 constituted less than 10% of all cases for each category we evaluated. During the time our data was generated, chief complaints and diagnoses were selected to be similar to the Centers for Disease Control (CDC) clinical criteria for ILI, which included fever, headache, dry cough, sore throat, rhinorrhea, and myalgias.[6] Nausea, vomiting and diarrhea can occur with ILI and were included in our analysis, although these are mainly symptoms in children. Because of the small proportion of pediatric patients, we did not include otitis media or otalgia in our categorization, even though it can be a presenting symptom in children. The complaint and diagnostic codes were then sorted into groups based on constellations of clinical complaints; i.e. upper respiratory infection, asthma exacerbation, viral illness, malaise and myalgias, fever, and pneumonia. In addition, we chose to evaluate the complaint of nausea/vomiting and diarrhea for evaluation of gastrointestinal outbreaks. We excluded abdominal pain due to the large proportion of non-infectious and surgical causes of abdominal pain in adults. Diagnoses were similarly selected based on their association with ILI and categorized into diagnosis groups suggestive of a possible infectious etiology (i.e. bronchitis, pneumonia, upper respiratory infection, acute sinusitis, pharyngitis, fever, and myalgias)

The EMR in use at our institution (IBEX by Picis, Inc.)

allows free text of the chief complaint, as well as entry from a pull-down menu by the triage nurse. In our EMR, some chief complaints are entered as symptoms and others entered as an interpretation by the triage nurse; for example, cough and fever, as compared to "pneumonia symptoms." Most chief complaints were entered from a pull-down menu as opposed to free text entry. In most cases, entering of the complaint as free text was the same as the pull-down (i.e. diarrhea or headache); in other cases the free text complaint was different but conveyed the same information; for example, "pneumonia symptoms" instead of pneumonia. One hundred percent of sore throat, fever, viral illness, headache, and myalgia were entered from the pull-down menu or were the same as the pull-down terms. For nausea/vomiting/diarrhea the entries were slightly more diverse, but 100% fell into one of the following categories: food poisoning, gastritis, n/v (nausea/vomiting), n/v/d (nausea/vomiting/diarrhea), and diarrhea. Thus, exclusion of the free text complaints would not have affected the results. Final diagnosis is entered by the physician (either by the attending physician, an EM resident or a junior resident under supervision) from a pre-determined set of ICD-9 codes used for billing purposes. It is typically entered at the time of patient disposition and is based on the clinical information available at the time of entry. Thus, in some cases the chief complaint and final diagnosis are the same if the clinician did not have additional information on the diagnosis at the time of disposition (for example, chest pain instead of pericarditis). In general, diagnoses are entered by EM providers (attendings, residents, and physician assistants) rather than first-year rotating residents; therefore, we feel these diagnoses are in general reflective of more mature clinical judgment.

Patients were cross-tabulated according to chief complaint and final diagnosis in three categories – respiratory, gastro-intestinal, and viral chief complaints – and the most common patterns were noted.

Data Analysis

Comparison between the specific chief complaints and diagnoses and CDC data for the 2005-2006 influenza season:

We also analyzed the chief complaint and diagnosis data for time trends between June 1, 2005 and May 24, 2006 for asthma, nausea/vomiting/diarrhea, pneumonia, sinusitis/ upper respiratory infection (URI) and viral illness, and we compared these trends to the CDC data for the 2005-2006 influenza season for the South Atlantic region in order to track the level of agreement between the ED data and the CDC data for this particular influenza season.[7]

Detection of outbreak of influenza in the 2005-2006 influenza season using syndromic surveillance systems based on complaint vs. diagnosis data:

To understand what may be gained from using diagnosis data as opposed to chief-complaint data in syndromic surveillance systems, we applied statistical detection algorithms to daily counts of both chief complaint and diagnosis data. For each condition, we standardized the daily counts by dividing the daily count by the mean number of cases in the non-influenza season, where the non-influenza season was defined to be May through November of each calendar year. Since only five dates had missing data, four of which occurred in the non-flu season, daily counts on these dates were set equal to zero for each condition. Dates with missing data were days that no complaint or diagnosis category used in the analysis had been assigned to any patients and impacted the viral-illness category only.

We used three statistical algorithms to determine the beginning of the influenza outbreak in the 2005-2006 influenza season: the univariate cumulative sum (CUSUM), the exponentially weighted moving average CUSUM, and the multivariate CUSUM. The univariate CUSUM algorithm monitors the daily statistic S_i, which is defined by the recursive formula

$$S_i = \max(0, S_{i-1} + (X_i - \mu) - k).$$

In this formula X_i denotes the observed daily count on day i, μ denotes the overall mean daily count estimated from the data, and k is an off-set parameter set by the user.[8,9] The algorithm alarms or flags whenever S_i exceeds a value h, where h is computed empirically to guarantee a user-defined false positive rate in the non-flu season.

The CUSUM based on deviations from an exponentially weighted moving average, which we refer to throughout as EXPO, adds one additional step to the CUSUM algorithm described above.[10] First, the EXPO algorithm predicts the daily counts, X_i, using an exponentially weighted moving average. Specifically, it defines

$$Z_i = \lambda X_i + (1 - \lambda)Z_{i-1}$$

where $0 \leq \lambda \leq 1$ is a user-specified parameter. The algorithm then monitors the differences between the actual and predicted counts using the statistic S_i, which is defined by the following recursive formula

$$S_i = \max(0, S_{i-1} + (X_i - \mu) - k).$$

As with CUSUM, the EXPO algorithm flags whenever S_i exceeds a value h, where h is computed empirically to guarantee a fixed, user-specified false positive rate in the non-flu season.

Finally, we utilized the multivariate CUSUM algorithm, which we refer to as MV CUSUM. The MV CUSUM was developed for monitoring multiple streams of data on a daily basis (e.g., streams of data from more than one hospital or streams of data representing multiple conditions within a hospital).[11] It follows the same logic as the standard CUSUM, except that now daily counts are represented by a vector $\boldsymbol{X}_i$. We define

$\boldsymbol{S}_i = (\boldsymbol{S}_{i-1} + \boldsymbol{X}_i)(1 - k/C_i)$, if $C_i > k$

and $\boldsymbol{S}_i = \boldsymbol{0}$ if $C_i \leq k$ where

$C_i = \{(\boldsymbol{S}_i^t \boldsymbol{\Sigma}^{-1} \boldsymbol{S}_{i-1}\}^{1/2}$

and Σ^{-1} is the estimated variance-covariance matrix for the p streams of data being analyzed using only daily counts from the non-flu season. The MV CUSUM algorithm flags whenever S_i exceeds a value h, where h is computed empirically to guarantee a fixed false positive rate (user-specified) in the non-flu season. For each algorithm, we set the detection threshold, h, to ensure that the false positive rate is 1 percent outside of the influenza season.

Before applying the three algorithms to the data, simulation studies were used to fine-tune the key parameters of each algorithm, namely k for the CUSUM, k and λ for the EXPO, and k for the MV CUSUM (see Stoto MA, Griffin BA, Jain A, Davies-Cole JO, et al. for details).[12] Syndromic surveillance systems based on a single stream of chief complaint or diagnosis data and based on multiple streams of chief complaint and diagnosis data were fine-tuned separately. We used the values of the key parameters that were determined to work best for a given system in the analysis below, which examines the ability of the system to detect the beginning of the influenza outbreak in the influenza season. We regard an influenza outbreak to be the period characterized by a sudden increase in the number of people with influenza-like complaints. This is distinct from the influenza season, which is generally defined to be the period during which influenza outbreaks are more likely to occur in the calendar year, generally taken to be between December and April.

RESULTS

Relationship between chief complaint and diagnosis*:*

In our analysis we included 5,682 ED encounters that fit the complaint or diagnostic categories from June 2005 to May 2006, out of 56,747 ED visits. Twenty-nine percent of patients presenting to the ED had a different diagnosis at the time of disposition than their chief complaint, as interpreted by the triage nurse.

Some chief complaints were more likely to be inconsistent with the final ED diagnosis. These differences can be viewed as a positive trait, in that they provide additional information for syndromic surveillance that may be worth the additional several-hour wait for the ED diagnosis. Specifically, the percent of disagreement was higher for gastrointestinal complaints (39%) than for respiratory or viral complaints (29% and 24%, respectively). Diagnoses that were consistent or the same as the chief complaint were labeled as "agreement." In particular, the chief complaints of weakness (15% "agreement"), body aches (41% "agreement"), upper respiratory infection (46% "agreement"), and "nausea and vomiting" (55% "agreement") were not informative about the diagnosis, while pneumonia symptoms (98% "agreement"), asthma (92% "agreement") and sore throat (99% "agreement") showed consistency between chief complaint and ED diagnosis. See Table 1 for detailed results. Highlighted values represent those diagnoses consistent with the corresponding chief complaint.

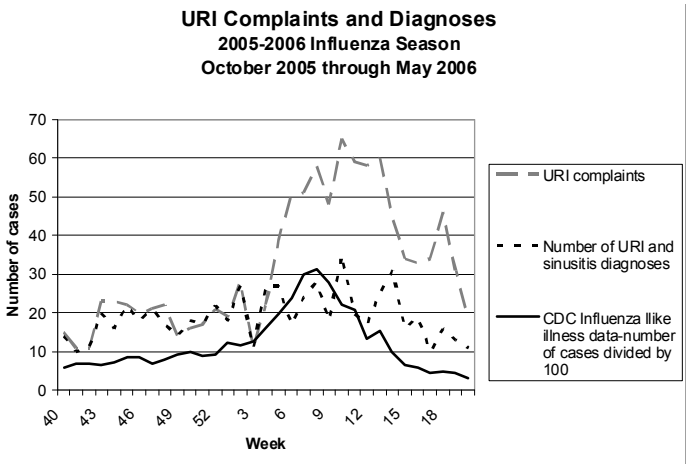

Figure 1. Upper Respiratory Infection (URI) Complaints and Diagnoses

Comparison between the specific chief complaints and diagnoses and CDC data for the 2005-2006 influenza season:

The weekly counts of ILI-related chief complaints and diagnoses from June 1st, 2005 through May 24, 2006 were analyzed for trends compared to the CDC data for ILI, as reported by laboratory and outpatient sentinel physician surveillance for the South Atlantic region. By convention, the weeks of the flu season are numbered starting on week 40 of the Fall and continuing through week 20 in the following year. The grouping for the complaint of URI includes chief complaints of URI symptoms as well as "flu." We grouped the diagnosis category for URI to include the upper respiratory categories of URI as well as acute sinusitis, as clinically acute sinusitis commonly occurs during upper respiratory infections. As seen in Figure 1, the peak for URI complaints and diagnoses occurs at week 10 with 35 cases daily, whereas the CDC ILI data shows peak at week 7. Complaints of sinusitis and URI rise at week 4 and peak at week 10. The trends for URI complaints and the CDC influenza data show similar trends. For our data, URI diagnoses were at their highest in week 10, at the same time as the peak for influenza A diagnoses for the region. Weeks 13 to14 represented the second wave of URI diagnoses for our data, correlating to another upswing in percentage of ILI across the South Atlantic region. The lowest points of reported ILI throughout the region also correspond exactly to the downward trends of URI diagnoses in Washington D.C., of particular note weeks 3, 17, and 20. It is interesting to note that URI complaint data appears to rise earlier in the influenza season than the URI diagnosis data and may be an earlier indicator for the beginning of the influenza season. Furthermore, because there is only 46% agreement overall for URI complaint and diagnosis, patients presenting with URI symptoms may be

Table. Respiratory, GI and viral complaints by diagnosis. Values highighted in gray represent those diagnoses consistent with the corresponding chief complaint.

Respiratory

Chief complaints	Asthma	Acute bronchitis	Cellulitis	Cough	COPD	Dyspnea	Fever	Influenza	Pleurisy/Pneumonia	Pharyngitis (strep)	Pharyngitis (other)	Sinusitis	URI	Viral illness	Other	Total	% "agreement"
Asthma	332	17													12	361	92%
Cough		1	2	64	2	4	1		14						13	101	63%
Pneumonia		1							160				1		1	163	98%
URI	3	382	3		1	3	3	1				278	602	3	28	1307	46%
Influenza								4							1	5	80%
Respiratory Complaint	3	1	1		4	5			15							29	0%
Sore throat										195	653				10	858	99%
Total																2824	71%

GI

Chief complaints	Abdominal Pain	Acute Pancreatitis	Dehydration	Diabates/DKA	Diarrhea	Electrolyte Abnormality	Enteritis/Colitis	Gastroenteritis (Food Poisoning or Viral)	GI Bleed	Gastritis	Hyperemesis Gravidarum	Influenza	N/V	Other	Total	% "agreement"
Diarrhea	2	4	7		43	2	54	29	2					14	157	27%
Food Poisoning	2							119		1	1				123	97%
Gastritis	3						1			123				2	129	95%
Nausea/ Vomiting	4	12	32	16	2	8	9	6	21	2	5	1	274	105	497	55%
Nausea/ Vomiting/ Diarrhea	4		1			1	3	1						2	12	0%
Total															918	61%

Viral

Chief complaints	Cardiac Diagnosis	Cellulitis	Cerebrovascular Disease	Fever	Headache	Meningitis	Myalgia	Pleural Effusion/Pneumonia	Sepsis	UTI	Weakness-Malaise-Fatigue	Viral Illness	Other	Total	% "agreement"
Viral Illness												317	7	324	98%
Weakness	20		31	3				9	7	5	30		94	199	15%
Malaise and Fatigue				1							136		6	143	95%
Myalgias	3	4		7			41	7	2	5			30	99	41%
Headache	8		17	7	748	21			2		2	6	78	889	84%
Fever		16		204				32	16	18				286	71%
Total														1940	76%

N/V, nausea/vomiting; *COPD*, chronic obstructive pulmonary disease; *URI,* upper respiratory infection; *UTI*, urinary tract infection.

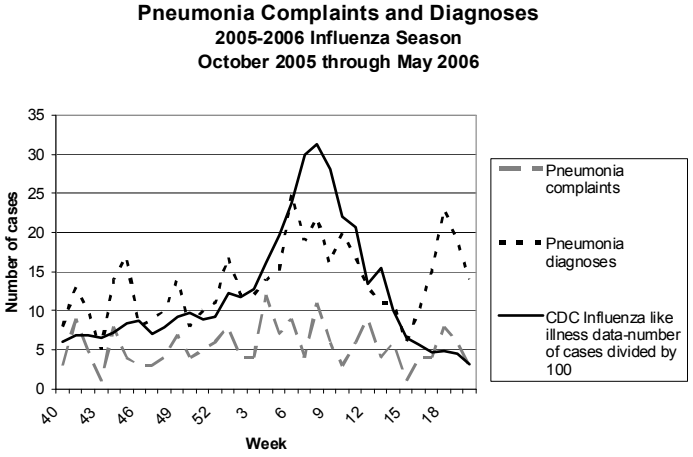

Figure 2. Pneumonia Complaints and Diagnoses

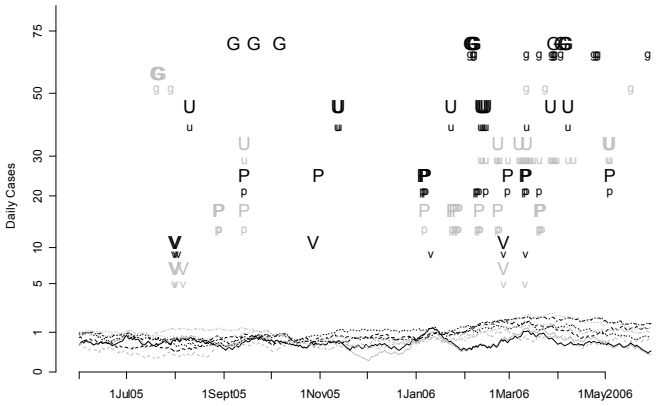

Figure 3. Univariate cumulative sum (CUSUM) and EXPO algorithm flags for each chief complaint and emergency department diagnosis category for 2005-2006. Gray and black lines denote observed daily counts for the complaint and diagnosis data, respectively. Gray and black symbols denote the algorithm flags (capital letters = EXPO flags; lowercase letters = CUSUM flags and v = viral illness; p = pneumonia; u = URI; g = gastrointestinal).

assigned an alternative diagnosis (such as viral illness or bronchitis, for example).

In a similar comparison (results not shown) of viral illness complaints and diagnosis compared to ILI data for the South Atlantic region for the 2005-2006 season as reported to the CDC, we found that the complaint and diagnosis graphs correspond well. We selected the category of viral illness from the triage nurse-entered chief complaint of viral illness and the final discharge diagnosis of viral illness. The diagnosis of viral illness peaked at week 10 (March 4-10) with 15 patients, and the most prominent bimodal crests for viral illness occur during week 52 to week 2 of the influenza season, and weeks 8-11.

Figure 2 shows pneumonia complaints and diagnosis compared to ILI data for the South Atlantic region for the 2005-2006 season, as reported to the CDC. There was a low level of background "pneumonia symptoms" chief complaint as interpreted by the triage nurse, which poorly follow the trends for ILI. However, pneumonia diagnoses for our data peak at week 6 with 25 patients, followed by week 18 with 23 patients; week 8 with 22 patients, and week 10 with 20 patients. These trends are consistent with ILI curves for the South Atlantic region.

The highest peak of the regional influenza corresponds to the highest peak of the number of pneumonia cases diagnosed for the South Atlantic region. Regional data and our ED diagnosis data for pneumonia also follow similar trends on week 1, where the percentage of ILI reports peaks for the South Atlantic region and our data peaks for the number of cases of pneumonia that were clinically diagnosed in the ED.

Fever and asthma exacerbation (not shown here) showed poor correlation with the CDC ILI trends. Asthma exacerbations peaked in the spring and fall, which did not correspond with the influenza season, but may be related to other factors such as seasonal allergies and environmental changes, including ozone and pollen counts.

Detection of outbreak of influenza in the 2005-2006 influenza season using syndromic surveillance systems based on complaint vs. diagnosis data:

Finally, Figures 3 and 4 display the dates upon which fine-tuned versions of the CUSUM, EXPO, and MV CUSUM algorithms flagged unusually high occurrences of a given chief complaint or diagnosis category, or group of categories, on a particular day from June 1, 2005 until May 30, 2006. The goal of these analyses is to determine which individual streams of data (Figure 3) and which groups of data streams (Figure 4) consistently and in a timely fashion flag the beginning of the influenza outbreak in the 2005-2006 influenza season. In these figures, smoothed values for the standardized number of cases are shown for each chief complaint and diagnosis group. The flagging of the detection algorithms is represented by symbols (lowercase letters for CUSUM, uppercase letters for EXPO, and Δ for MV CUSUM) plotted according to the day they flagged on the horizontal axis and along different fixed values on the vertical axis to help distinguish more clearly between the data streams being compared. Thus, for example, in Figure 3, pneumonia complaints (marked by the lower and upper case *p*'s in gray) were at unusually high occurrences at the end of August and beginning of September as indicated by both the CUSUM and EXPO algorithms. In Figure 4, both the circles and triangles denote unusually high occurrences of the diagnosis and complaint data, respectively, where high occurrences are measured jointly across three categories of data: viral illness, URI, and pneumonia.

Figure 3 displays the performance of the CUSUM and EXPO algorithms for flagging the beginning of the influenza outbreak when only applied to one stream of data (e.g. either one chief complaint or diagnosis group). Taken individually,

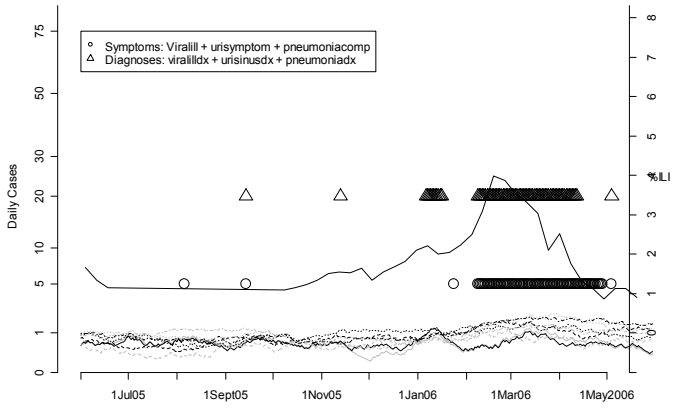

Figure 4. Multivariate cumulative sum (CUSUM) algorithm flags for two different syndromic surveillance systems for 2005-2006, one based on three streams of chief complaint data (flags denoted by circles) and one based on three streams of emergency department diagnosis data (flags denoted by triangles). The CDC regional influenza like illness (ILI) curve is plotted in the center of the graph for reference. The gray and black lines at the bottom of the graph denote observed daily counts for the complaint and diagnosis data, respectively.

only URI complaints (gray lower and upper case *u*'s) appears to flag the beginning of an influenza outbreak in the winter of 2006 with any consistency, indicating that an influenza outbreak in the winter of 2006 began in the beginning of March. Pneumonia compliant cases (gray lower and upper case *p*'s) also appear to flag with some consistency during the winter of 2006, indicating the possibility that an influenza outbreak began in mid-January. Pneumonia diagnosis cases (black lower and upper case *p*'s) follow a similar trend to URI and pneumonia complaint but do so with more sporadic flags. It is interesting to note that URI complaint data flags the detection of an influenza outbreak more consistently than URI diagnosis data (black lower and upper case *u*'s). This difference of information between the chief complaint and the diagnosis may vary depending on the time of the year; therefore, the chief complaint remains useful even in the case where one has the additional information provided by the diagnosis. The performance between pneumonia complaint and pneumonia diagnosis data is much less clear with complaints flagging more consistently earlier on in the influenza season and diagnosis data flagging more consistently at the end.

Figure 4 displays the results from applying the MV CUSUM to two different possible surveillance systems, which could be comprised using the ER data: one that only uses the complaint data of viral illness, URI symptoms, and pneumonia complaints and one that uses confirmed diagnosis data from viral illness, URI, and pneumonia. Each system flags an influenza outbreak in 2006. The system based on diagnosis data flags the start of an influenza outbreak about one month earlier than the system based solely on the chief complaint data. Figure 4 also plots the CDC regional data for ILI for the 2005 to 2006 influenza season, showing how well the three syndromic surveillance algorithms, univariate CUSUM, exponentially weighted CUSUM and multivariate CUSUM, did at flagging the beginning of the flu season in the winter of 2006.

DISCUSSION

Certain chief complaints are more accurate than others in predicting final ED diagnosis. Because 29% of the patients studied had a different final ED diagnosis compared to chief complaint, for those categories in which there is significant variation, ED diagnosis is presumably more specific, and may be worth using in syndromic surveillance systems if one can accept the small delay of several hours in action for greater information. It is important to note that this delay may be more significant for traditional paper record systems, thus emphasizing the advantage of the EMR for syndromic surveillance of ILI.

For respiratory syndromes, prior studies have found good sensitivity of chief complaint and diagnosis. Using an EMR, it has been found that diagnosis is superior to chief complaint alone for respiratory illness in the pediatric population, and longitudinal studies have found that respiratory syncytial virus and influenza testing corresponded well with respiratory syndrome counts.[13, 14] A study by the University of Pittsburgh Realtime Outbreak Disease Surveillance Laboratory (RODS) concluded that using ICD-9 coded chief complaints for acute respiratory illness yielded moderate sensitivity (44%) but very high specificity (97%) – this study found no difference for the ICD-9 coded diagnoses.[15] For our data this pattern is apparent for pneumonia, asthma and URI complaints; however, other complaint indicators such as weakness, myalgias, and gastrointestinal complaints are less accurate. Other studies have found better agreement between surveillance forms and ED diagnosis data when compared to chief complaint data.[16]

In our data set, certain clinical complaint and diagnostic categories retrospectively show the rise and peak of the influenza season, such as pneumonia, URI and viral illness; whereas others, such as fever, do not appear to correspond as well to the influenza season. Fine-tuned statistical detection algorithms applied to single complaint and diagnosis categories, even those found to be accurate for the start of the ILI season, performed rather poorly at detecting the onset of an influenza outbreak in real-time modeling. Except for URI complaints, none of the chief complaint and diagnosis categories consistently flagged the influenza outbreak that occurred in the winter of 2006 when examined in isolation. It is particularly interesting to note that URI chief complaint data flag the influenza outbreak more consistently than URI diagnosis data. However, when three of the most predictive complaint and diagnosis categories were modeled using multivariate flags, they indicate the outbreak of influenza more

consistently and clearly. Use of such multivariate syndromic surveillance systems plays an important role in improving syndromic surveillance systems currently in use. Moreover, our results suggest that syndromic surveillance systems based on more than one stream of diagnosis data might allow for more timely detection of influenza outbreaks than systems based on more than one stream of chief complaint data with the system based on diagnosis data flagging the start of an influenza outbreak about one month earlier than the system based solely on the chief complaint data.

Although the influenza season for 2005-2006 had a less intense peak and occurred over a longer period of time compared to the three prior seasons,[7] we feel this does not impact the validity of our analysis, since we were interested in detecting the onset rather than the peak of the influenza season. Furthermore, our analysis demonstrates that even in this atypical year, we were able to detect the onset of the influenza season using the chief complaint and diagnostic categories. The diagnosis added information that was valuable for earlier detection, which might be especially true in an atypical season where the onset of the outbreak may not be "obvious" to clinicians.

System stability may depend on coding, such as the shift from ICD-9 to ICD-10 billing codes.[17] Use of the EMR at our institution mitigates this, as diagnoses are selected from a drop-down menu where available ICD codes have already been assigned. One limitation is the inability to select for an "unusual" ICD-9 diagnosis that has not already been pre-loaded into the system. The EMR may yield syndromic data that may be more sensitive and specific in detecting outbreaks than the patient-centered chief complaint data more commonly used. It provides the opportunity for collaboration between ED healthcare providers and health officials and any needed response to aberrant signals.[18,19] The goal of syndromic surveillance is a sensitive system that minimizes costly false alarms.[20] The use of an EMR system may mitigate concerns regarding timeliness, as delays of only hours are expected between reporting of chief complaint and discharge diagnosis. Electronic systems that allow for immediate clinician assignment of diagnoses such as ours may enhance specificity. This type of information technology may facilitate earlier detection, communication between entities, and the use of database systems for epidemiologic intelligence.[1]

The use of individual hospital syndromic surveillance has many potential benefits. It may lead to earlier local detection of influenza-like illness without the delay of traditional sentinel surveillance and subsequent institution of control measures, such as flu vaccination campaigns for hospital employees and patients, earlier use of isolation precautions in the ED for patients with suspected ILI or who have upper respiratory complaints, and earlier collaboration with health department officials.

LIMITATIONS

Our data is based on a retrospective review of a single institution's EMR system for one year of data. This analysis should be replicated on more years of data, as well as in other hospitals, to confirm the potential benefit careful monitoring of diagnosis data might have for syndromic surveillance systems. The complaint and diagnostic criteria used for analysis have not been validated in other syndromic surveillance systems and were derived by the investigators based on the CDC clinical criteria for ILI for the 2005-2006 season. If the CDC definition for ILI changes, it is possible that the categories we used would need to be revised. Nonetheless, we do not expect the symptoms of influenza to change significantly from year to year, and would still include fever, upper respiratory symptoms, myalgias, etc. We do not have laboratory confirmation of influenza cases to validate our criteria. Additionally, the CDC data used for comparison in our study is for a broad geographic area, the South Atlantic region. Comparing a single urban hospital's ED data to this broad regional data may not be an accurate comparison if the data for the District of Columbia was significantly different than the CDC regional data. Although it may be worth the wait for ICD-9 diagnoses, this depends on early electronic coding of the diagnosis, which does not occur in all hospital systems.

A strength of the paper is that even though the diagnosis of influenza was not laboratory confirmed, we were still able to demonstrate the beginning of the influenza season by our data using fine-tuned statistical detection algorithms. In this urban center, testing is not currently part of triage protocols, as it is at some other hospitals. Thus, reliance on chief complaint or diagnosis codes may provide earlier indication of the start of the influenza season in this case.

CONCLUSION

Both analyses suggest the ED diagnosis may contain more specific and useful information for detection of outbreaks of ILI than chief complaint. This is not to say that the ED diagnosis is more accurate, more useful, or even different than the chief complaint for all patients. However, where an EMR is available, the short delay between chief complaint and diagnosis may be a price worth paying for the additional information for patients whose ED diagnosis is more accurate than their chief complaint, so both are desirable.

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Emergency Department Crowding: Factors Influencing Flow

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Background: The objective of this study was to evaluate those factors, both intrinsic and extrinsic to the emergency department (ED) that influence two specific components of throughput: "door-to-doctor" time and dwell time.

Methods: We used a prospective observational study design to determine the variables that played a significant role in determining ED flow. All adult patients seen or waiting to be seen in the ED were observed at 8pm (Monday-Friday) during a three-month period. Variables measured included daily ED volume, patient acuity, staffing, ED occupancy, daily admissions, ED boarder volume, hospital volume, and intensive care unit volume. Both log-rank tests and time-to-wait (survival) proportional-hazard regression models were fitted to determine which variables were most significant in predicting "door-to-doctor" and dwell times, with full account of the censoring for some patients.

Results: We captured 1,543 patients during our study period, representing 27% of total daily volume. The ED operated at an average of 85% capacity (61-102%) with an average of 27% boarding. Median "door-to-doctor" time was 1.8 hours, with the biggest influence being triage category, day of the week, and ED occupancy. Median dwell time was 5.5 hours with similar variable influences.

Conclusion: The largest contributors to decreased patient flow through the ED at our institution were triage category, ED occupancy, and day of the week. Although the statistically significant factors influencing patient throughput at our institution involve problems with inflow, an increase in ED occupancy could be due to substantial outflow obstruction and may indicate the necessity for increased capacity both within the ED and hospital. [West J Emerg Med. 2010; 11(1):10-15]

INTRODUCTION

A survey of 250 Emergency Departments (ED) published in the *Annals of Emergency Medicine* in 2003 found that 11% of them regularly were on diversion, 73% had two or more boarded patients, 59% used hallways for patients, 38% doubled up patients in rooms, and 47% used non-clinical space for patient care.[1] This situation is not foreign to most EDs in the country and has been termed as "crowding." As alarming as these statistics sound, those within the realm of emergency care know that it is not new and, most importantly, the problem is getting worse.[2]

Given our saturated healthcare system, medical personnel dread the proverbial "straw" that will break the camel's back. In the setting of emergency health care, that "straw" could be a mass casualty incident, such as a natural disaster or terrorist attack. Several sources have voiced concerns about disaster preparedness in our crowded EDs, although a single massive incident is not all that is required to stress a saturated system.[3] During times of crowding, something as minor as a heavy flu season or local hospital closure can push an already struggling ED over the brink. Social factors, such as the current economic climate, can also increase volume as patients turn to EDs for primary care after losing jobs with health benefits. A common response to crowding is to create more room

within the department to accommodate the influx of patients. However, it has been suggested that increasing capacity in an already inefficient system only serves to potentiate the problem, not solve it.[4,5]

Therefore, it's imperative to first examine which factors within the institution contribute to crowding and then maximize efficiency within this system before addressing physical space limitations. Crowding is a complex issue and no single factor can explain why it occurs.[6] The goal of our study was to evaluate those factors, both intrinsic and extrinsic, which influence patient flow through the ED. The components of patient flow studied were "door-to-doctor" time and dwell time (time from disposition to physical transport to in-patient bed).

METHODS

Study Design

We conducted a prospective cross-sectional cohort study of all adult patients seen or waiting to be seen at 8pm, Monday through Friday, over a 1.5 month period (September 25–November 21, 2006). We chose this methodology to provide a "snapshot" or static view of the department that could be used to reflect the status at the busiest time of the day. The developed protocol met the criteria for exemption from institutional review board review at our facility.

Setting

This study took place in an urban Level II Trauma Center ED with a volume of 50,000 adult visits per year. The department, which has 55 adult treatment bays, is located in a 570-bed acute care facility.

Selection of Participants

We included all adult patients older than 18 who were being seen or waiting to be seen at 8pm in the main ED from Monday through Friday. Weekends were excluded due to limited research department staffing. Pediatric patients, as well as category C patients seen in our "fast track" service, were not accounted for in this study. Both are separate operating entities outside of our main ED and were not followed due to different patient-flow dynamics.

Methods and Measurements

Trained research assistants documented the various study times using different modalities. The "door" time, for example, was taken from a triage form that is automatically time-stamped when the patient is triaged by a nurse, either in the ED waiting room or ambulance triage area. The "doctor" time was taken from the emergency physician's (EP) notes, which have to be manually entered when the EP first makes contact with a patient. The "door-to-doctor" time was the difference between these two variables. After patient disposition is decided, whether admitted or discharged, the time is entered into a computer tracking system in the ED by either the resident or attending EP. "Dwell" time was determined to be the time a patient physically left the ED, subtracted by the disposition time, and was only applied to those patients who were admitted to the hospital from the ED. Also noted each day was the breakdown of the acuity of patients waiting to be seen as decided by a three-tier triage system, the number of ED patients already admitted, the total number of ED patients, number of nurses, physicians and technicians in the ED, as well as the number of admitted patients in the hospital, number of open beds in the hospital, and number of critical care beds available. The latter two components included total available beds within the institution and were independent of staffing demands at those times.

Primary Data Analysis

All entries were recorded on a standardized data entry form. The response variables of interest were "door-to-doctor" time and dwell time. ED variables measured included acuity, daily volume/admissions, number of boarders (admitted patients waiting for in-hospital beds in the ED), occupancy (number of occupied beds divided by the total number of ED beds), and number of staff. We defined acuity as triage assessment of level A, B, or C in a three-tier triage system with triage category A patients listed as emergent, category B as urgent but able to wait, and category C as non-urgent. Hospital variables measured were hospital volume, daily admissions, and intensive care unit (ICU) volume.

At 8 pm, some patients had not yet been seen by an EP or had been seen but had not yet been discharged from the ED. Partial "door-to-doctor" and dwell times for each of these patients were still measured, but their total times were considered censored in accordance with standard survival analysis methodology.[7] Both log-rank tests and time-to-wait (survival) proportional-hazard regression models were fitted to determine which variables were most significant in predicting "door-to-doctor" and dwell times, with full account of the censoring for some patients.

RESULTS

We reviewed 1,543 patient visits over a period of 42 days. Our study captured 27% of patients who came through the ED with 68% in triage category A, 29% in B, and 3% in C. The disproportionately small percentage of category C patients captured was due in part to the operation of our "fast track" service until 10pm. Thus, our study only captured those category C patients requiring further workup than could be provided in "fast track." The distribution of data for the studied variables with appropriate ranges is shown in Table 1.

The ED operated at an average of 85% capacity (61-102%) with 27% of patients admitted and only awaiting bed assignment. During the same time period, the hospital had a median of 510 occupied beds (range 473 – 573). ED visits

Table 1. Medians with ranges of studied variables

Variables	Daily Median	Range
ED occupancy	0.69	0.34-0.87
ED boarder volume	13	4-26
ED daily volume	141	109-191
ED daily admissions	60	34-74
Acuity	0.41	0.27-0.54
Number of ED staff	30	25-38
Hospital volume	510	473-573
ICU volume	30	22-34

averaged 138 per day (133-143) with a median "door-to-doctor" time of 1.8 hours and median dwell time of 5.5 hours.

A log-rank test indicated significant differences in "door-to-doctor" times for the three triage categories. The model-adjusted median "door-to-doctor" times for categories A, B, and C were 1.6, 2.2, and 2.4 hours respectively; these were significantly different (p-value<0.001). Median dwell times were also different for categories A, B, and C with times of 5.0, 9.8, and 4.4 hours respectively; these were also significantly different (p-value<0.001). Days of the week also had significantly different times (Table 2), with Mondays having longer "door-to-doctor" and dwell times. Figure 1 shows the estimated probability of waiting at least as long as a fixed number of hours for times between 0 and 10 hours. The "+" symbols indicate censored data points. Thus, full accounting of censored data was used to estimate the curves using survival analysis methodology. Category A patients had consistently shorter "door-to-doctor" times, while category B and C patients had a higher probability of longer times. Figure 2 is the same plot but for dwell times. Here, the differences between the triage categories are more apparent and indicate significantly longer dwell times for category B patients.

Table 2. "Door-to-doctor" and dwell times by day of the week

	Day of the Week					p=
	M	T	W	Th	F	
"Door-to-doctor"	2.4	1.8	1.5	1.9	1.7	<0.001
Dwell	7.1	5.5	5.1	5.2	5.4	<0.001

The next step was to control for the important clinical and hospital census variables. Proportional hazard regression models for "door-to-doctor" and dwell times were computed controlling for triage category, ED occupancy, daily ED volume/admissions, ED boarder volume, acuity, number of ED staff, daily hospital volume, and ICU volume. These models predict the probability of being seen or boarded at any given time; therefore, odds ratios less than one indicate a lower

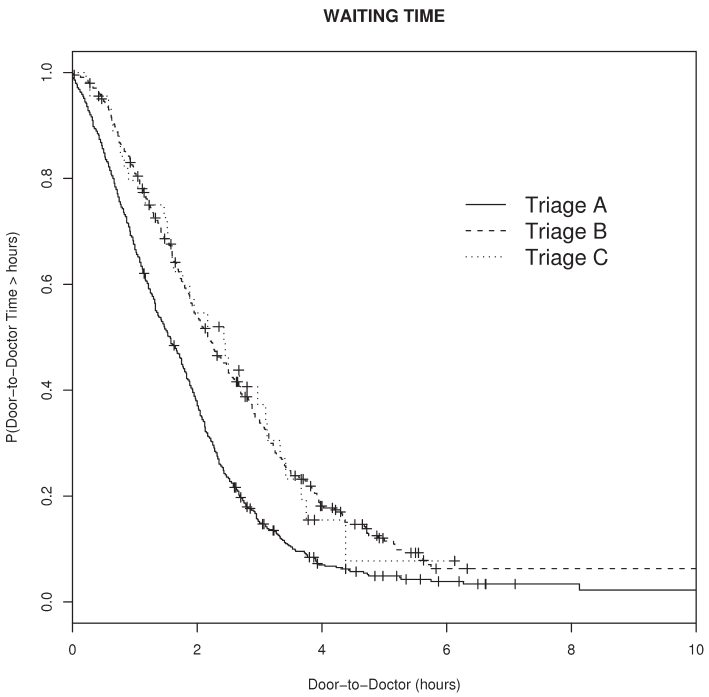

Figure 1. The estimated probability of "door-to-doctor" time being greater than the stated number of hours. The censored data points are indicated by the "+" symbol.

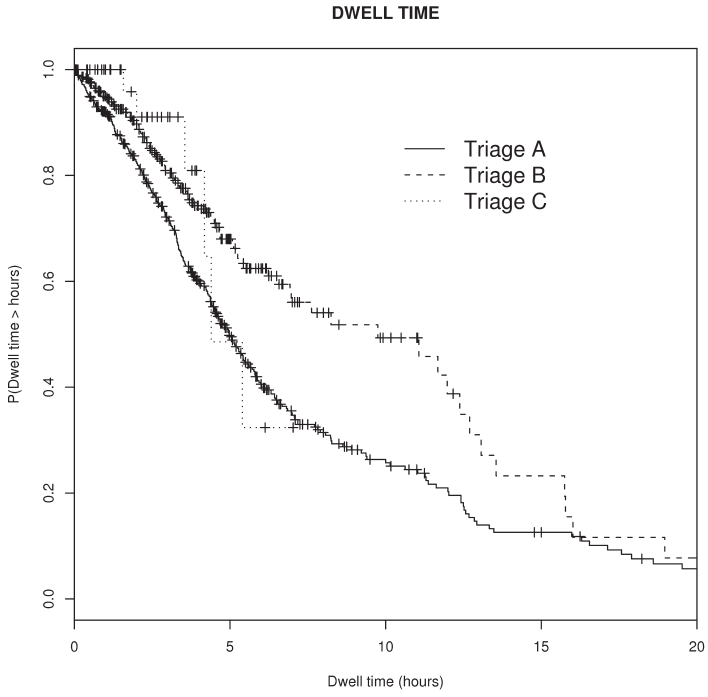

Figure 2. The estimated probability of dwell time being greater than the stated number of hours. The censored data points are indicated by the "+" symbol.

Table 3a. Adjusted proportional hazards odds ratio for variables affecting "door-to-doctor" time

Variables	Odds Ratio	95% CI
Triage type B	0.60	0.53 - 0.69
Triage type C	0.61	0.43 - 0.88
ED occupancy	0.25	0.13 – 0.48
ED boarder volume	1.02	1.00 – 1.03
ED daily volume	.99	0.99 – 1.00
ED daily admissions	1.00	0.99 – 1.01
Acuity	0.35	0.11 – 1.08
Number of ED staff	0.98	0.96 – 1.01
Hospital volume	1.00	1.00 – 1.01
ICU volume	0.98	0.95 – 1.00

Table 3b. Adjusted odds ratio for variables affecting dwell time

Variables	Odds Ratio	95% CI
Triage type B	0.60	0.48 - 0.74
Triage type C	0.57	0.25 - 1.28
ED occupancy	0.20	0.07 - 0.58
ED boarder volume	1.03	1.01 – 1.06
ED daily volume	1.00	0.99 – 1.01
ED daily admissions	0.99	0.99 – 1.01
Acuity	0.36	0.07 – 1.8
Number of ED staff	0.99	0.94 – 1.03
Hospital volume	0.99	0.99 – 1.00
ICU volume	1.03	0.99 – 1.07

probability, and therefore longer times. For the "door-to-doctor" model (Table 3a), triage category and ED occupancy were significantly associated with "door-to-doctor" time. Category B and C patients had odds of 0.6 times less than Category A patients to be seen by a doctor at any given time. Higher ED occupancy was also associated with lower probabilities of being seen at any time, hence longer "door-to-doctor" times.

In the dwell-time model, (Table 3b) only triage category B had significantly longer times than did category A; category C patients were not significantly different than A. This latter finding may be true, or it may be a consequence of fewer category C patients being sampled. Higher ED occupancy was again a significant predictor of longer dwell times.

ED Boarder Volume, although statistically significant, was clinically unimportant for both "door-to-doctor" times and dwell times. (Tables 3a and 3b)

The advantage of the proportional hazards regression is that it allows us to take full account of censored data and all variables simultaneously. As such, our main results must be expressed in terms of odds ratios and not absolute time. Odds indicate the chance of being seen by an EP (time to "doctor") or being discharged (waiting time) at any given moment; the odds themselves are found my multiplying the value of the stated variables by the odds coefficients (class variables, such as Triage category, take a value of one). An odds ratio for a variable indicates the chance of being seen or discharged changes in a multiplicative way by the amount of the ratio. Odds ratios greater than one thus imply a higher chance of being seen or discharged; while odds ratios less than one imply a proportionately lower chance.

DISCUSSION

In 2002 more than 110 million ED visits occurred in the Unites States, a 23% increase since 1992.[8] An April 2002 report for the American Hospital Association (AHA) found that officials at many hospitals in urban areas described their EDs as operating at or above capacity, with some directors reporting that patient care was compromised and patients experienced poor outcomes as a result.[6] ED crowding is no longer insider information known only to those on the front lines. On the contrary, it is now on the minds of the public. A survey published by the American College of Emergency Physicians (ACEP) in 2005 showed that 69% of Americans believed there was an impending crisis within our EDs.[9]

This sharp rise in ED use has been blamed on a multitude of factors, many of which are extrinsic. Recent trends indicate that much of the increased volume seen in EDs can be attributed to visits for non-emergent cases and may be interpreted as "problems or dissatisfaction with the performance and accessibility of local primary care delivery systems."[10,11] Although ED use by the uninsured is a major contributor to the recent surge in volume seen at many hospitals, the majority of growth in recent years has been attributed to the privately insured seeking a "one-stop" healthcare source.[10] In addition to these factors, there are staffing shortages, lack of materials to measure and manage patient flow, and fewer available beds due to local hospital closures.[12,13]

Our study determined that "door-to-doctor" time differences based on triage category was statistically significant with category A patients being seen sooner than category B and C patients. This is an expected finding since emergent patients warrant immediate attention. Category C patients waited slightly longer to see a physician when compared to category A and B patients. Bordoloi et al.[14] conducted a study looking at the impact of non-urgent patients, the equivalent to our category C patients, on ED flow

and concluded that these patients are "receiving the brunt of the punishment" as far as "door-to-doctor" time. Although their findings were consistent with ours, the observed outcome was not as dramatic as expected. This may be due in large part to the fact that Bordoloi looked exclusively at patients who presented with symptoms consistent with Acute Coronary Syndrome, whereas we included all adult ED patients.

More interesting was the observed statistically significant differences in dwell time based on triage category. Category A patients had boarding times slightly longer than category C patients. Previous studies have correlated elevated dwell times with high acuity patients to the limited available space for intensive care in the hospital as well as the complexity of the presenting cases.[5,15,16] The difference, however, is not as pronounced as expected in our study possibly due to the siphoning of A and C patients into type B patients. In other words, some patients triaged into category B are actually A or C patients but are placed in the B category due to an erroneous initial first impression. This finding brings to light a flaw in this classification scheme. Since many EDs are finding the "B" patients too general a category, they are effectively breaking it apart and instituting a five-tier numbered system for triaging patients.[17] For this reason, ACEP codified this new triage system into policy in 2003. Another interesting point is that category B patients may encompass those who are awaiting elective surgery. Although this variable was not accounted for in our study, it is a topic worth mentioning and was recently discussed in a study by Rathlev et al.,[18] who found a direct correlation between the number of elective surgical admissions from the ED and increased dwell times at their institution.

The day of the week was found to correlate with fluctuations in "door-to-doctor" as well as dwell times. We saw a distinct increase in both measured time intervals for patients seen in the ED on Mondays. Our findings differ from those of Chan et al.[19] who concluded that the day of the week has no significant influence over throughput in the ED. One possible point of difference is their use of throughput, which they define as the time a patient enters the ED to the time of discharge, whereas we looked at specific periods during a patient's overall visit. Another point of difference could be differences in the patient population. The spike in patient visits on Mondays could be attributed to patients who wait over the weekend to see their primary care physician for an urgent condition and are thus referred to the ED.

To take into account the continuous nature of the variables, we used a time-to-wait or proportional-hazard regression model.[7] Although measured variables included those considered inflow as well as outflow factors, we observed statistically significant effects on both "door-to-doctor" and dwell times for those variables representing primarily inflow factors, including triage category. With the recent advent of "fast track" in EDs nationwide, it is important to comment on the impact of low acuity patients on ED flow. This topic was addressed by Schull et. al.,[20] who concluded that these patients are associated with a negligible increase in "door-to-doctor" time for other ED patients. Thus, it can be inferred that although "low-complexity" patients may affect the overall statistical "door-to-doctor" times in an ED, lowering their number may not have an effect on overall flow. ED occupancy was another variable that played a large role in patient flow. It is intuitive that a decreased capacity to receive patients in the ED would invariably increase "door-to-doctor" times.

It was interesting to see that ED occupancy was also correlated with increased dwell times. This could be due to a lack of physical space within the hospital, resulting in more patients boarding in the ED and occupying more beds. One of the limiting factors to ED patient output of admitted patients is the "bottleneck" effect addressed in several publications.[5,15,16] On the top of a long list of "bottleneck" culprits, including backups in radiology, patient transport, and laboratory, is hospital capacity. According to the AHA, the number of inpatient beds in the U.S. decreased 39% between 1981-1999. Reduced inpatient capacity is reported to be a major cause of overcrowding in ED treatment areas. A study by Forster et al.[16] found that the duration admitted patients wait in the ED is influenced by the hospital's occupancy. With a 10% absolute increase in occupancy, patients waited on average 5% longer to get to their inpatient beds. Our study could not confirm these findings, as our results did not produce a statistically significant correlation between hospital occupancy and wait time in the ED.

The importance and necessity of real-time ED flow models have become more apparent over the years. These models would both relay minute-to-minute data on current patient flow conditions, enabling quick interdepartmental response and possible avoidance of a bottleneck, and could potentially use that data to predict future flow patterns. Hoot et al.[21] recently published a study dealing with the use of multiple flow models to create an advance warning system. They concluded that none of the measures provided substantial warning before crowding with low rates of false alarms. We agree with other study findings that a hospital's efficiency should be maximized prior to considering an increase in physical space. We also believe that a better understanding of factors influencing crowding could potentially improve upon existing prediction models in the future.

LIMITATIONS

Our study had several limitations, first of which was that it took place in a single clinical center. This limits the ability of our results to relate to other clinical centers as they may have dissimilar staffing and patient demographics. Our study took place in an urban teaching hospital and may show different trends than in a rural setting.

We looked at ED admissions at only 8pm because it was the busiest time of day. Alternative methods of collecting data,

e.g. a method that samples patients at several times a day, was too time consuming and impractical at our clinical center, which uses an integrated paper and computer system to track patients' progress.

Another limitation was the length of time in which our study was done. Because it was prospectively done over a period of 1.5 months, this did not allow for variations in ED admissions associated with the seasons and could account for the variability observed in some of our results.

Finally, we did not account for differences in those patients arriving by ambulance and those who were ambulatory. It is possible that those patients arriving by ambulance are seen faster regardless of their triage level and warrants further study.

CONCLUSION

In our study the ED and hospital operated near capacity on a daily basis, and the major determinants of "door-to-doctor" and dwell times were triage category and ED occupancy. The day of the week also proved to be significant with an observed spike in both "door-to-doctor" and dwell times on Mondays. We did not find that hospital or ICU occupancy affected the measured ED time intervals at our institution. As we cannot alter the triage category or day of week our patients present to the ED, future efforts to reduce "door-to-doctor" and dwell times must center on improving ED occupancy through improved efficiency or increased physical space. Further study is warranted, encompassing an entire year's worth of data, while accounting for the limitations addressed within the scope of this study.

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Eschmann Introducer Through Laryngeal Mask Airway: A Cadaveric Trial of An Alternate Means of Rescue Intubation

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Study Objective: Laryngeal mask airways (LMAs) are often used as airway rescue devices where laryngoscopy is difficult. The LMA does not protect the airway and is preferably replaced with a cuffed endotracheal tube. There are reports of cases where an Eschmann tracheal tube introducer (ETTI) was successfully used to bridge between a standard LMA and an endotracheal tube. This project was designed to determine whether an Eschmann stylet can reliably be passed through an LMA into the trachea as a means of rescue intubation.

Methods: Nineteen emergency medicine residents and attending physicians, who were participants in a cadaveric airway course, placed and inflated a size 4 LMA (The Laryngeal Mask Company Ltd., San Diego, CA) on each of six unembalmed human cadavers in the usual fashion. They then attempted to pass a lubricated, 15 Fr, reusable, coude-tipped ETTI (Portex, Smiths Medical, Keene, NH)) through the airspace/handle of the inflated LMA. The LMA was then deflated and removed while the ETTI was held in place. Investigators then determined the location of the ETTI by laryngoscopy.

Results: Of 114 attempts at the rescue procedure, 59 resulted in placement of the bougie into the trachea, yielding an overall success rate of 52% (95% CI 48%-56%). There were no significant differences in performance based on level of training of residents or years of experience of attending physicians.

Conclusions: While not a primary difficult airway option, the use of a ETTI as a bridge device between LMA and endotracheal tube was successful about 50% of the time.
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INTRODUCTION

Larngeal masks airways (LMA) are frequently used in the emergency department (ED) as an airway rescue device, to help ventilate patients when endotracheal intubation is impossible. They are especially useful in cases where the laryngoscopic view is limited by inability to optimally position a patient's neck, as in cases of trauma. Although the LMA may make ventilation easier, it does not protect the airway the way a cuffed endotracheal tube does, and thus it is desirable to transition to a cuffed endotracheal tube as soon as feasible. The intubating LMA (I-LMA), or LMA Fastrach™ (LMA North America, Inc., San Diego, CA) was invented for this purpose.

Anecdotal experience of the authors, as well as reports in the literature,[1] have included using an Eschmann tracheal tube introducer (ETTI), sometimes called a gum elastic bougie,[2] as a bridge device between a standard (classic, non-intubating) LMA and a cuffed endotracheal tube in an emergency airway setting. This maneuver is performed by inserting a lubricated ETTI down the ventilating lumen/handle of the LMA, hopefully directing it into the trachea. The LMA is then withdrawn, while holding the ETTI in place. The endotracheal tube is then railroaded down the ETTI into the trachea, and placement is confirmed in the usual fashion. This procedure could achieve the same result as the I-LMA device,

Table 1. Performance characteristics by level of training

	N Operators	N attempts	Mean (95% CI) % success rate	Best individual % success rate	Worst individual % success rate
Medical Student	3	18	50 (35-65)	83	17
Post-graduate year 1	9	54	46 (40-52)	83	0
Post-graduate year 2	1	6	67		
Post-graduate year 3	3	18	56 (44-68)	83	33
Attending	3	18	61 (57-65)	67	50
Overall	19	114	52 (48-56)	83	0

in situations where only a classic LMA is available.

The goal of this investigation is to determine how often one might expect an ETTI placed down the lumen of an LMA to be positioned in the trachea and thus aid in completing a difficult airway. If LMA-guided ETTI placement is frequently successful, this technique might be of value in the emergency physician's (EP) armamentarium for managing difficult airways.

METHODS

Study Design

This was a prospective experiment utilizing a human cadaveric model. The study was approved by the institutional review board of the hosting institution. Participants were fourth-year medical students entering emergency medicine (EM) residencies, EM residents, and attending physicians, who were all participants in or faculty of a residency-based emergency airway course, which included a cadaver laboratory practical session. The residency was a PGY1-3 EM residency, based at a suburban, academic community hospital.

Airway laboratory participants received a didactic lecture on the use of the ETTI, LMA, and other airway adjuncts. Those who wished to participate in this study were presented the clinical scenario of a patient with a difficult airway, and the need for endotracheal intubation was described. They were instructed in the technique of passing an ETTI through the LMA as described previously.[1] Six unembalmed human cadavers were used for the experiment. Participants placed a size 4, classic LMA (The Laryngeal Mask Company Ltd., San Diego, CA), and inflated the LMA cuff, in the usual fashion, to obtain proper seating of the LMA. Seating was determined solely by watching the LMA rise into position when the cuff was inflated and was not confirmed with fiberoptics. Participants made no attempt to ventilate the cadaver through the LMA. They then attempted to pass a lubricated, 15 Fr, 60 cm, coude-tipped, reusable ETTI (Portex, Smiths Medical, Keene, NH) through the airspace/handle of the inflated LMA. Participants then deflated and removed the LMA while holding the ETTI in place by hand. An investigator then determined the location of the ETTI (trachea vs esophagus) using direct laryngoscopy and recorded the results on a data collection form. Procedural performance times were not limited or recorded in this experiment.

Data Analysis

The only recorded outcome was whether each placement of the ETTI was tracheal or esophageal. Independent variables recorded for each attempt included operator (with level of training) and cadaver. We input into a Microsoft Office Excel 2003 SP-2 spreadsheet (Microsoft Corp., Redmond, WA) and performed descriptive statistics. Ninety-five percent confidence intervals were computed using the Wald equation.

RESULTS

Nineteen residents and staff performed the procedure on each of six cadavers for a total of 114 attempts at the airway technique. Successful tracheal placement of the bougie stylet was achieved in 59 of the 114 attempts, for a total overall success rate of 52% (95% CI 48-56%). Success rates were not predicted by level of training of participants; however, individual success rates varied from 0% (one operator) to 83% (three operators). Success rates varied on individual cadavers from a low of 21% to a high of 79%. The test characteristics by level of experience of operator and by cadaver are presented in Tables 1 and 2.

On post-trial inspection of the cadavers, two were noted to have distorted laryngo-tracheal anatomy, such that successful seating of the chosen LMA was deemed unlikely. These two

Table 2. Performance characteristics by cadaver

Cadaver	1	2	3	4	5	6
Percent tracheal	79%	63%	37%	53%	58%	21%

cadavers had significantly lower rates of successful tracheal stylet placement. Eliminating them from the analysis increased the overall success rate to 63%.

LIMITATIONS

As this trial was performed on fresh frozen cadavers, the responsiveness of cadaveric tissue to this technique of rescue intubation may be different from that of live tissue. Thus, as with any cadaveric study, our findings may not generalize to clinical practice.

In addition, the study was performed after numerous attempts at direct laryngoscopic intubation during the course of an airway lab. It was already noted that the laryngeal tissue in two cadavers had significant trauma and distortion, making proper LMA placement unlikely. It is possible that the other cadavers had some occult distortion of their anatomy that was not recognized and thus contributed to poor placement of the LMA.

DISCUSSION

In the management of the difficult airway, many adjuncts are available. The LMA is gaining popularity as a means of field airway management and rescue airway management in the ED; however most patients with an LMA will require eventual endotracheal intubation. Our study suggests that in patients with an LMA, a tracheal tube introducer may be passed through the LMA into the trachea 50-60% of the time, thus facilitating placement of an endotracheal tube.

There have been a number of reports in the anesthesia literature on the use of the ETTI as a bridge between the LMA and endotracheal intubation. Chadd et al.[3] first described the technique of placing an ETTI through an LMA in two patients with known difficult airways. Both attempts were successful and were confirmed with fiberoptic laryngoscopy prior to placement of the endotracheal tube. Another study by Allison et al.[4] used the same technique on 25 live patients in the operating room and reported an 88% success rate for correct tracheal placement. This study used fiberoptic laryngoscopy to confirm adequate LMA placement prior to placement of the ETTI, and again used fiberoptic laryngoscopy to confirm the location of the ETTI prior to endotracheal tube placement. They noted that the four failures occurred in patients with fiberoptically confirmed poor LMA placement. A larger study by Gabbott and Sasada[5] used the same technique in simulated emergency airway conditions by applying cricoid pressure and manual in-line stabilization to 40 adult ASA 1 or 2 patients undergoing elective surgery requiring general anesthesia. With manual in-line stabilization and cricoid pressure the authors found the bougie entered the trachea in only nine of 40 patients (23%). They also performed the procedure in the standard fashion, without emergency precautions, and found the bougie entered the trachea in only 11 of 40 patients. Ahmed et al[6] attempted to study the effect of head position on the technique in 20 patients undergoing elective surgery. They reported a success rate of 20% when patients were in the standard intubating position, and 0% when patients were in the neutral position.

Early studies reported very high rates of tracheal passage using this technique, while more recent studies have failed to achieve similar success rates. Our success rate is not surprising given the data already present.

We feel that the success of this procedure is facilitated by a number of variables. First, the LMA must be properly seated to ventilate the patient. In patients with distorted airway anatomy, and in those whom proper seating and ventilation are not possible, it is less likely that bougie stylet passage through the LMA will result in tracheal placement. This conclusion is supported by other literature.[4,6] We also observed during the course of the experiment that the procedure was facilitated through maneuvering of the coude-tip of the stylet. Initially the stylet is more easily advanced through the LMA if the angle of the tip follows the angle of the LMA handle and points anteriorly. Once the stylet has passed the angle of the LMA handle and is passing beyond the LMA into the trachea, we found that spinning the stylet 180 degrees so that the coude-tip points inferiorly, along the patient's trachea, allows a smoother passage into the trachea. Allsion and McCrory[4] specifically used this technique and achieved high success rates, while later studies[5,6] failed to use this technique and report much lower numbers. We did not inform participants of this technique or control for its use, but we did note that participants who used this rotational technique of their own volition seemed to achieve higher rates of successful tracheal placement. This rotational technique perhaps contributed to our success rates midway between those of Allison and McCrory and later studies. We had very little difficulty in removing the LMA while maintaining the position of the bougie stylet. It is uncertain whether the sole participant who was successful on 0% of his or her attempts in our study used the rotational technique or not. In future investigations it would be helpful to standardize the use of the rotational technique, to ensure uniform optimization of the procedure.

This study also did not include blind methods of determining ETTI placement, or opportunities for operators to reposition and reattempt insertion, in its methodology. An ETTI's location in the trachea is classically confirmed after blind placement by tactile stimuli, including "clicks" of the ETTI deflecting off the tracheal cartilage rings, and "hold up", when forward advancement of the ETTI is halted at the carina.[7] Were tactile confirmation and reattempts allowed, a higher ultimate success rate potentially could have been achieved.

CONCLUSION

Overall, use of this technique could successfully bridge between an LMA and endotracheal intubation 50-60% of

the time. However, manipulation of the ETTI could result in higher rates of success.

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Early Glycemic Control in Critically Ill Emergency Department Patients: Pilot Trial

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Objective: Glycemic control in the critically ill intensive care unit (ICU) patient has been shown to improve morbidity and mortality. We sought to investigate the effect of early glycemic control in critically ill emergency department (ED) patients in a small pilot trial.

Methods: Adult non-trauma, non-pregnant ED patients presenting to a university tertiary referral center and identified as critically ill were eligible for enrollment on a convenience basis. Critical illness was determined upon assignment for ICU admission. Patients were randomized to either ED standard care or glycemic control. Glycemic control involved use of an insulin drip to maintain blood glucose levels between 80-140 mg/dL. Glycemic control continued until ED discharge. Standard patients were managed at ED attending physician discretion. We assessed severity of illness by calculation of APACHE II score. The primary endpoint was in-hospital mortality. Secondary endpoints included vasopressor requirement, hospital length of stay, and mechanical ventilation requirement.

Results: Fifty patients were randomized, 24 to the glycemic group and 26 to the standard care cohort. Four of the 24 patients (17%) in the treatment arm did not receive insulin despite protocol requirements. While receiving insulin, three of 24 patients (13%) had an episode of hypoglycemia. By chance, the patients in the treatment group had a trend toward higher acuity by APACHE II scores. Patient mortality and morbidity were similar despite the acuity difference.

Conclusion: There was no difference in morbidity and mortality between the two groups. The benefit of glycemic control may be subject to source of illness and to degree of glycemic control, or have no effect. Such questions bear future investigation. [West J Emerg Med. 2010; 11(1):20-23].

INTRODUCTION

The critical care patient population is presenting more frequently to the emergency department (ED).[1] Accordingly, critical care interventions are becoming a routine part of ED practice, [2] and it is a logical progression to investigate the delivery of proven critical care therapies to critically ill ED patients.

Glycemic control in critically ill patients in the intensive care unit (ICU) has been shown to attenuate both morbidity and mortality.[3-5] Early therapeutic intervention in critical care patients has been shown to yield the greatest improvement in patient outcomes.[6, 7] The concept of early intervention and glycemic control makes the ED an opportune arena for study. There is controversy regarding the efficacy of glycemic control. One current study challenging its practice did not have adequate power to support the discontinuation of this practice.[8] The most recent study discourages intensive control, but allows for investigation of the benefit of less restrictive

guidelines.[9] Glycemic control remains an option in the Surviving Sepsis Campaign.[10]

Extrapolation of the concept of glycemic control from the ICU to the ED may have the potential for added benefit. To address this, we conducted a randomized prospective pilot study that, to our knowledge, is the first effort to investigate the effect of early management of blood glucose in critically ill ED patients.

METHODS

This was a local institutional review committee-approved study of critically ill adult patients presenting to ED at the University of Massachusetts Medical School, a tertiary referral center with approximately 75,000 adult visits per year. The University ED has a 25% inpatient admission rate, and 20% of these are admitted to the ICU. We enrolled a convenience sample between December 2004 and April 2006. Inclusion criteria were: age $\geq$ 18 years; critical illness (based on assignment to the ICU by a board-certified ED attending physician); and ability to obtain informed consent from the patient or surrogate. Prospective exclusion criteria were trauma-related illness; diabetic ketoacidosis or hyperosmolar hyperglycemic nonketotic coma; insulin allergy; overdoses involving hypoglycemic agents, beta-blockers or calcium channel antagonists; pregnancy, incarceration; and inability to obtain informed consent. Trauma patients have service specific protocols that would not permit inclusion in this study.

Consented patients were randomized to standard ED therapy or glycemic control. To maintain allocation concealment, patients were randomized by opening a sealed envelope determining patient's group assignment after consent was obtained. Standard ED care was based on glucose management at the discretion of the attending physician. Patients randomized to glycemic control were managed with a standardized order sheet and nurse-driven protocol developed by the investigators specifically for the study. The goal of the protocol was to reach and maintain a blood glucose level of 80-140 mg/dL. Glycemic control patients had bedside whole blood glucose levels checked every 1-2 hours. Patients with glucose levels greater than 140 mg/dL were placed on an insulin drip (prepared off-site at a standard concentration by the hospital pharmacy), bedside glucose levels were checked every hour, and the drip rate was adjusted based on glucose levels. The standard protocol order sheet provided for drip cessation for glucose levels < 80 mg/dL. Hypoglycemia (glucose levels < 60 mg/dL) was treated with a 50 ml of 50% dextrose in water. The insulin drip was temporarily stopped when the patient left the ED for testing and was permanently discontinued at the time of discharge from the ED.

We reviewed charts from all enrolled patients. The primary endpoint of the study was in-hospital mortality. Secondary endpoints included hospital length of stay, vasopressor use, mechanical ventilator days, transfusion requirement, and renal failure requiring dialysis. Patient demographics and APACHE II (Acute Physiology and Chronic Health Evaluation) scores were recorded. Continuous variables are reported as mean $\pm$ SEM and compared between the glycemic control versus standard care groups by Student t-test. Categorical variables are presented as percentage of total and compared between groups by Fisher's exact test.

RESULTS

We identified 66 patients as eligible for the study. Fourteen patients or their families declined, one patient was legally incompetent to consent and did not have a guardian present, and one patient was not offered treatment at the discretion of the ED physician. The remaining 50 patients were successfully consented and enrolled, with 26 assigned to receive standard therapy and 24 to glycemic control.

In the standard treatment arm, 19 of 26 patients (73%) presented with serum glucose greater than 140 mg/dL. Five of these 19 (26%) were managed by the ED with insulin therapy. Four received intravenous boluses of insulin, while one patient with sepsis was placed on an insulin drip. Insulin was initiated for these five patients in response to high glucose levels. Mean glucose for this cohort was 302 $\pm$ 127.

In the glycemic control arm, 10 of the 24 randomized patients (42%) had initial glucose values >140 mg/dL. The difference in initial glucose level between the standard and glycemic control cohort was statistically significant (p=0.04). Four patients had a glucose of >140 mg/dL and did not receive treatment per protocol at any time. These patients were included in the analysis on an intention-to-treat basis. Of the 24 patients in the glycemic control group, 16 (67%) achieved the glucose values within 80-140 mg/dL target. There was a trend toward a reduction in blood glucose levels in the 24 patients assigned to receive glycemic control versus the standard therapy (167 $\pm$ 14 versus 210 $\pm$ 22 mg/dL; p=0.11).

Four of 24 patients randomized to glycemic control (17%) experienced one episode of hypoglycemia. While three of 24 patients (13%) were actually receiving insulin at the time of the event, one of the four patients developed hypoglycemia without insulin therapy, presumably as a function of his illness. No hypoglycemic events occurred in the standard therapy group (p=0.05).

Demographics and in-hospital outcome

Both groups were well matched for age and gender. Despite randomization, there was a trend toward higher APACHE II scores in the treatment group as opposed to controls: mean scores of 17.2 $\pm$ 1.5 in the treatment group versus 14.7 $\pm$ 1.3 for the standard therapy group (p=0.20). Hospital length of stay trended toward a longer duration in

Table 1. Demographics and in-hospital outcome

	Standard Therapy (n=26)	Intensive Glycemic Control (n=20)	
Age (years)	58±4	60±4	p=ns
Gender (% male)	15/26 (58%)	7/20 (35%)	p=ns
Acute Physiology and Chronic Health Evaluation II Score	14.7±1.3	17.3±1.5	p=0.20 (ns)
Prevalence of diabetes	9/26 (35%)	3/20 (15%)	p=0.18 (ns)
ED length of stay (hours)	13.4±1.7	17.4±3.9	p=0.31 (ns)
Hospital length of stay (days)	10.4±2.1	15.6±3.8	p=0.20 (ns)
Intubated	13/26 (50%)	10/20 (50%)	p=ns
Required vasopressors	11/26 (42%)	9/20 (45%)	p=ns
Duration of vasopressors (hours)	102 ± 57	196 ± 133	p=ns
Required transfusion	13/26 (50%)	8/20 (40%)	p=ns
Required dialysis	2/26 (8%)	2/20 (10%)	p=ns
Incidence of blood infection	4/26 (15%)	4/20 (20%)	p=ns
Mortality	6/26 (23%)	4/20 (20%)	p=ns

Table 2. Patient diagnoses

	Standard Therapy (n=26)	Intensive Glycemic Control (n=24)
Sepsis	6/26 (23%)	10/24 (42%)
Gastrointestinal bleed	5/26 (19%)	1/24 (4%)
Acute coronary syndrome	3/26 (12%)	0/24 (0%)
Toxic ingestion	2/26 (8%)	2/24 (8%)
Pulmonary embolus	1/26 (4%)	2/24 (8%)
Congestive heart failure	1/26 (4%)	2/24 (8%)
Chronic obstructive pulmonary disease/asthma Exacerbation	2/26 (8%)	1/24 (4%)
Hemorrhagic/ischemic stroke	1/26 (4%)	1/24 (4%)
Hepatic failure	0/26 (0%)	2/24 (8%)
Other	5/26 (20%)	3/24 (13%)

the glycemic control group (Table 1). The requirement for intubation, vasopressors, transfusion and dialysis were similar in the two cohorts (Table 1). There was a higher percentage of patients with diabetes mellitus, based on past medical history in the standard treatment group (9/26 [35%]), as opposed to the glycemic control group (4/24 [17%]) (p=0.20). Critical care diagnoses were variable, ranging from sepsis to gastrointestinal bleed (Table 2).

DISCUSSION

The ED offers an opportunity for early intervention as it is frequently the first point of entry for the critically ill patient population.[6,7] This pilot study represents, to our knowledge, the first attempt to administer early glycemic control in the ED.

Multiple logistic issues in the ED may limit the ability to deliver critical care therapies, including management of blood glucose. The onset of therapy may be delayed or deferred in instances in which patient volumes are high and nursing resources limited. In four patients enrolled in the current study, insulin per protocol was not administered despite randomization to the intensive glycemic control group. Conversely, four patients had hypoglycemia in the treatment arm. We hypothesize that these protocol violations and complications may have occurred at times of high ED volume and nursing workload.

We hypothesize that the ED environment also provided a barrier to successful glycemic goals. Insulin drip initiation or glucose level monitoring may have been delayed due to high nursing workload. Insulin drip delivery

from the pharmacy may have added to treatment delay. Patients also were transferred to the ICU prior to successful completion of the glycemic protocol. Average transfer time to the ICU during the study period was 15 hours, with a range of 2 -72 hours.

Despite these challenges, we report that 24 critically ill patients with high APACHE II scores were treated with a glycemic control protocol, and in 16 of these 24 patients the goal of successful glycemic control was achieved. Hypoglycemia did occur, but we did not measure a resultant increase in hospital mortality. We acknowledge again that the study population is too small to appreciate a significant mortality effect from hypoglycemia.

There was a trend toward higher acuity in the glycemic control group with equivalent mortality, but this trend was not statistically significant. Hypoglycemia in the treatment group presented a challenge as in other studies.[8, 9] The risk of hypoglycemia in the ED environment can be of greater consequence as it may not be recognized as quickly as in a more controlled ICU. Further evaluation of glycemic control in the ED should provide for stringent precautions for hypoglycemia.

LIMITATIONS

Conclusions regarding the potential benefits of early insulin therapy initiated in the ED are precluded by the small sample size. Our study was not powered to discern a difference in mortality, hospital length of stay, vasopressor use, mechanical ventilator days, transfusion requirement, or renal failure requiring dialysis.

CONCLUSION

The NICE-SUGAR investigators have confirmed the lack of utility of intensive glycemic control as well as increased hypoglycemia risk.[9] Questions regarding range of glucose control and appropriate critical care patient population remain unanswered. Larger-scale, randomized protocols should be considered in order to pursue this concept and establish whether early management of blood glucose in the ED will improve patient outcome.

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Frequency of Incidental Findings on Computed Tomography of Trauma Patients

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Objective: To determine the incidence and frequency of follow-up instructions for incidental findings on computed tomography (CT) scanning of the abdomen and pelvis in trauma patients.

Methods: We performed a retrospective chart review of all adult patients triaged to the trauma service at a Level I trauma center between July 1, 2003 and June 30, 2004. Included patients were 16 years of age and older who underwent abdomen and pelvic CT scans as part of their primary evaluation. We excluded patients under the age of 16 years, patients unable to complete radiographic studies due to deterioration in condition, patients with missing CT scan reports, and transferred patients who had CT scans done at outside facilities.

Results: A total of 1,633 patients presented to the trauma service during the study period; 922 patients met inclusion criteria. Of these, 392 had incidental findings noted on the formal radiology report. Twenty patients with incidental findings either received additional workup during their hospital admission for their trauma injuries or were notified of the findings on discharge. Nine died prior to discharge. One hundred twenty-two patients with incidental findings had those findings noted in the history and physical or discharge summary with no documentation of follow-up. There was no documentation of any incidental findings in the electronic record for the majority of patients (242) with incidental findings.

Conclusion: The majority of incidental findings discovered on abdomen and pelvic CT scanning of trauma patients are not documented; therefore, many patients may not receive the appropriate recommended follow up. [West J Emerg Med. 2010; 11(1):24-27].

INTRODUCTION

Computed tomography (CT) scanning has replaced diagnostic peritoneal lavage and serial abdominal exams in the evaluation of patients who have sustained abdominal trauma. CT allows for the rapid identification of intra-abdominal injuries in patients with acute trauma with a high level of specificity and sensitivity and can assist the trauma surgeon in determining operative versus non-operative management.

In addition to providing information regarding the presence or absence of acute intra-abdominal trauma, CT scans also reveal pathology unrelated to the trauma that may or may not be clinically significant. These incidental findings may require additional evaluation on an emergent or urgent basis and should be communicated to the patient. Failure to notify patients of incidental findings could adversely impact their health and potentially give rise to legal action by patients for harm caused by this omission.

We reviewed the abdominal and pelvic CT scans of trauma patients presenting to a Level I trauma center over a one-year period to determine the incidence of incidental findings and the nature of the follow-up for these findings.

METHODS

This was a retrospective chart review of 1,633 patients triaged to the trauma service at a Level I trauma center at an urban teaching hospital between July 1, 2003 and June 30, 2004. Patients were identified through the trauma registry maintained at the hospital. The purpose was to identify findings

noted on abdominal and pelvic CT scans that were unrelated to trauma and to classify those findings that required additional interventions or diagnostic studies. Included patients were those over 16 years of age who underwent CT scans of the abdomen and pelvis as part of the initial evaluation after arrival to the trauma bay. All mechanisms (i.e. blunt vs. penetrating trauma) were included. Exclusion criteria included: patients less than 16 years old; patients whose condition deteriorated, thus preventing completion of radiographic studies; patients transferred to the trauma center with CT scans performed at another facility; and patients managed primarily by the emergency physicians but who received a trauma team consult. All CT scans were reviewed by board-certified radiologists.

The electronic medical records (EMR) were reviewed for each patient who met inclusion criteria by three reviewers who were not blinded to the objectives of the study. Only those findings included in the final impression portion of the radiologist's formal report that were not related to trauma were included; findings noted in the narrative portion of the dictation but not included in the final impression were excluded. Specific recommendations made by the radiologist interpreting the study were noted and included as well. In some instances, findings were made regarding the lower lung fields seen on the CT scan of the abdomen and pelvis and these were included. Excluded findings included: atelectasis; physiologic pelvic fluid; evidence of old trauma; surgical changes; and findings that could be related to trauma. Incidental findings that were to be excluded were determined prior to the start of the study.

For all patients with incidental findings not related to trauma, we reviewed the EMR to determine if any subsequent studies or further workup was performed during the hospital admission for the traumatic injuries. This included specialty consultation, further radiographic studies and clinical correlation. In addition, the discharge summaries for each patient were reviewed to determine if the patient was notified of the findings and/or given any discharge instructions that included outpatient follow-up recommendations. In those instances where the patient was discharged directly from the emergency department (ED), the dictated history and physical was reviewed as well as it often included the patient's disposition as well as discharge instructions. This study was approved by our Institutional Review Board.

RESULTS

From July 1, 2003 to June 30, 2004, 1,633 trauma patients presented to our trauma center. Of these patients 1,045 had a CT scan of the abdomen and pelvis performed on initial presentation and had a report available in the EMR. One hundred twenty-three patients were less than 16 years old, leaving 922 patients who met inclusion criteria.

A total of 530 patients either had normal CT scans or CT scans consistent with acute trauma without incidental findings, while 392 had incidental findings on CT scan with or without evidence of trauma (Tables 1-7). In 62% (242/392) of patients with incidental findings noted on CT scan, no further documentation was found in the EMR regarding the incidental findings. Five percent of patients (20/392) either received specialty consult or additional studies related to their incidental findings while in the hospital, or were notified of their results according to the dictated discharge summaries. Nine patients received specialty consult while in the hospital (four urology consults, two OBGYN consults, two internal medicine consults and one vascular surgery consult); one patient had a testicular ultrasound performed; and the rest were given discharge instructions regarding follow up of their incidental findings. Thirty-one percent of patients (121/392) with incidental findings had these noted either in the dictated history and physical or discharge summary without mention of notifying the patient or recommending additional outpatient work-up. Nine patients died prior to discharge from the hospital.

Table 1. Incidental findings: genitourinary findings for both sexes

Findings	Number
Renal cyst or hypodensity	96
Multiple renal cysts	16
Nephrolithiasis	13
Renal mass	9
Enlarged prostate	8
Other renal abnormaility	5
Duplicated collecting system	4
Horseshoe kidney	3
Hydronephrosis	3
Malrotation of kidney	3
Prostate calcification	3
Kidney scarring	2
Scrotal hydrocele	2
Seminal vesicle cysts	2
Atrophic kidney	2
Thickened bladder wall	1
Dilated bladder	1
Wedge-shaped kidney infarcts	1
Scrotal lesion	1
Ectopic kidney	1
Perinephric space density	1

DISCUSSION

Patients being evaluated for multisystem trauma frequently undergo CT scans to evaluate for injury. It is not uncommon for a single trauma patient to have a CT scan of the head, cervical spine, chest, abdomen and pelvis as part of the workup. CT scans are an excellent modality for detecting traumatic injuries, as well as for detecting other pathologic conditions present that are unrelated to the trauma. The issue then becomes how best to

Table 2. Incidental findings: hepatobiliary

Findings	Number
Hepatic cyst or hypodensity	44
Gallstone(s)	16
Hepatic lesion-single	13
Hepatic lesions-multiple	9
Fatty liver	8
Gallbladder abnormality, nitric oxide synthase	5
Pancreatic calcifications	3
Hepatic soft tissue mass	3
Cirrhotic liver	2
Pancreatic cyst	2
Pancreatitis, non-traumatic	2
Hepatomegaly	1
Pancreatic abnormality	1
Portal vein thrombosis	1
Increased attenuation in liver	1
Cholecystitis	1
Portal venous hypertension	1

Table 3. Incidental findings: female genitourinary

Findings	Number
Ovarian cyst	32
Uterine fibroid/calculus	7
Adnexal mass	5
Endometrium changes	3
Tubular abnormality	3
Pelvic mass	3
Adnexal abnormality	2
Leiomyoma	2
Lower uterine segment cyst	1
Ovarian dermoid	1
Nabothian cyst	1
Gravid uterus	1

Table 4. Incidental findings: musculoskeletal

Findings	Number
Bony lesion	26
Degenerative joint disease	16
Spondylolysis	3
Paget's disease	1
Bony lucency/metastases	1
Bilateral sacroiliac ankylosis	1
Spina bifida occulta	1
Sacroiliac nonunion variant	1
Pseudoarthrosis	1
Spinal stenosis	1
Disc bulge	1

Table 5. Incidental findings: immunologic

Findings	Number
Lymph node or lymphadenopathy	16
Splenic cyst	6
Splenic granuloma	3
Splenomegaly	3
Splenic calcifications	2
Accessory spleen	2
Splenic lesions	2
Lymphoma	1
Multiple splenic lobulated areas	1

Table 6. Incidental findings: pulmonary

Findings	Number
Nodular lung lesions	16
Pleural calcifications/granulomas	5
Lung density nitric oxide synthase	3
Emphysematous changes	3
Air space disease/infiltrate	2
Lung based cystic structure	1
Pleural thickening	1
Thoracic soft tissue mass	1

handle the additional information obtained.

In many cases, the incidental findings simply need to be verbalized to the patient for outpatient follow up with his primary care physician. In other cases, more emergent or urgent follow up is warranted with further imaging or specialist consultation.

Our findings are consistent with similar studies regarding incidental findings on CT scans. In one retrospective study performed in the ED, only 21% of incidental findings noted on abdominal CT scans to evaluate for renal stones were noted in the record and only 18% had any evidence of followup.[1] In a Level I trauma center in San Diego, 34% of patients were found to have incidental findings on CT scan, and only 50% of patients with findings requiring attention prior to discharge had adequate documentation of the management of their incidental finding.[2]

A similar study to ours found that 43% of trauma patients had incidental findings on CT scans of the abdomen and pelvis and only 27% of those had documentation of the findings.[3] Interestingly, the frequency of incidental findings on CT scans of brains of trauma patients is much lower, as evidenced by a retrospective review of 3,000 patients that found only 30

Table 7. Incidental findings: other

Findings	Number
Diverticulosis	19
Adrenal mass	10
Adrenal nodule/hyperplasia	10
Atherosclerosis	9
Hiatal hernia	8
Inguinal hernia	8
Aortic abnormality	4
Colon fat stranding	3
Other vascular calcifications	2
Breast abnormality	2
Fluid collection, not trauma related	2
Umbilical hernia	2
Abdominal wall hernia	2
Lipoma	1
Ovarian vein thrombosis	1
Adrenal complex cyst	1

incidental abnormalities.[4] In one study of patients undergoing CT scans for pulmonary embolism in the ED, 59% of patients who did not have a pulmonary embolism had incidental findings that ranged in severity from indeterminate to requiring immediate intervention.[5]

As technology advances, the capability of CT to identify incidental findings will continue to increase. Emergency medicine and trauma are not the only specialties to face this issue; cardiology and endocrinology have struggled with the appropriate way to address incidental findings.[6,7,8]

LIMITATIONS

There were 588 patients who either did not have a CT scan of the abdomen and pelvis performed or who had no EMR of the results of the CT scans available in the hospital databases. For the majority of incidental findings, there was no documentation of the findings in the dictated patient chart. It is possible that in some cases patients were verbally notified of these incidental findings and this was simply not documented in the record. We used only the EMRs and not the actual physical chart for our study. We limited our study to the frequency of incidental findings and did not make any classifications of the findings in terms of their clinical significance.

CONCLUSION

Incidental findings are a common occurrence with abdominal and pelvic CT scans performed for trauma patients. In our study most of these findings were not documented, and it is presumed that many of the patients were not informed of their findings. Communication of this information has a number of legal and ethical considerations. In many cases, the findings are clinically insignificant and likely will not have any impact on the patient. In other cases, it is clear that close follow up is warranted to ensure exclusion of serious, life-threatening processes such as malignancy. At other times, follow up could lead to unnecessary, costly and invasive testing.

While the immediate priority is to address the acute traumatic injuries, implementing additional safeguards into the system to ensure that patients are notified of incidental findings is important. Further research is necessary to determine the impact of these incidental findings. This includes outcomes of the patients who were notified and those who were not notified of their CT scan findings. In some cases the findings may be lifesaving, while in others it may lead to unnecessary and invasive procedures or increased radiation exposure.

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Luxatio Erecta Complicated By Anterior Shoulder Dislocation During Reduction

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Luxatio erecta humeri is an uncommon form of glenohumeral dislocation, resulting in the inferior displacement of the humeral head. Treatment with traction-counter traction techniques is usually successful in reducing most cases. We describe an unusual complication of this condition where initial reduction attempts of a *luxatio erecta humeri* repositioned the shoulder to an anterior dislocation position. After a thorough search of the literature, we were unable to find a similar case report of this type of complication during the reduction of a *luxatio erecta* shoulder dislocation.
[West J Emerg Med. 2010; 11(1):28-30].

INTRODUCTION

Luxatio erecta humeri is a rare type of shoulder dislocation with an estimated incidence of 0.5% of all shoulder dislocations.[1-3] This entity is usually treated successfully with traction-counter traction in the majority of cases. We describe an unusual complication that occurred during reduction of this type of shoulder dislocation. The initial attempts to reduce the *luxatio erecta* dislocation resulted in the shoulder being repositioned to an anterior dislocation position. The anterior shoulder dislocation was subsequently reduced without difficulty to its proper anatomic position. This appears to be a rare but potential complication of efforts to reduce the dislocation.

CASE REPORT

A 62-year-old male presented to the emergency department (ED) after falling to the ground from a 12-foot scaffold. He described falling with his right arm extended above his head. He recalled attempting to grip the scaffolding with this arm, jerking his arm upward as he fell. He denied any loss of consciousness or any complaints except for right shoulder pain and inability to lower his right arm. He denied any numbness in this arm. The patient had no prior history of shoulder injury.

Physical examination revealed an age-appropriate male in severe pain. He was awake and oriented. His right upper extremity was abducted at the right shoulder, flexed at the elbow, with his right hand resting against his temple, a position characteristic for an inferior shoulder dislocation.[1] His humeral head was palpated inferior to the glenoid fossa, abutting the lateral chest wall in the inferior axilla. Capillary refill in that arm was less than two seconds. His radial pulse was easily palpable and normal. Motor and sensory function was intact. Any attempt at movement of the right shoulder elicited extreme pain and apprehension by the patient. Radiographs revealed an inferior glenohumeral dislocation. The shaft of the humerus was parallel to the spine of the scapula. No fractures were noted.

We administered procedural sedation with fentanyl (50 mcg) and midazolam (5 mg), which achieved adequate sedation for approximately 30 minutes. Closed reduction using traction-counter traction was attempted. We pulled the right upper extremity in a cephalad and outward direction in line with the humerus, while a sheet slung around the patient's chest and middle clavicle was used for counter traction. During this process we noted a palpable click, and the arm moved into a position where the humeral head was anteriorly displaced on the thoracic cage, with the arm in external rotation. Repeat shoulder x-rays revealed an anterior dislocation without fracture. The patient's neurovascular exam was reassessed and remained unchanged and intact. We administered additional doses of fentanyl (50 mcg) and midazolam (5 mg), which achieved adequate sedation for an additional 45 minutes. The patient was turned into a prone position with his arm hanging over the side of this stretcher. We performed scapular manipulation, with medial rotation

of the scapular tip and downward traction of the humerus to the ground. Again we noted a palpable click. The patient was rolled back to a supine position. After recovery from procedural sedation he stated that his arm felt "much better." With the arm now comfortably resting against his chest, a sling and swath shoulder immobilizer was placed. A post-reduction x-ray of the shoulder showed complete reduction of the humerus without fracture. Repeat post-reduction neurovascular evaluation was normal. Orthopedic follow-up was arranged.

DISCUSSION

Luxatio erecta is a rare injury occurring in less than 1% of all shoulder dislocations with no age predilection.[1-3] Two mechanisms of injury exist. One is a direct loading force on a fully abducted arm, with elbow extended and forearm pronated. The second and more common mechanism is a sudden, forceful hyperabduction of an abducted extremity, causing inferior displacement of the humeral head, usually producing a rupture of the inferior glenohumeral capsule and disruption of the rotator cuff.[4-6]

Clinically the patient presents with an abducted extremity which s/he will be unable to lower. The elbow is flexed and the forearm pronated. The hand is often resting on or next to the head. The glenoid fossa is empty and the humeral head is palpable on the lateral chest wall.[3,7,8] Secondary injuries are usually neurovascular in nature, including impingement of the axillary artery and/or brachial plexus.

Radiologic evaluation reveals a humeral head located inferiorly to the glenoid fossa and a humeral shaft lying parallel to the scapular spine. The exact location of the humeral head is variable, particularly on anterior-posterior radiographs. The humeral head can be found at or beneath the glenoid rim and against the rib cage at the third or fourth intercostal space.

The true distinguishing feature of *luxatio erecta* is the abducted position of the humeral shaft parallel to the spine of the scapula.[2,6] While the clinical picture is considered pathognomonic, a missed case of *luxatio erecta* has been reported.[7] An atypical clinical picture, where the arm was not fully abducted over the patient's head, misled the involved physician, thus emphasizing the importance of full roentgenogram evaluation.

Closed reduction can usually be performed when adequate sedation and analgesia are obtained. This is performed by upward and outward traction in-line with the humerus while counter traction is applied across the acromion. After the humeral head is reduced, the arm should easily adduct in an arc back toward the body.[3,4,9] Occasionally closed reduction will not be successful secondary to a buttonholing of the humeral head through a defect in the inferior glenohumeral capsule caused by the injury. This "buttonholing" mandates an open reduction.[3,5,7,8]

Many complications of an inferior glenohumeral dislocation have been noted in the literature, including associated fracture of the clavicle/acromion; coracoid; greater tuberosity and/or humeral head; brachial plexus injuries, considered secondary to stretching; and axillary artery occlusion at its origin at the subscapular branch or distal to the circumflex humeral arteries.[2,5-7,9-12] Approximately 59% of inferior shoulder dislocations have some nerve injury, and 37% have associated fracture.[5,13] In addition, due to the strong forces required to produce this injury, there is significant local soft tissue damage, with approximately 50% having associated rotator cuff tears.[6]

In our case presented above, we initially attempted closed reduction utilizing traction-counter traction. During this process the inferior dislocation was converted to an anterior shoulder dislocation. *Luxatio erecta*, although referred to as an inferior shoulder dislocation, is in fact an anterior-inferior displacement of the humeral head. It is foreseeable that a dislocation inferiorly might be prone to convert to an anterior dislocation because of the significant tissue damage. Despite that, our literature search did not identify any case reports of similar complications associated with reduction for *luxatio erecta* shoulder dislocations. However, Nho et al.[14] describes a specific reduction technique for inferior shoulder dislocations that involves converting the inferior to an anterior dislocation before reduction to its proper anatomic position. These authors hypothesize that this two-step reduction process is easier than the traditional one-step traction-counter traction used in most cases.

In conclusion, we present a case of *luxatio erecta* that was complicated by the production of an anterior dislocation during attempted reduction. Although this complication appears to be uncommon, it is important to consider the potential for inferior shoulder dislocations to convert to other dislocation positions during the process of reduction.

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Effect of a Medical Student Emergency Ultrasound Clerkship on Number of Emergency Department Ultrasounds

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Objective: To determine whether a medical student emergency ultrasound clerkship has an effect on the number of patients undergoing ultrasonography and the number of total scans in the emergency department.

Methods: We conducted a prospective, single-blinded study of scanning by emergency medicine residents and attendings with and without medical students. Rotating ultrasound medical students were assigned to work equally on all days of the week. We collected the number of patients scanned and the number of scans, as well as participation of resident and faculty.

Results: In seven months 2,186 scans were done on the 109 days with students and 707 scans on the 72 days without them. Data on 22 days was not recorded. A median of 13 patients per day were scanned with medical students (CI 12-15) versus seven (CI 6-9) when not. In addition, the median number of scans was 18 per day with medical students (CI 16-20) versus eight (CI 6-10) without them.

Conclusion: There were significantly more patients scanned and scans done when ultrasound medical students were present. [West J Emerg Med. 2010; 11:31-34].

INTRODUCTION

Emergency ultrasonography is part of the core curriculum for emergency medicine (EM) residents.[1] Prior studies suggest the best way to train residents and attending physicians in emergency ultrasonography is through a combination of didactic and hands-on training.[2-10] For example, Mandavia et al.[7] states that emergency ultrasound can be taught with a high degree of accuracy with eight hours each of lecture and hands-on training. Lanoix et al.[8] states that adequate efficiency can be obtained though a four-hour training course with three hours of hands-on training and a one-hour didactic session. Various policy statements from the American College of Emergency Physicians[11], the American Academy of Emergency Medicine[12], and the Society for Academic Emergency Medicine (SAEM)[13] have proposed different standards for competency. SAEM recommends 40 hours of didactics and 150 scans across all applications.[2] Other suggestions range from 25 scans of each primary application to 300-500 total scans.[9,10] While all groups agree it is important to encounter pathologic findings for each application, no organization requires this for formal credentialing. Furthermore, skills necessary for competence have not achieved consensus.[14] Nonetheless, residents cannot learn emergency ultrasonography without hands-on experience.

There are many barriers to resident performance of emergency ultrasonography. An important impediment is time, or its perception.[15] For a busy resident, time to scan (locating,

Table 1. Median daily patients scanned and total scans (with 95% confidence intervals) by physician group with and without student presence.

	With students	Without students	p-value (Mann-Whitney U test)
Days observed	109	72	
Patients scanned	13 (12-15)	7 (6-9)	<.0001
Total scans	18 (16-20)	8 (6-10)	<.0001
Patients scanned with residents	8 (8-9)	6 (5-8)	.002
Total scans with residents	10 (9-11)	7 (6-9)	.0005
Patients scanned with faculty	6 (5-7)	3.5 (3-5)	.0001
Total scans with faculty	8 (7-9)	4 (3-5)	<.0001

cleaning, entering patient information, performing the scan) can seem prohibitive. At our institution, we have a medical student elective in emergency ultrasonography. Fourth-year students spend four weeks under the guidance of a Registered Diagnostic Medical Sonographer-certified, fellowship-trained director and emergency ultrasonography fellow. Students bring the machine to the bedside, perform their own scans, and then repeat the scans with the resident/faculty caring for the patient, for robust clinical teaching.

Our goal was to determine whether a medical student emergency ultrasound clerkship changes the number of patients undergoing ultrasound and the number of scans in the emergency department (ED).

METHODS

This prospective Institutional Review Board-approved study was conducted at a university hospital Level I Trauma Center with an annual ED census of 38,000 patients. All patients who received an emergency ultrasound by ED personnel were eligible. There were no exclusions.

From January 24, 2005 to August 15, 2005, ultrasound students were assigned to specific days of the week, with all days equally represented. The students worked from 7 am to 2 am. EM residents and faculty were not aware that the number of scans was being monitored, nor that students purposely were not scheduled on some days.

We recorded the number of patients scanned, the number of scans done, and if medical students were present that day. Some patients received more than one scan, for example, right upper quadrant and the kidney. We also recorded if a resident or faculty member participated in the scan. We defined participation as presence at the bedside during the scan, regardless of who held the probe. Of note, each trauma patient (approximately 7-8 per day) receives a Focused Assessment of Sonography for Trauma (FAST) regardless of medical student presence. At our institution, it is common to have several physicians/students at the bedside assisting in image acquisition and interpretation.

All scans were done with either a BK Medical Hawk 2102 or Sonosite TITAN machine. Each scan was recorded and reviewed in its entirety during weekly educational sessions in the division of emergency ultrasound led by the emergency ultrasound fellow and the fellowship director.

Research assistants added the total from each day and data were entered into Excel (Microsoft Corporation, Redmond, WA) and analyzed with Stata (version 9.2, StataCorp, College Station, TX). Because we did not expect the number of patients and scans to be normally distributed, we used nonparametric statistics. We compared the number of patients that received scans and the number of scans with and without a medical student present. The distributions of scans and patients with and without a medical student were compared using the Wilcoxon rank sum test. We calculated medians and 95% exact binomial confidence limits for scans and patients with and without a medical student present.

RESULTS

In seven months we performed 2,186 scans on the 109 days when students were present and 707 scans on the 72 days when students were not present. The ultrasound log sheets were missing for 22 days and these were excluded. Statistically more patients were scanned and more scans were performed per day when the medical students were present [patients:(n=13, CI 12-15); scans:(n=18, CI 16-20)] versus when they were not [patients:(n=7, CI 6-9); scans:(n=8, CI 6-10)] (Table 1). Figure 1 represents the median number of patients scanned per day, and Figure 2 represents the median number of scans performed per day.

DISCUSSION

In this prospective, single-blinded non-randomized study of the effect of a medical student rotation on the number of scans performed by faculty and residents, significantly more scans were performed and more patients were scanned when medical students were present.

Much of the literature on training of EM residents cites the need for hands-on training to reach an appropriate competency level.[2-12] As the number of scans for any resident

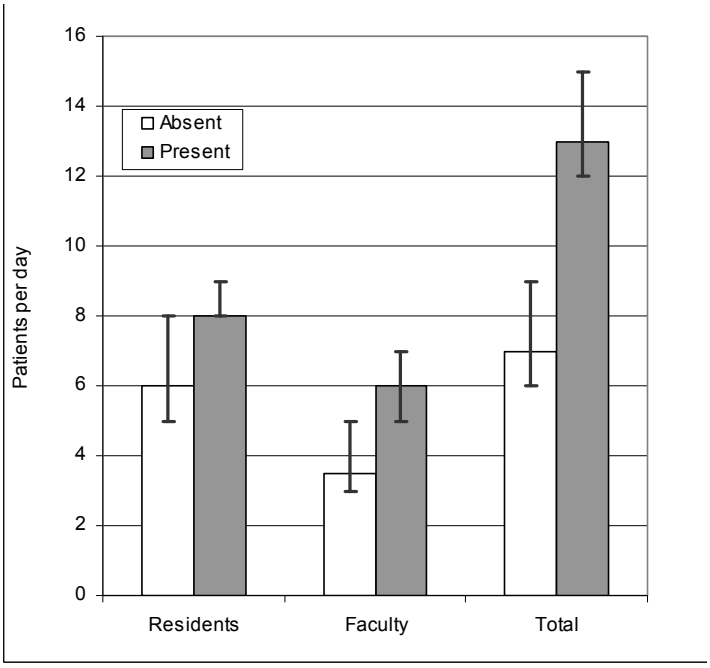

Figure 1. Patients scanned, by physician group and student presence.

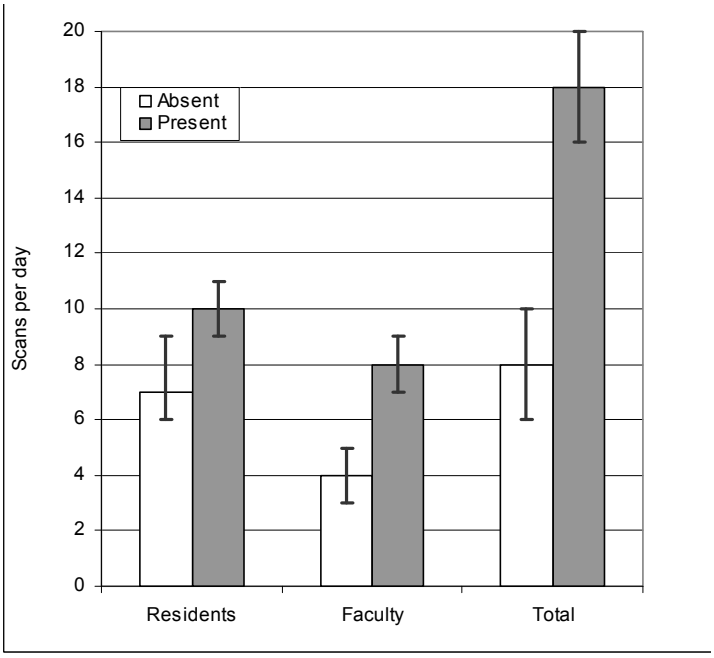

Figure 2. Scans performed, by physician group and student presence.

increases, accuracy and efficiency increases. Since this study shows a statistical increase in the number of scans, the presence of medical students may contribute to competency in emergency ultrasound.

This residency program far exceeds the SAEM guidelines of 150 scans, requiring a minimum of 500 scans per resident by graduation. Having a medical student ultrasound rotation contributes significantly to fulfilling this requirement. For institutions where residents perform fewer scans, a medical student rotation may significantly increase the number of scans. Further prospective studies should test whether resident competency is enhanced by increasing the number of scans.

LIMITATIONS

This study has several limitations. First, results of a single-site study may not be generalized to other practice settings. Second, FAST scans were performed on trauma patients regardless of medical student presence or day of the week. This factor would act to equalize the number of scans done per day, and not mitigate the statistical difference we found. Third, we collected and reported data for full 24-hour days, but medical students, if assigned, were present only 19 hours per day. This factor would serve to dilute any difference found. We did not correct for the absence of medical students during the early-morning hours. Finally, there were 22 days unaccounted for due to missing log sheets. Had this data been available, it may have altered the results.

CONCLUSION

Our study showed there are statistically more patients scanned and more scans performed in the presence of an ultrasound medical student at our institution. Further prospective studies are needed to test if there are significantly more scans done in other EDs. As mentioned, since the volume of scans is critical for effective education of emergency physicians, implementation of an ultrasound medical student clerkship should be encouraged.

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Dedicated Shift Wrap-up Time Does Not Improve Resident Sign-out Volume or Efficiency

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Objectives: Sign-out (SO) is a challenge to the emergency physician. Some training programs have instituted overlapping 9-hour shifts. The residents see patients for eight hours, and have one hour of wrap-up time. This hour helps them complete patient care, leaving fewer patients to sign-out. We examined whether this strategy impacts SO burden.

Methods: This is a retrospective review of patients evaluated by emergency medicine (EM) residents working 9-hour (eight hours of patient care, one hour wrap-up time) and 12-hour shifts (12 hours patient care, no reserved time for wrap-up). Data were collected by reviewing the clinical tracker. A patient was assigned to the resident who initiated care and dictated the chart. SO was defined as any patient in the ED without disposition at change of shift. Patient turn-around-time (TAT) was also recorded.

Results: One-hundred sixty-one postgraduate-year-one resident (PGY1), 264 postgraduate-year-two resident (PGY2), and 193 postgraduate-year-three resident (PGY3) shifts were included. PGY1s signed out 1.9 patients per 12-hour shift. PGY2s signed out 2.3 patients on 12-hour shifts and 1.8 patients on 9-hour shifts. PGY3s signed out 2.1 patients on 12-hour shifts and 2.0 patients on 9-hour shifts. When we controlled for patients seen per hour, SO burden was constant by class regardless of shift length, with PGY2s signing out 18% of patients seen compared to 15% for PGY3s. PGY1s signed out 18% of patients seen. TAT for patients seen by PGY1s and PGY2s was similar, at 189 and 187 minutes, respectively. TAT for patients seen by PGY3s was significantly less at 175 minutes.

Conclusion: The additional hour devoted to wrapping up patients in the ED had no affect on SO burden. The SO burden represented a fixed percentage of the total number of patients seen by the residents. PGY3s sign-out a smaller percentage of patients seen compared to other classes, and have faster TATs. [West J Emerg Med. 2010; 11(1):35-39].

INTRODUCTION

Shift work is inherent to emergency medicine (EM) practice and is becoming more common in other disciplines, as many centers switch to a hospitalist-based admission system. Inherent to any shift-based medical system is the need to transfer care of patients to new providers at change of shift. It has been noted in the literature that overlapping shifts might help reduce the sign-out (SO) burden by allowing physicians the opportunity to wrap up patients and have fewer undispositioned patients at change of shift;[1] however, the impact of this shift paradigm on SO burden has not been studied.

We sought to determine whether there is any difference in SO burden by post-graduate year (PGY) among PGY1s, PGY2s, and PGY3s. We also studied differences in SO burden from PGY2s and PGY3s working 12-hour versus 9-hour

shifts, with an hour of shift overlap specifically dedicated to wrapping up existing patients. Since SO burden is partly determined by the number of patients seen by each resident and partly determined by the turn-around time (TAT) of each patient seen, we collected these data points for each class, as well. We hypothesized that residents would sign out fewer patients on 9-hour shifts compared to 12-hour shifts because the additional hour of wrap-up time would allow residents to disposition more patients prior to shift termination. We also hypothesized that residents of more advanced training would sign out fewer patients than residents with less training, as we expected they would have shorter TATs as a function of their higher level of experience.

METHODS

This is a retrospective chart review of patients evaluated by EM residents in an urban tertiary care referral center. The emergency department (ED) has 45 beds with an annual volume of 65,000. The study period was three consecutive months beginning November 1, 2006. This time period was chosen to avoid the summer, when residents are adjusting to their new roles, as well as the spring, when residents are allowed to trade shifts with those of different levels of training. All EM residency shifts during the study period were included. Shifts were a combination of 9-hour shifts (7am – 4pm, 3pm – 12am, and 11pm – 8am) and 12-hour shifts (7am – 7pm, 8am – 8pm, 9am – 9pm, 1am – 1pm, 2pm – 2am, 7pm – 7am, and 8pm – 8am). All residents working 9-hour shifts are expected to see new patients for eight hours and devote their last hour to wrapping up existing patients. They are aware of this expectation, which is reinforced as part of their ED orientation. During the study period, no resident working a 9-hour shift initiated care on a patient in the last hour of his shift. PGY1s only worked 12-hour shifts, while PGY2s and PGY3s worked a combination of shift lengths. Shifts worked by off-service residents were excluded. We also excluded shifts worked on the weekly conference days, as residents work shifts of differing lengths compared to the rest of the week and because there is a different proportion of attending physician and physician assistant coverage on those days.

We collected data by review of the clinical tracker (VitalWorks version 2.7.2, modified 4/26/05), which creates a permanent electronic record of time of resident assignment and time of patient disposition. The difference between these times was defined as the TAT. We did not use time-to-bed assignment or time-to-removal of the patient name from the tracker for our data collection, as these items are based upon bed availability and secretarial work-load, which are parameters beyond the residents' control. We checked data against the patient's medical record and the residents' work schedule to verify the provider assigned to the patient. A patient was assigned to a resident if the resident initiated care on the patient and dictated the chart. Ten percent of the data was collected by a second data abstractor, with an interobserver reliability of 97% for identification of both the specific resident assigned to the patient and for time of patient care initiation. When patients were in the ED through multiple shifts and cared for by multiple providers, the resident who first initiated care and dictated the chart was credited with that given patient and that patient's TAT.

SO burden was defined as the number of patients remaining in the ED with no disposition at change of shift. Change of shift was defined as the pre-determined time at which a provider is scheduled to end his clinical shift. SO burden and TAT by shift length were examined by two-tailed T test, and ANOVA was used to assess SO burden and TAT by resident training level. Trained data abstractors entered data into a standardized spreadsheet. The study protocol was reviewed by the institutional review board and found to be exempt.

RESULTS

A total of 161 PGY1 shifts (all twelve-hour shifts), 264 PGY2 shifts (101 twelve-hour shifts, 163 nine-hour shifts), and 193 PGY3 shifts (156 twelve-hour shifts, 37 nine-hour shifts) were included. PGY1s signed out an average of 1.9 patients per twelve-hour shift. PGY2s signed out an average of 2.3 patients on twelve-hour shifts and 1.8 patients on nine-hour shifts ($p = 0.004$). PGY3s signed out an average of 2.1 patients on twelve-hour shifts and 2.0 patients on nine-hour shifts ($p = 0.45$). When we controlled for the volume of patients seen per hour during the course of a shift, SO burden was constant for PGY2s and PGY3s respectively, regardless of shift length. In other words, PGY2s saw more patients per hour during their shorter shifts, and this accounted for the increased SO burden on the shorter shifts. PGY2s signed out 18% of the patients they saw ($p = 0.91$ between different shift lengths) and saw 1.13 patients per hour. PGY3s, on the other hand, signed out 15% of the patients they saw, and saw 1.25 patients per hour. There was no significant difference between the percentage of patients SO on 12-hour compared to 9-hour shifts for PGY3s ($p = 0.08$). The difference between percentage of patients signed out by PGY3s and PGY2s was statistically significant ($p=0.005$), although the total number was not. PGY1s signed out 18% of the patients they saw, and saw 0.85 patients per hour. Residents working 12-hour shifts reported staying an average of 60 minutes beyond the end of their shift, while residents working 9-hour shifts reported staying on average about 30 minutes late. There was a wide range of overtime described by residents, with some residents reporting staying two hours late regardless of shift length and others reporting leaving within 15 minutes. However, the majority reported staying later after longer shifts than shorter shifts.

TAT for patients seen by PGY1s was 189 minutes (95 percent confidence interval, 7 minutes). TAT for patients seen

by PGY2s was similar, at 187 minutes (95 percent confidence interval, 5 minutes). TAT for patients seen by PGY3s was significantly less at 175 minutes (95 percent confidence interval, 5 minutes, $p<0.01$). For PGY2s and PGY3s, there was no statistically significant difference in TAT for 9-hour compared to 12-hour shifts.

DISCUSSION

The Joint Commission for the Accreditation of Healthcare Organizations made better communication between medical providers at patient sign-out a National Patient Safety Goal in 2006.[2] The evidence that there is room for improvement in inter-provider communication is well supported in the literature. Incomplete communication between providers in the inpatient and outpatient setting has been shown to be both common and deleterious to patient care.[3] Because of work-hour restrictions, SO between house officers in the inpatient setting is becoming more frequent, but few programs have standardized the SO process or provide training in appropriate SO procedures,[4,5] and patients are more likely to suffer an adverse event after SO to a new provider.[6,7] This is compounded by incomplete attending-level supervision, since attendings are often not present during SO and housestaff may be unable to effectively communicate or understand the critical issues regarding a given patient's care.[5,8] The surgical literature identifies miscommunication at SO as being an integral contributor to medical errors.[9] Although there is a growing body of research regarding how to make SO safer, more complete, and more effective,[1,5, 10-15] SO continues to be a high-risk time in patient care, as information may be lost that results in medical errors and near misses.[11,16-19] Therefore, in addition to seeking to make the SO process safe, standardized and comprehensive, it is also desirable to limit the number of patients signed out each day. Data on EM provider satisfaction have led many training programs to reduce the length of shifts worked,[20-23] which intuitively leads one to think that more patients will be signed out each day, as there are more total daily shifts for the same provider coverage. For example, an ED that utilizes 12-hour shifts with two SO per day should sign out fewer total patients during the course of a day than an ED that utilizes 8- or 6-hour shifts with three or four sign-outs per day. A reasonable solution to this is to provide residents with scheduled time during a shift to disposition existing patients while having no responsibility for seeing new patients. This is the reasoning behind 9-hour overlapping shifts.

Our study did not find any evidence to support this practice as a means of reducing SO burden. The additional hour devoted to wrapping up existing patients in the ED had no affect on the number of patients signed out at change of shift. For PGY2s, the SO burden was higher after shorter shifts than longer shifts, and for PGY3s, the number was the same. Instead, we found that PGY2s and PGY3s signed out a fixed percentage of the total patients they saw, and they saw more patients per hour on the shorter shifts. Indeed, staffing the ED with residents working nine-hour shifts would result in more total patients signed out in a 24-hour period, compared to staffing with residents working 12-hour shifts. It is unclear why this occurred. It is possible that residents working 12-hour shifts see fewer new patients in the last hour of their clinical shifts, thereby giving themselves time to finish up patients from the first 11 hours. This would mimic the built-in hour at the end of the 9-hour shifts, which is devoted simply to patient wrap up. It may also be that residents working 9-hour shifts signout the same total number of patients, but their SO may be more complete and more "tidied up" than residents working 12-hour shifts. An additional reason for this phenomenon might be that residents working 12-hour shifts pick up lower acuity complaints near the end of their shifts, while those working 9-hour shifts continue to pick up higher acuity complaints with the anticipation of an hour to complete care.

The ability to multi-task and work efficiently is an important goal of EM training. In our study, PGY3s saw more patients and dispositioned them more quickly than their counterparts who had completed less training. This is probably because of their increased experience and ability to act independently in a clinical setting. The improved ability to see patients per hour as residents progress though the course of training has been well documented in the literature,[24-28] and one study has shown that PGY1s have longer TATs than PGY2s and PGY3s.[24] Although our study period intentionally began five months into the academic year so that PGY1s would have become oriented to their roles as resident physicians, we believe that less experienced providers are possibly less facile at navigating any hospital system. It is also possible that as residents spend more time in a given hospital, they develop interpersonal relationships with consultants, nurses, clerical staff, and other residents, which may help facilitate patient disposition. Ultimately, it can be argued whether a decrease in TAT by 12 minutes between PGY2s and PGY3s is clinically significant or merely statistically significant. Twelve minutes for a single patient encounter may not make a significant difference in patient flow in a busy ED, but the same 12 minutes could potentially be very consequential on the larger scale of dozens of patients seen by residents each day.

Most likely, it is this increased efficiency that led to PGY3s having a lower SO burden at the end of their shifts when compared to PGY2s and PGY1s. Additionally, PGY3s may be better able to anticipate the end of their shifts and assess the level of complexity of new patients, leading them to choose patients with straightforward dispositions and resulting in a lower SO burden.

LIMITATIONS

There are a number of limitations with our study. We were unable to control for patient acuity, as the electronic tracking system utilized for data acquisition did not record triage levels during the study period. This is important, as higher acuity or more complex patients may sometimes (but certainly not always) take longer to disposition than lower acuity patients. This could result in changes in TAT and SO burden. At another institution, it was shown that PGY3s see lower acuity patients than PGY2s or PGY1s.[24] It is unknown if this is generalizable to our resident population. However, PGY2s at our institution are more commonly assigned to "trauma" shifts, which are 12-hour shifts from 8 am to 8 pm and 8 pm to 8 am during which they are responsible for procedures on trauma patients, and this could conceivably impact those residents' TATs and SO burden. The impact of this should be small, however, since other residents often care for trauma patients, and there are no other clearly defined patient type to which residents are assigned.

There was no way to quantify the quality of SO. In other words, there was no way to determine how concise, complete, or error-free each SO was by residents of varying levels or working different length shifts. We likewise could not find a reliable way to determine the number of procedures signed out. This is significant, because the SO burden, defined as the number of patients remaining with no disposition, may be less or more of a work-load to a provider starting his clinical shift depending on the complexity and further workup involved with the patient. Indeed, a SO involving a single poorly understood patient with incomplete information can result in an incoming provider's inability to see new patients or attend to other work; whereas a SO involving many patients that is complete and focused may interfere very little with seeing new patients.

Another possible limitation is that we did not look at patient length of stay (LOS), or time from triage to disposition. We only looked at the time in which residents were directly involved in patients' care. Therefore, we cannot address the rapidity with which residents pick up waiting patients. We also cannot state whether residents of different levels of training or working different length shifts contribute differently to patient total LOS. For instance, it may be that PGY2s and PGY1s have the same patient TATs, but one of those classes may see waiting patients more rapidly and therefore have decreased total ED LOS. We did not undertake this assessment because it relies heavily on when patients are placed in rooms to be seen, and residents have little control over this portion of the patient's timeline in their ED.

Finally, our data were drawn from a single institution, and may not be generalizable to other institutions. Our ED LOS averages 180 minutes for discharged patients, and our overall boarding times are 7.5 hours for admitted patients. This is lower than the national average and may speak to systems issues that are unique to our institution.

CONCLUSION

Shifts with a built-in hour for wrapping up existing patients did not result in a reduction of SO burden. Instead, the number of patients signed out represented a fixed percentage of the total number of patients seen by PGY2s and PGY3s. This may be because of end-of-shift behavior differences in residents working 12-hour versus 9-hour shifts. PGY3s saw more patients and signed out a smaller percentage of patients seen compared to other classes.

PGY3s have faster patient TATs than PGY2s or PGY1s. PGY2s and PGY1s have the same TATs, but PGY2s see more patients during the course of their shifts. There was no difference in TAT for PGY2s or PGY3s as a function of their shift length.

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Need for Injury-Prevention Education in Medical School Curriculum

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Injury is the leading cause of death and disability among the U.S. population aged 1 to 44 years. In 2006 more than 179,000 fatalities were attributed to injury. Despite increasing awareness of the global epidemic of injury and violence, a considerable gap remains between advances in injury-prevention research and prevention knowledge that is taught to medical students. This article discusses the growing need for U.S medical schools to train future physicians in the fundamentals of injury prevention and control. Teaching medical students to implement injury prevention in their future practice should help reduce injury morbidity and mortality. Deliberate efforts should be made to integrate injury-prevention education into existing curriculum. Key resources are available to do this. Emergency physicians can be essential advocates in establishing injury prevention training because of their clinical expertise in treating injury. Increasing the number of physicians with injury- and violence- prevention knowledge and skills is ultimately an important strategy to reduce the national and global burden of injury. [West J Emerg Med. 2010; 11(1):40-43].

INTRODUCTION

Paramedic: *"University Med, this is Rescue 1."*
Radio Nurse: *"Rescue 1, this is University Med. Your contact time is 23:45."*
Paramedic: *"University Med. our patient contact time was 23:35. We have a critical male trauma. He is a 19-year-old male, 90 kg, driver of single vehicle rollover crash, with altered level of consciousness, heavy ethanol odor, high rate of speed with severe vehicle damage and large amount of intrusion. There was no treatment prior to our arrival; airway open, breathing labored; circulation rapid; skin cool, pale and moist; no seatbelt but airbag deployed; left pupil blown, right responds but sluggish; 15 liters non-rebreather; spinal stabilization – back board and c-collar. At patient contact time, Glasgow Coma Score was 2-3-4. At 23:40 pulse of 130, reps are 18 shallow, blood pressure 90/60, sinus tach. University Med, you are our closest trauma center, ETA is 5 minutes."*
Radio Nurse: *"10-4, Rescue 1. I will activate our trauma team."*
Paramedic: *"10-4, University Med. We are going 902-H to your facility"*

In emergency departments (ED) across the nation, it is far too common to receive the paramedic base station call that heralds the needless loss of limb or life due to preventable injury.

Despite increasing recognition of the global epidemic of injury, medical schools have not collectively included injury prevention as an important component of their curriculum. Association of American Medical Colleges (AAMC) data from its 2004 Curriculum Management and Information Tool show that just a over one-quarter of allopathic medical schools in the U.S. require coursework in topics associated with injury.[1] Former Surgeon General Richard Carmona wrote in an opinion article that ours is a "treatment-focused society, when the real social and economic benefits arise from being prevention-focused."[2] We believe it is the goal of many national and international organizations [Centers for Disease Control and Prevention (CDC), World Health Organization (WHO), Association of American Medical Colleges (AAMC)]) that the number of physicians with expertise in injury prevention will increase and ultimately improve the injury-prevention infrastructure.

Table 1. Haddon Matrix: adapted and reproduced with permission of The McGraw-Hill Companies, Inc.[23]

	Human	Agent/Vehicle	Environment	
			Physical	Social
Pre-Event	Driver age, gender, experience, drug or alcohol use, vision, fatigue, frequency of travel, risk-taking behavior	Vehicle speed, brakes, tires, road-holding ability, visibility (e.g., daytime running lights)	Road design and traffic flow, road conditions, weather, traffic density, traffic control (lights, signals), visibility	Speed restrictions, impaired driving laws, licensing restrictions, road rage, seat belt and child restraint laws
Event	Age, pre-exisiting conditions (e.g., osteoporosis), restraint use	Vehicle speed, size, crash-worthiness, type of seat belts, airbag, interior surface hazards	Guardrails, median dividers, break-away poles, road-side hazards	Enforcement of speed limits
Post-Event	Age, co-morbidities	Integrity of fuel system	Distance from emergency medical care, obstacles to extrication	EMS planning and delivery, bystander control, quality of trauma care, rehabilitation

In the treatment-focused ED, emergency physicians (EP) do their best to control the consequences of devastating injuries. However, a study conducted by Stewart et al.[3] showed that nearly 90% of trauma deaths occur in patients who sustain injuries that are physiologically and anatomically non-survivable. Clearly, new trauma treatment protocols do not have the potential to reduce mortality as prevention strategies can. Reduction of injury-related mortality can be quickly realized with the systematic implementation of broad prevention efforts aimed at intentional and unintentional injuries.[4] However, the paucity of physician training in basic injury prevention and control makes injury-related mortality reduction unlikely. This article highlights the need and ability of medical schools in the U.S. to train physicians in the fundamentals of injury prevention and control.

DISCUSSION

Global Impact of Injury

Worldwide, injury accounts for five million deaths annually, 9% of the world total. Many million more suffer non-fatal injuries.[5] In the U.S. injury is the leading cause of death and disability from age 1 to 44 years, killing more than 179,000 people annually.[6] In 2007 nearly 30 million suffered non-fatal injuries in the U.S.[7] The CDC estimates this number is rising and annually costs approximately 10% of U.S. medical expenditures.[8,9]

Teaching Medical Students Injury Prevention

The accreditation standards for medical education established by the Liaison Committee on Medical Education mandate inclusion of prevention and preventive medicine, as well as behavioral and socioeconomic subjects.[10] A recent AAMC report outlined the need for future physicians to be adequately trained in injury prevention and control.[1] To improve medical student education regarding injury, the AAMC collaborated with the CDC to form the Injury Prevention and Control Education for Medical Students Panel, which was further supported by the CDC's National Center for Injury Prevention and Control. Through coordinated efforts, they addressed what medical students should learn about injury prevention and treatment and what kind of educational experiences allow students to achieve these learning objectives.[1]

Using general skills from the AAMC Medical School Objectives Project report, the panel identified three categories specific to injury prevention and treatment: 1) Understanding the epidemiology of injury; 2) developing the ability to deliver appropriate clinical care for injuries; and 3) understanding injuries in the context of health systems. A useful tool to contextually depict the first objective is the Haddon Matrix (Table 1). Originally developed by Dr. William Haddon Jr. in 1970, this matrix examines factors involved in an injurious event and categorizes it into an epidemiological triad of agent-host-environment and the event sequence.[11,12] Using the Haddon Matrix to establish the factors involved in the presenting case in this article, we can establish a framework for the development of injury-control interventions. Delivering appropriate clinical care for injuries (second objective) involves multiple criteria, including the ability to provide anticipatory guidance based on behavioral risk factors, to recognize injuries related to mass casualty events, and to remain nonjudgmental and avoid stereotyping. Finally, understanding injuries in the context of health systems (third objective) involves understanding the medical-legal aspects of injury and the various systems of acute care. It also encompasses understanding the importance of the quality of patient-level surveillance data and the role of environmental and policy interventions to reduce injury risk, morbidity and mortality.

Table 2. Core Competencies: adapted and reproduced with permission of the National Training Initiative for Injury and Violence Prevention (NTI).

Essentials of Injury & Violence Prevention: Core Competencies
1. Ability to describe and explain injury and/or violence as a major social and health problem.
2. Ability to access, interpret, use and present injury and/or violence data.
3. Ability to design and implement injury and/or violence prevention activities.
4. Ability to evaluate injury and/or violence prevention activities.
5. Ability to build and manage an injury and/or violence prevention program.
6. Ability to disseminate information related to injury and/or violence prevention to the community, other professionals, key policy makers and leaders through diverse communication networks.
7. Ability to stimulate change related to injury and/or violence prevention through policy, enforcement, advocacy and education.
8. Ability to maintain and further develop competency as an injury and/or violence prevention professional.
9. Demonstrate the knowledge, skills and best practices necessary to address at least one specific injury and/or violence topic (e.g. motor vehicle occupant injury, intimate partner violence, fire and burns, suicide, drowning, child injury, etc.) and be able to serve as a resource regarding that area.

Educational Strategies and Resources for Medical Student Teaching

Injury-related learning objectives should be integrated in pre-clinical and clinical years. A combination of didactics and experiential learning exercises should also be used.[1] Two notable training tools are Teach Violence and Injury Prevention (TEACH-VIP) by the World Health Organization, and Core Competencies: Essentials for Injury and Violence Prevention by the Society for the Advancement of Violence and Injury Research (SAVIR) and the State and Territorial Injury Prevention Directors Association (STIPDA).[13,14]

TEACH-VIP is designed for classroom instruction and includes PowerPoint slide presentations and supporting lecture notes that address a broad range of topics. The curriculum consists of 21 core lessons and 39 advanced one-hour lessons. Core lesson topics include injury prevention principles, measurement of injuries, injury surveillance, community methodology survey methods, ethical issues in the injury field, types of injuries, and policy development/advocacy. Advanced lessons help to deepen understanding of all aspects of the field of emergency medicine. Almost 80% of surveyed medical and public health students who received injury prevention education via TEACH-VIP felt it was effective.[15]

In 2000 SAVIR and STIPDA formed the National Training Initiative for Injury and Violence Prevention and began a process to define essential knowledge and skills required by injury-prevention professionals. This guideline lists nine core competencies, some of which are the ability to describe and explain injury as a major social and health problem, and design and implement injury prevention activities (Table 2). These core competencies guide future training and curriculum development. Incorporating this in the curriculum would facilitate teaching students the skills that best serve injury and violence prevention in the clinical setting.

The AAMC report discussed earlier provides a few examples of medical schools that have succeeded in creating educational opportunities in injury prevention. Brown Medical School collaborated with the Injury Prevention Center at Rhode Island Hospital to provide fourth-year medical students rotating through the emergency medicine (EM) elective focused instruction on injury prevention. Instructors deliver an introductory lecture about the history and science of injury prevention, injury as a disease process, the analysis of injury events, and methods of prevention. Students later attend a case conference where they present injured patients they cared for in the ED. They must discuss host risk factors, mechanisms of injury, energy transfer, injury-prevention strategies, and patient education. Finally, students are observed with patients to assess their ability to conduct injury-prevention counseling. The medical students at Brown also receive concentrated exposure during required community health clerkships. One to three students per clerkship are assigned to the Injury Prevention Center and participate in community outreach, including disseminating information, advocating for prevention, and coalition building to promote lasting community change.

Applicability of Injury Prevention to Medical Students

Within the curriculum of the third-year clerkships, medical students are exposed continuously to the end result of injuries. During the fourth year, this effect is seen especially during the EM and trauma surgery rotations. The proper use of such clinical encounters to educate patients must be taught to future physicians, and this is best done during medical school. Students may emphasize injury prevention during their preclinical education while taking a history and performing physical examination. Clinical vignettes could include anticipatory guidance questions and focused injury inquiry. This includes screening for intimate partner violence, alcohol and drug problems, and asking older adults and their families about fitness to drive vs. driving cessation.[16] Such training will allow future physicians to play an important role in the safety of patients both in the office and the hospital.

Role of Emergency Medicine

Over the last four decades, injury prevention and control and EM have had parallel evolution. EM provides a unique

perspective on injury prevention and control, and EPs are well-suited to help reduce the national burden of injury. Injury prevention and control is now recognized as integral to EM residency training, although it still needs more emphasis in the core curriculum. In 2006, EDs across the U.S. received 119 million visits. Of those, 42.4 million (36%) were the consequence of injury.[17] ED prevention efforts can be effective in preventing injury and reducing risky behavior.[18-23] EPs should therefore lead efforts to implement injury prevention control in medical school curricula.

CONCLUSION

Future and current physicians have a vital role in prevention of injury. They must be involved in developing strategies, practices and behaviors that promote safety and health in patients as well at the community. We need to incorporate these principles into the medical school curriculum, so that all medical students have a basic understanding of injury prevention and control, which parallels their knowledge of other major health conditions. Physicians, especially EPs, should lead the charge.

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Comparability of Results between Point-of-Care and Automated Instruments to Measure B-type Natriuretic Peptide

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Objectives: Heart failure is one of the leading causes of death in the U.S. The incorporation of B-type natriuretic peptide (BNP) measurements when triaging patients presenting with shortness of breath has improved the diagnostic and prognostic ability of physicians. Currently, there are no point-of-care systems for quantifying BNP that can be used without sacrificing accuracy. We compared the analytical performance of the Abbott i-STAT analyzer, a handheld point-of-care system for measuring BNP, with the lab-based system, the Abbott ARCHITECT.

Methods: One-hundred fifty samples were collected from three clinical settings: 41 from the Emergency Department, 58 from the inpatient wards, and 51 from heart failure outpatient clinics. Linear regression and bias difference analyses were run to evaluate the accuracy of the i-STAT. Correlation between the i-STAT and Architect BNP values were made with values of BNP.

Results: The correlation coefficient was r=0.977 (N=150, p<.0001). The average bias was significant (-36) and there were concentration-dependent differences at higher BNP values. Precision of the i-STAT was poor compared to the lab-based platform.

Conclusion: Although the precision of the i-STAT was poor, there was good clinical agreement between the i-STAT and the lab-based platform. [West J Emerg Med. 2010; 11(1):44-48].

INTRODUCTION

Heart failure (HF) is one of the leading causes of death in the U.S. About five million Americans have this disease, and approximately 550,000 new cases are identified each year.[1] The estimated direct and indirect cost of HF in the U.S. for 2006 was $29.6 billion.[1] With improving diagnosis and management of acute myocardial infarction and HF, it is likely this cost will continue to increase over time. The number of HF-related hospital admissions has been steadily rising in developed countries. The economic burdens of HF are caused by the high number of hospital admissions for initial treatment and high costs of long term care for these patients.[2] While the most common disease group in patients over 65 is HF,[2] it remains difficult to diagnose due to a lack of sensitive and specific presenting symptoms.[3] Furthermore, a misdiagnosis in the emergency department (ED) could place a dyspneic patient at increased risk for both morbidity and mortality.[4] The "gold standard" for diagnosis is echocardiography, which is not generally available in the emergency setting. Due to the alarming costs of HF, there is an urgent need to detect patients at risk of developing HF and establishing timely therapy to prevent irreversible changes that can lead to chronic HF.

Incorporation of B-type natriuretic peptide (BNP) measurements when triaging patients presenting with shortness of breath has improved the diagnostic and prognostic ability of treating physicians. In the "Breathing Not Properly Multinational Study," in 1,586 ED patients presenting with acute shortness of breath, BNP levels measured on arrival had higher diagnostic accuracy than did the ED physician in diagnosing HF, with an area under the receiver-operating characteristic curve (AUC) of 0.90.[5] A BNP cut-point of 100 pg/mL was 90% sensitive and 76% specific

for diagnosing HF as the cause of dyspnea.

Current turnaround times for BNP values, including time to draw sample, transport to central lab, analyze and report values, using lab-based automated analyzers on ED patients is typically around one hour.

Shortening this turnaround time in the emergent setting could potentially help physicians make a more rapid "rule-in" or "rule-out" diagnosis of HF. Mueller et al.[6] and Troughton et al.[7] demonstrated that rapid evaluation of BNP in HF patients shortened the time to treatment initiation, decreased the time to discharge, decreased the total medical costs for that patient, reduced total cardiovascular events, and delayed time to first event.

Attempts at providing a more rapid, point-of-care (POC) BNP test have suffered from analytical, regulatory, and management issues. Our objective in this study was to compare the analytical performance of the POC i-STAT® system for measuring BNP levels with a standard, lab-based ARCHITECT® instrument (Abbott Laboratories, Abbott Park, IL).

METHODS

Patients for this study were enrolled from the ED, inpatient setting, and heart failure clinics at the San Diego Veterans Affairs Healthcare System between January 2007 and January 2008. There were 114 patients, with 41 samples collected from the ED setting, 58 samples from the inpatient setting, and 51 samples from the clinic/outpatient setting. Thirty-six patients from the ED were later admitted and were sampled again as inpatients. Distribution of patients included 110 males (mean age 68, range 38-90 yrs) and four females (mean age 59, range 46-83 yrs.). Inclusion criteria were presentation with heart failure (HF) symptoms in the ED, hospitalization for HF, or visitation in a heart failure clinic. Patients on dialysis, patients with trauma-related shortness of breath and patients unwilling to sign a consent form were not enrolled in the study. The study was approved by review through the Institutional Review Board at the University of California, San Diego.

The i-STAT BNP test is a handheld in vitro diagnostic test for the quantitative measurement of BNP. The i-STAT BNP cartridge uses a two-step sandwich immunoassay using monoclonal antibodies specific for BNP. The i-STAT BNP test uses the same antibodies as the ARCHITECT BNP assay. The capture antibody recognizes amino acids 5 to 13 and the detection antibody that recognizes amino acids 26 to 32 of the BNP molecule.[10] The i-STAT analyzer and BNP cartridges and controls were provided by Abbott, as was the ARCHITECT. Statistical analysis was conducted using SigmaPlot (Systat, San Jose, CA).

Lavender-top, ethylenediaminetetraacetic acid (EDTA) whole blood specimens were obtained in plastic tubes; plasma was isolated and stored at -80 degrees Celsius until analysis.

Table 1. Demographics and lab values

	Number (n=114)	Percent
Age	63.7 ± 11.8	
Sex		
Male	110	96 %
Female	4	4 %
Race		
Caucasian	75	67 %
African American	19	17 %
American Indian / Alaskan Native	4	4 %
Asian / Pacific Islander	3	3 %
Hispanic	9	8 %
Other/Unknown	4	4 %
Past Medical History		
CHF	96	84 %
CAD	64	56 %
HTN	86	75 %
CHF Etiology		
Alcohol	8	7 %
Cocaine	3	3 %
Hypertensive	6	5 %
Hypertropic	2	2 %
Idiopathic	6	5 %
Ischemic	47	41 %
Myocarditis	1	1 %
Valvular	6	5 %
Other/Unknown	17	15 %

Admission Labs	Average	Range
BNP pg/mL	319	12-4560
Sodium mEq/L	139	127-145
Glucose mg/dL	107	60-390
BUN mg/dL	22.5	5-125
Creatinine mg/dL	1.3	0.7-20
WBC x 10^3/μL	7.3	2.3-56
Hemoglobin g/dL	12.9	8-124
Platelets x 10^3/μL	206	12-559

CHF, congestive heart failure; *CAD*, coronary artery disease; *HTN*, hypertension; *BNP*, B-type natriuretic peptide; *BUN*, blood urea nitrogen; *WBC*, white blood count.

Samples were thawed and analyzed weekly in batches on the ARCHITECT and i-STAT. The ARCHITECT and i-STAT measurements were performed at the same time. All personnel running the devices were laboratory staff, trained on the operation of both devices. Linearity and precision of each device or assay was performed using materials provided by the manufacturer.

Table 2. Within-run and Run-to-run Precision of i-STAT and ARCHITECT

	Within-run			Run-to-run		
	N	Mean pg/mL	CV %	N	Mean pg/mL	CV %
i-STAT	15	122	17	30	122	14
	15	3275	19	30	3275	9.8
ARCHITECT	15	99	1.8	20	99	5.5
	15	3428	5.7	20	3428	3.2

CV%, run-to-run precision.

Linear regression analyses were done and bias differences were analyzed according to Bland and Altman.[11] Within-run and run-to-run precision data was obtained on the i-STAT analyzer at both a high and low level. High and low controls were run on the i-STAT analyzer 15 times in one day for within-run calculations. High- and low-level precision controls were run on the i-STAT analyzer twice a day for 15 days for run-to-run calculations. High- and low-level precision controls were run on the ARCHITECT 15 times in one day for within-run calculations. High- and low-level precision controls were run on the ARCHITECT in duplicate twice a day for five days for run-to-run calculations. An F test was used to compare the variance of the i-STAT and the ARCHITECT. A p-value < 0.05 was considered significant.

RESULTS

Sample population characteristics and median lab values are shown in Table 1. Results of precision testing comparing the i-STAT and ARCHITECT are shown in Table 2. For the i-STAT, run-to-run precision (%CV) for the low level (mean=122 pg/mL) was 14% and for the high level (mean=3274 pg/mL) 9.8%. Within-run precision on the i-STAT analyzer for the low level was 17% and for the high level 19%. For the ARCHITECT instrument, run-to-run precision (%CV) for the low level (mean=99 pg/mL) was 5.5% and for the high level (mean=3428 pg/mL) 3.2%. Within-run precision using the ARCHITECT instrument for the low level was 1.8% and 5.7% for the high level.

To determine the accuracy of the BNP i-STAT analyzer, we compared results with those obtained on the ARCHITECT. The range of BNP values obtained on patients for the i-STAT and ARCHITECT was 5 – 5000 pg/mL. Correlations between plasma measurements made with i-STAT and those made with ARCHITECT are shown in Figure 1. Linear regression between the i-STAT and the reference system showed r=0.977 (p<.0001).

In Figure 2, a difference bias plot for the total sample population was constructed according to Bland and Altman.[9] The average bias was -36.01 with significant concentration-dependent differences at higher BNP values.

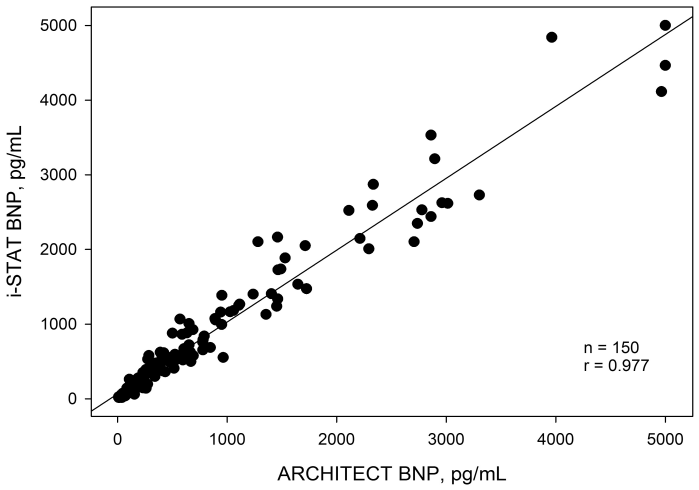

Figure 1: B-type natriuretic peptide (BNP) values as determined with the i-STAT vs ARCHITECT for the entire patient cohort.

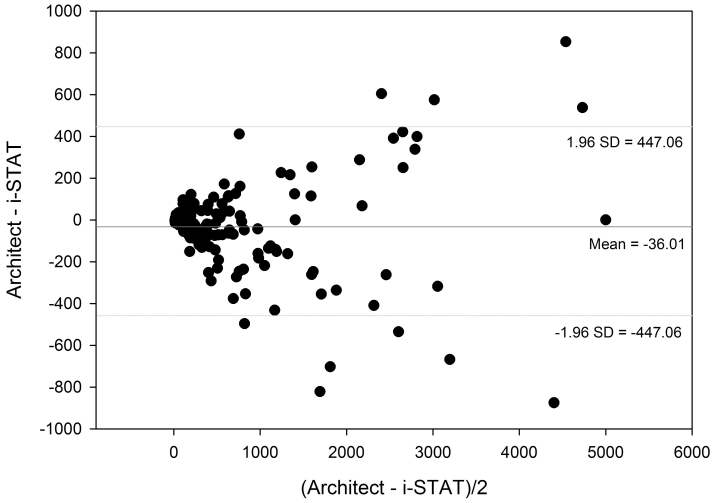

Figure 2: Bland-Altman plot of B-type natriuretic peptide (BNP) values as determined with the i-STAT vs ARCHITECT

DISCUSSION

In this study we evaluated the performance of a handheld POC BNP analyzer against a standard lab-based model. In terms of correlation with the laboratory analyzer, the i-STAT analyzer performed remarkably well with a cumulative correlation of 0.977 for the entire cohort. However, the precision of the i-STAT was poor as compared with the ARCHITECT system.

POC testing for BNP, similar to use of troponins in ACS, is a logical progression in the treatment and risk stratification of patients with HF; however, the i-STAT, with its unique strengths (decreased therapeutic turnaround time, rapid data availability, accuracy) and weaknesses (precision, handling error, cost), proves to be most useful

in the emergent setting as a bridge to the inpatient stay and subsequent lab-based analyses. The main weakness of the i-STAT BNP, like other POC systems, is its lack of precision. From the emergency physician's (EP) perspective, knowledge of the BNP upon presentation is important in guiding treatment plan. The positive predictive value of BNP at 100 pg/mL is 75% and 86% at 400 pg/mL.[5] In addition, a presenting BNP value of below 200 pg/mL is an excellent predictor of 90-day prognosis.[8] While a BNP value of over 480 pg/mL was a strong predictor of 6-month CHF death, hospital readmission, or repeat ED visits.[9] Therefore, knowledge of a specific BNP value (not just a "rule-in" vs. "rule-out" value) is useful to the EP in directing treatment of a patient presenting with CHF exacerbation. The average bias of -36.01 pg/mL and the relatively poor precision of the i-STAT analyzer has to be taken into account when considering implementation of the device, because the difference in precision does make a clinical difference in managing a patient with CHF exacerbation.

The strength of the i-STAT BNP complements the current evolution of the treatment and management of HF as a disease. Once thought to be simply a hemodynamic instability where a patient was either "in" HF or "out of" HF, there is now a greater appreciation for the progressive nature of the disease. Recognizing that remodeling of the heart is constant and gradated means treatment no longer focuses solely on the hemodynamics (diuretics and digitalis) but also includes attention to the heart as a dynamic neuroendocrine organ (ACE inhibitors).[12] The need for a rapid POC system to evaluate BNP in HF patients is two-fold: rapidity and integration into HF management.

While the ARCHITECT instrument takes less than 16 minutes to analyze BNP values, turnaround times of results generally less than one hour due to specimen-processing and transportation issues. The i-STAT analyzer takes only 10 minutes and can be readily available in the ED. Early assessment of the degree of hemodynamic compromise (measured indirectly with BNP) allows physicians to make the appropriate medical interventions necessary to minimize damage to the heart. A rapidly obtained BNP value could prove useful in the ED setting or in the clinic setting, for ruling in/out HF. Furthermore, previous studies have shown that shortened times to BNP evaluation in the emergent setting resulted in quicker treatment initiation and shorter hospital stays.[3]

Cost analysis is another factor to be considered when contrasting the i-STAT analyzer with the ARCHITECT instrument. Studies have shown that the cost of using POC testing over central laboratory can increase costs 1.1 to 4.6 times.[13] The ability to gain a rapid BNP value in the emergent setting would most likely come at a higher cost than continuous use of a central laboratory. However, the i-STAT analyzer, providing a more rapid result, would lead to shorter hospital stays which would reduce costs for the institution.[3] Fiscal considerations should be urged before erroneously implementing this platform into a hospital setting.

LIMITATIONS

The study population was drawn from the Veterans Affairs Medical Center and was 96% male. Thus, these results need to be confirmed in a non-Veterans Affairs population and with women. In addition, the analyses were not performed in real time. Samples were frozen and batch-run, so the study can be considered "in-vitro." However, the strength of the i-STAT remains valuable to the EP in the event of an emergent presentation.

CONCLUSION

Previous POC systems correlate poorly with the lab-based instruments, making it difficult for the physician to interpret and track changes in the BNP levels from ED presentation throughout the hospital stay.[14] In contrast, the i-STAT BNP test utilizes the same antibody as the ARCHITECT BNP assay and, consequently, demonstrates reasonable agreement between the two methods. This provides essential continuity in tracking BNP changes throughout the hospital stay and could allow for accurate charting of a patient's response to therapy. The emerging technology of a rapid POC BNP assay allows physicians to rapidly triage patients and may allow physicians to initiate treatment more rapidly. This could potentially reduce medical costs and total cardiovascular events. Although the i-STAT lacks precision, it could serve as a practical tool in the clinic setting and emergent setting for acquiring a rapid initial BNP value for managing patients.

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The Physiologic Effects of Multiple Simultaneous Electronic Control Device Discharges

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Objectives: Law enforcement and military personnel use electronic control devices to control non-compliant and actively resistive subjects. The TASER® Shockwave is a new electronic control device designed specifically as an area denial device capable of delivering multiple simultaneous discharges. This is the first study to examine the effects of multiple simultaneous device discharges in humans.

Methods: Volunteers were exposed to multiple (two to three), simultaneous 5-second discharges from the Shockwave device to the chest, back, chest to abdomen, or thighs. Blood was analyzed before and after discharge for pH, lactate, potassium, creatine kinase (CK), and troponin. Continuous spirometry was performed before, during, and after the discharge. In addition, electrocardiograms (ECGs) before and after discharge were recorded, and echocardiography was used to determine the rhythm during discharge.

Results: Small elevations of lactate occurred. Moderate increases in CK at 24 hours occurred and appeared to be related to the number of simultaneous discharges. There was a trend to a decrease in minute ventilation in the volunteers exposed to two simultaneous discharges, but it did not reach statistical significance. ECG changes only reflected an increase in vagal tone, and there was no evidence of capture by echocardiography. Five-second, simultaneous, multiple exposures to the TASER Shockwave device were reasonably tolerated by our human volunteers.

Conclusion: Our study suggests that this device may have a reasonable risk/benefit ratio when used to protect an area from a threat. [West J Emerg Med. 2010; 11(1):49-56].

INTRODUCTION

Law enforcement and military personnel use electronic control devices to control non-compliant and actively resistive subjects. The TASER® X26 is the most commonly used handheld electronic control device. It fires two nitrogen-propelled probes up to 25 feet to cause incapacitation of the target.

The TASER® Shockwave is a new electronic control device designed specifically as an area denial device. It operates as a remotely triggered stationary platform that deploys multiple standard TASER cartridges (the same cartridges used in the TASER X26) to saturate an area and immobilize multiple subjects or a moving single subject. As with other electronic control devices, the probes deliver a charge that stimulates the motor neurons, which causes involuntary sub-tetanic muscle contraction and subject incapacitation. The charge is delivered for five seconds, and can be repeated multiple times. This device is available to law enforcement and military authorities to prevent unwanted persons from entering protected areas. The human physiologic effects of the TASER X26 have been previously studied, but this is the first study to examine the effects of multiple,

simultaneous device discharges.

METHODS

This was a prospective, observational study of human subjects. The subjects were a convenience sample of law enforcement officers receiving an exposure as part of a TASER training course. The local institutional review committee approved the study. Subjects provided informed consent and completed a medical screening questionnaire that was reviewed by a study physician. The questionnaire was used to collect demographic data such as age, height and weight, past medical history, and current medications. There were no specific exclusion criteria, but all subjects had to be at full duty status with their agencies. In addition, the ultimate safety of the subjects was the responsibility of the supervising physician on that study day and that physician could exclude subjects based on a review of their medical questionnaire. Advanced age or orthopedic problems that could make the subject unnecessarily at risk from the muscle contractions could have been reasons for exclusion, as well as recent cardiovascular events. Any subjects excluded and the reason for exclusion would be declared. Subjects were given a TASER X26, donated by TASER International, as compensation for their participation.

Human volunteers were exposed to multiple (two to three), simultaneous 5-second discharges from the Shockwave device as determined by the training instructors. The conductive wires were taped into conducting gel on the skin surface. To simulate field conditions where subjects are 5-10 feet from the device placed on level ground, the training instructors decided to do four types of exposures with a 6-10 inch horizontal spread between pairs of electrodes and a 9-18 inch vertical spread between the top and bottom electrodes in a pair:

- Chest to abdominal area – Three simultaneous devices and a smaller spread between pairs of electrodes (simulating close distance to the device when it is activated)
- Thigh – Two simultaneous devices and a smaller spread between pairs of electrodes (simulating close distance and the likelihood that the probes fired from the middle cartridge would miss due to separation between the legs)
- Chest – Two simultaneous devices and a larger spread between pairs of electrodes (to simulate the expected dispersion at a farther distance)
- Back – Two simultaneous devices and a larger spread between pairs of electrodes (to simulate the expected dispersion at a farther distance)

Blood was drawn before, immediately after (within 1-2 minutes), and at 24 hours post exposure, and was analyzed for pH, lactate, potassium, and troponin on the Abbott Point-of-Care i-STAT® (East Windsor, NJ). Creatine kinase (CK) values were also determined by LabCorp independent testing (Scottsdale, AZ). A breath-by-breath analyzer was used to collect continuous respiratory data (Med Graphics CPX Ultima®, Minneapolis, MN). Electrocardiograms (ECGs) were measured before and immediately (within one minute) after the exposures (Welch Allyn Cardio-perfect System®, Skaneateles Falls, NY). A blinded cardiologist read the ECGs.

In a convenience sample (based on the availability of the echocardiographer), a non-blinded emergency physician expert in ultrasonography performed limited echocardiography using a Sonosite (Bothell, WA) M-Turbo portable ultrasound device with a P21x 5-1 MHz 21-mm broadbandphased array probe. Heart rate and rhythm were obtained before, during, and after the exposure. The echocardiographer kept the probe in place continuously so the heart could be observed immediately before and immediately after the exposure, although pre-exposure heart rates were recorded in the minute before the exposure, the heart rates during the exposure were recorded at the end of the 5-second exposure, and the post-exposure heart rates were recorded in the minute after exposure. E and A waves viewed in the continuous M-mode, using the parasternal long axis view through the anterior leaflet of the mitral valve, were used as evidence for sinus rhythm. The E wave corresponds to the mitral valve opening with passive filling of the left ventricle. The A wave corresponds to the mitral valve opening with atrial contraction.

Subjects had percentage of body fat measured by a commercial skin resistance analyzer (Omron Fat Loss Monitor HBF-306, Omron Healthcare, Inc., Bannockburn, Illinois). Subjects also had blood pressure and heart rate measured before and immediately (within 1-2 minutes) after the exposure (Nonin 2120, Nonin Medical, Inc., Plymouth, MN). Subjects were told not to engage in physical exertion for 48 hours before exposure and until after the final blood draw at 24 hours post exposure.

Data were entered into an Excel spreadsheet (Microsoft Corp, Redmond, WA) and exported into STATA 10.0 (Stata Corp, College Station, TX). Descriptive statistics were used where appropriate. Laboratory values were compared to baseline using Wilcoxon Sign Rank tests. Values between the 2- and 3-exposure groups were compared using Wilcoxon rank sum tests.

RESULTS

Sixteen subjects were enrolled: 13 males and 3 females. No subject was excluded based on review of his or her medical screening questionnaire.

Eight subjects received two simultaneous exposures; three of these had chest exposures with 15-18 inch vertical spreads and 10-inch horizontal spreads of electrodes, and three had back exposures with 14-18 inch vertical spreads and 9-10 inch horizontal spreads of electrodes. The remaining two had thigh

Table 1. Demographics

Subject	Exposures	Location	Age	Sex	Body Fat %	BMI	PMH	Medications
1	3	C-A	48	M	22.0	28.0	none	none
2	3	C-A	32	M	25.1	30.5	none	none
3	3	C-A	22	M	35.0	36.8	none	none
4	2	thighs	24	F	36.0	27.2	depression	paroxetine
5	2	thighs	27	F	35.1	28.9	orthopedic surgery	OCP
6	3	C-A	26	M	34.1	40.5	orthopedic surgery	none
7	2	back	57	M	14.0	21.5	orthopedic surgery	none
8	2	back	34	M	21.6	27.2	hernia repair	none
9	2	back	34	M	25.8	18.8	allergies	loratadine
10	2	chest	38	M	27.5	31.2	orthopedic surgery, GERD	esomeprazole, hydrocodone
11	2	chest	25	F	39.6	34.2	orthopedic surgery	none
12	2	chest	21	M	21.7	29.5	orthopedic surgery	none
13	3	C-A	39	M	16.8	24.4	vasectomy	none
14	3	C-A	19	M	17.0	23.1	spontaneous pneumo-thorax, asthma	albuterol
15	3	C-A	37	M	22.7	27.8	orthopedic surgery	amoxicillin
16	3	C-A	39	M	18.5	24.3	hypothyroidism	levothyroxine

BMI, body mass index; *PMH,* past medical history; *C-A,* chest to abdomen; *M*, male; *F*, female; *OCP*, oral contraceptive pills; *GERD,* gastroesophageal reflux disease;

Table 2. Blood results

	Pre	2 v. 3 p (Wilcoxon rank sum)	Post	p= (Wilcoxon sign rank)	2 v. 3 p (Wilcoxon rank sum)	24 Hour	p= (wilcoxon sign rank)	2 v. 3 p (wilcoxon rank sum)
Two Probe Pairs								
Lactate(median, range) mmol/L	1.05, 0.66-2.88	0.44	3.49, 1.41-4.49	0.03	0.06	1.34, 0.86-2.30	0.75	0.12
pH(median, range)	7.35, 7.29-7.40	0.49	7.33, 7.27-7.38	0.24	0.008	7.35, 7.33-7.40	0.18	0.999
K(median, range) mmol/L	4.0, 3.7-4.3	0.19	4.0, 3.7-4.3	0.865	0.09	4.15, 4.0-4.4	0.02	0.08
Total creatine kinase (median, range) ng/mL	130, 39-1956	0.35	137, 36-1940	0.15	0.42	508, 41-902	0.34	0.20
Troponin (median, range) ng/mL	0.0, 0.0- 0.02		0.0, 0-0.02			0, 0-0.01		
Three Probe Pairs								
Lactate (median, range) mmol/L	1.81, 0.64-2.24		2.74, 0.95-3.78	0.09		1.72, 1.39-2.15	0.35	
pH(median, range)	7.36, 7.30-7.46		7.38, 7.30-7.41	0.61		7.36, 7.33-7.39	0.35	
K(median, range) mmol/L	3.85, 3.4-4.5		3.6, 3.0-4.3	0.397		3.95, 3.8-4.7	0.02	
Total creatine kinase (median, range) ng/mL	173, 130-392		173, 129-380	0.06		1016, 158-2482	0.03	
Troponin (median, range) ng/mL	0.0, 0.0- 0.02		0.0, 0.0- 0.02			0.0, 0.0-0.01		

Table 3. Breathing results

	Pre	2 v. 3 p	During	p=	2 v. 3 p	Post	p=	2 v. 3 p
			Two Probe Pairs					
RR – (median, range) Breaths per minute	13.5, 10-16	0.5	12, 0-71	0.6	0.24	17.5, 13-22	0.01	0.33
TV (median, range) Liters (L)	0.775, 0.35-1.05	0.05	0.71, 0.40-1.49	0.86	0.05	0.98, 0.53-1.11	0.012	0.25
MV (median, range) L/minute	15.6, 11.6-18.2	0.71	10.8, 6.4-28.5	0.23	0.57	15.6, 11.6-18.2	0.01	0.71
			Three Probe Pairs					
RR – (median, range) Breaths per minute	13.0, 8-21		8, 0-45	0.16		15.5, 12-19	0.08	
TV (median, range) Liters (L)	0.955, 0.44-1.92		1.9, 0.44-3.04	0.116		1.075, 0.69-1.39	0.674	
MV (median, range) L/minute	15.1, 12.6-21.8		16.6, 8.9-43.1	0.24		15.1, 12.6-21.8	0.01	

RR, respiratory rate; TV, tidal volume; MV, minute ventilation.

Table 4. Blinded electrocardiogram interpretations

Subject	ECG Before	ECG After	Change
1	NSR at 86	NSR at 74	none
2	NSR at 95	NSR at 74	Rate decreased by 21
3	NSR at 79	NSR at 67	Rate decreased by 20
4	NSR at 90	NSR	none
5	NSR at 85	NSR at 88	none
6	NSR at 98	NSR at 79	Rate decreased by 19
7	NSR at 65, LVH, LAE	Sinus bradycardia at 55, LVH, LAE	Rate decreased by 10
8	NSR at 81	Sinus rhythm at 68	Sinus node exit block and sinus arrhythmia
9	NSR at 75, non-specific inferior ST abnormality	NSR at 74, non-specific inferior ST abnormality	none
10	NSR at 74	NSR at 87	Non-specific inferior T wave change, QT interval increased by 50 ms from 394ms to 443ms
11	NSR at 95	NSR at 94	none
12	NSR at 80, LVH	NSR at 83, LVH	none
13	NSR at 85	NSR at 64	Rate decreased by 21
14	Sinus tachycardia at 100, RSR'	Sinus tachycardia at 102, RSR'	none
15	NSR 88	NSR 92	none
16	NSR 71	NSR 67	none

ECG, electrocardiogram; *NSR,* normal sinus rhythm; *LVH,* left ventricular hypertrophy; *LAE,* left atrial enlargement.

exposures with 9-inch vertical spreads on each thigh.

Eight subjects received three simultaneous exposures on the lower chest (five inches below the nipple line) to lower abdomen with 9-inch vertical spreads and 6-inch horizontal spreads between electrodes.

The mean age of all subjects was 33 (range 19-57). The mean body mass index (based on stated heights and weights) was 27.9 (range 18.8-40.5). The mean percentage body fat was 23.9 (range 13-39.6). Demographics of the subjects are presented in Table 1. Other than some minor muscle soreness, there were no adverse outcomes reported. Several subjects even engaged in exercise routines that same day or the next day (compliance was variable for the physical exertion requirement: subjects 8, 9, 11, and 16 exercised moderately both the day of the exposure and the day after, prior to the repeat testing).

The blood results are presented in Table 2. No statistically

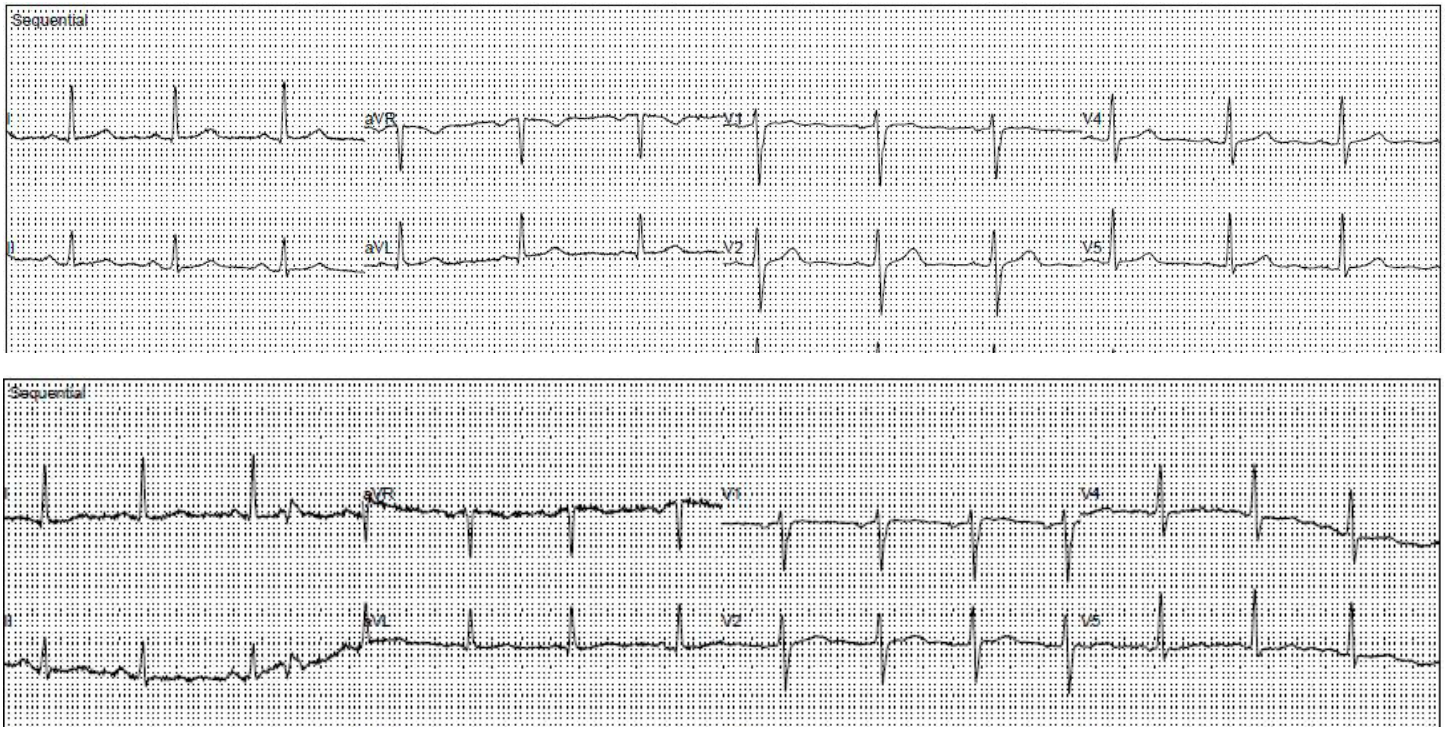

Figure 1. Electrocardiograms (ECGs) from Subject 10 showing non-specific inferior T wave changes (before and after ECGs).

Table 5. M-mode echocardiography results

Subject	Pre Heart Rate (Beats per minute)	During Heart Rate (Beats per minute)	Post Heart Rate (Beats per minute)	Sinus?
1	78	111	73	Sinus
2	71	113	63	Sinus
3	83	118	59	Sinus
4	98	143	82	Sinus
5	78	79	78	Indeterminate
6	87	158	77	Indeterminate

or clinically important changes in pH occurred. Small elevations of lactate occurred. Moderate increases in CK occurred at 24 hours and this seemed to be related to the number of simultaneous exposures. No clinically important or statistically significant changes in potassium occurred. Troponin remained within the reference range for the i-STAT device for the 24 hours.

The breathing results are presented in Table 3. There was a trend to a decrease in minute ventilation in the subjects with chest or back exposures (two simultaneous exposures), although it did not reach statistical significance.

The ECG results are presented in Table 4. Generally, the changes only reflected some increased vagal tone after the discharge. There were no important rhythm changes. One subject had non-specific inferior T wave changes. His "before" and "after" ECGs are in Figure 1.

The echocardiography results are presented in Table 5. Four of the subjects had chest-to-abdomen exposures, and two had thigh exposures. In four of the six subjects, the echocardiographer was able to determine that the rhythm during discharge was sinus. In two subjects, one with thigh exposures and one with chest-to-abdomen exposures, motion artifact precluded this. One of these subjects (the thigh exposures) had a heart rate during the exposure of 79, not suggesting electrical capture. The other subject had a heart rate that was not a divisor of the 19 pulses per second, making capture less likely (4:1 capture for one device would give a rate of 143). The exposure locations are shown schematically in Figure 2. Vital signs are presented in Table 6.

DISCUSSION

The TASER Shockwave, like the TASER X26, fires two probes from a single cartridge. Each probe pair forms an electric circuit (if one probe misses the intended target, the device cannot discharge through that cartridge). Depending

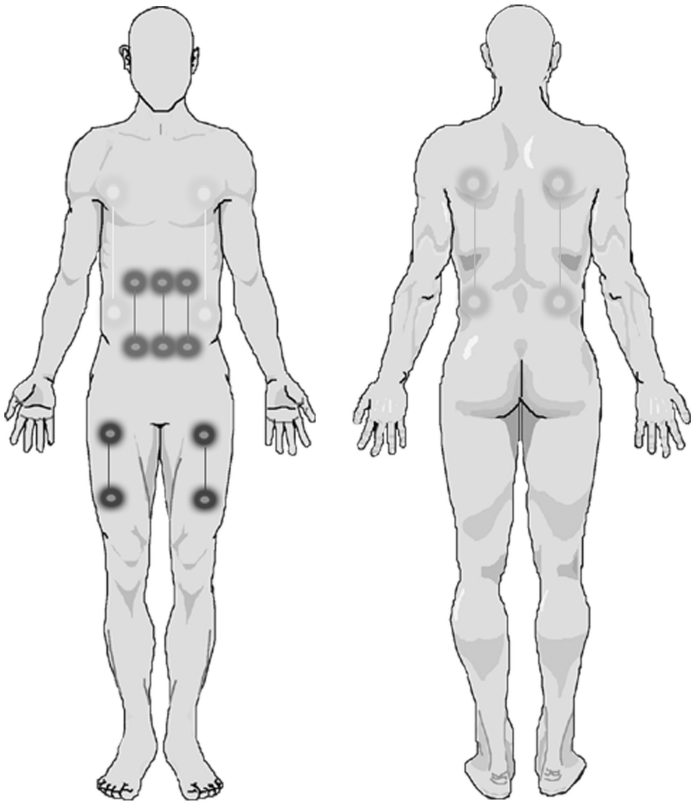

Figure 2. Types of exposures

Table 6. Vitals signs before and after discharge

Subject	Vital Signs Pre (mmHg, beats per minute)	Vital Signs Post (mmHg, beats per minute)
1	143/79, 81	198/93, 84
2	142/79, 89	133/80, 104
3	134/78, 82	137/77, 60
4	131/85, 105	157/84, 90
5	141/93, 90	141/79, 81
6	139/85, 101	151/70, 85
7	131/78, 92	154/70, 88
8	116/76, 70	155/66, 69
9	143/61, 87	131/76, 75
10	158/83, 69	133/75, 79
11	122/83, 98	154/83, 97
12	159/80, 83	147/79, 70
13	130/73, 76	117/70, 75
14	159/76, 90	126/85, 120
15	155/85, 88	157/80, 91
16	122/85, not recorded	157/71, not recorded

on the configuration, the Shockwave can fire a large number of cartridges at one time, saturating an area and incapacitating a single moving subject or multiple subjects. Because of the trajectory of the fired probe pairs, it is unlikely that more than three electrical circuits would be completed on a single target. Because the electrical circuit is the same as the TASER X26, and this has been previously studied with single deployments, we elected to only study the effects of 2-3 simultaneous discharges. Spreads were decided by the trainers and were based on trajectory determined by TASER International for a ground-level deployed device.

There has been controversy in the lay press and medical literature about the use of conducted electrical weapons and temporally associated in-custody deaths. Amnesty International claims that these devices have caused more than 300 deaths.[1] Several animal studies have shown that the TASER X26 can electrically capture the myocardium when discharged on the thorax. In Nanthakumar et al.,[2] capture occurred in 78% of thoracic discharges. There was one episode of ventricular fibrillation in this study, but only after infusion of epinephrine. In Walter et al.,[3] capture occurred in 100% of thoracic discharges. There was one episode of ventricular fibrillation in this study.

These results have not been reproduced in human studies. In Ho et al.,[4] 37 subjects received a 15-second TASER X26 exposure to the chest after a maximal exercise regimen. Mean heart rates were 86, 153, 140, and 115 pre-exercise, post-exercise, during-TASER X26 exposure, and post-TASER exposure, respectively, as determined by echocardiography. In half of the subjects, sinus rhythm was apparent by echocardiography. In a second study,[5] 34 subjects received a 10-second exposure in the cardiac axis. Mean heart rates were 106, 123, and 94 pre-TASER X26 exposure, during TASER exposure, and post-TASER exposure, respectively. In more than half of the subjects, sinus rhythm was apparent by echocardiography. Neither of these studies determined there was any evidence of myocardial capture by echocardiography. In a study by Jauchem,[6] the swine had respiratory arrest during each discharge. However, that data has also been contradicted by human studies.[7]

It would be expected that skeletal muscle activation would vary as a function of electrode locations and spread, as well as numbers of electrodes activated (i.e., two versus three cartridges). Any muscle groups activated by both devices in the two exposure group (i.e., muscles within the effective "capture zone" of both device electrodes) will effectively receive a train of stimuli at 38 pulses per second (twice the normal 19 pulses per second of the TASER X26); muscles captured by all electrode pairs for the three-exposure group would receive 57 pulses per second of stimulation (three times 19 pulses per second). Maximal physiological firing rates of human motor neurons vary considerably dependent upon

size-related properties of the neurons and the skeletal muscle fibers they innervate, but in general such maximal discharge rates are below 40 pulses per second for mixed fiber-type muscle groups, such as those of the torso and extremities.[8] Forces and torques elicited by electrical stimulation of human skeletal muscles rise considerably as a function of frequency, becoming well tetanized by 38 pulses per second (our two-exposure group) with some expected additional fusion and peak force generation at 57 pulses per second (our three-exposure group).[9]

In our study, we found that there were small elevations of lactate immediately post-exposure. The subjects who had two devices, and therefore the larger spreads, had significantly larger increases in lactate compared to the subjects who had three devices ($p<0.06$). This suggests that the dominant factor in correlating to overall level of muscle activation with this marker may be related to electrode location and spread rather than number of devices. There was no significant, either statistical or clinical, change in pH. Our results were similar to other authors studying single-device exposures.[10] In a study by Gass et al.,[11] venous lactate increased to 14.2 mmol/L after a maximal exercise regimen on a treadmill in trained subjects. The changes in lactate in our study are small by comparison. We observed only moderate increases in CK at 24 hours for the majority of subjects across both exposure groups. A previous study by Ho et al.[12] examined the CK changes after a 5-second TASER X26 discharge to the back (large spread). This study found that the mean CK value was elevated to a level of 242.3 U/L at 24 hours. In our current study, the median CK at 24 hours was somewhat higher in the three-exposure group compared to the two-exposure group ($p<0.2$). This may be explained by the fact that CK is a marker of rhabdomyolysis (muscle damage), not necessarily muscle mass activated, and in the three-exposure group, the pulses per second from the three devices (19 x 3) could be slightly more damaging than from the two devices (19 x 2). In a study by Lin et al.,[13] 119 healthy teenagers engaged in an exhaustive exertion regimen consisting of 120 push-ups in five minutes. CK values in these subjects ranged from 55-174,260 with a mean of 36, 512. Sinert et al.[14] observed average CK levels of 40,471 at admission for 35 patients with a discharge diagnosis of exercise-induced rhabdomyolysis in an urban tertiary care center study.

Prior studies on the TASER X26 showed no deleterious effects on breathing.[7,10] In this study, there was a trend to a decrease in minute ventilation in the subjects with chest or back exposures (two devices), although it did not reach statistical significance. The subjects with three devices had lower chest to abdomen activation. These subjects did not show a trend to decreased minute ventilation. This may be because they had predominantly abdominal muscle activation rather than chest wall activation. This also clearly demonstrates that the diaphragm is not captured in this position.

The only change in ECG reflected some increased vagal tone after the discharge. There were no important rhythm changes. One subject had new non-specific inferior T wave changes as interpreted by the blinded cardiologist. The significance of these changes is not clear. This subject did not report any cardiac complaints, and had a normal troponin at 24 hours. These results are consistent with those of other authors.[15,16] The echocardiography results showed no evidence of capture of the myocardium. In one subject, the location of the exposure and the heart rate would not be suggestive of capture. In the other subject, the rate was not a divisor of the pulse rate, suggesting that there was not capture. In addition, although the echocardiographer reported the heart rate increased within the first few seconds, the rate slowed more gradually after the exposure to the rate of 77. It was not an abrupt transition. Also, the initial heart rate (87) was measured in the minute before the exposure, not necessarily immediately before the exposure. It was clear to subjects when the exposure was about to take place, so his immediate initial heart rate may have been much higher than 87. So, even though capture cannot be excluded with certainty, it seems unlikely. In any event, the rate was not concerning.

Because the Shockwave device is similar to simultaneous exposures from the TASER X26, this data may be extrapolated to multiple simultaneous X26 exposures of similar duration. The Shockwave device is programmed to deliver the exposures such that the pulses do not overlap. While this would not be the case for multiple, simultaneous X26 exposures, the low duty cycle of the device would make overlap unlikely. At 19 pulses per second, there is 53 msec between each 0.1 msec pulse.

LIMITATIONS

This study has several limitations. First, the small number of subjects limits the ability to draw conclusions. Second, we were unable to determine sinus rhythm in two of the six subjects, although one had a heart rate that would not be worrisome for cardiac capture, and the other did not have a divisor of the device pulse rate and capture was not likely given the observations of the echocardiographer. Third, the probe positioning varied between the two-device groups and three-device group. This was intentional, determined by training, to reflect expected field deployments, but it makes some of the comparisons, particularly with regard to lactate and CK, difficult. For example, while it is well known that a majority of human skeletal muscles usually comprise a relative balance of slow twitch and fast twitch fibers (about 40 to 70% of one type versus the other), variations do, in general, exist between muscles with a predominately postural function (tending then to have higher proportions of slow twitch fibers) versus those with mainly phasic activities (which tend to have higher percentages of fast fibers).[17] Significant variations in skeletal muscle slow-versus-fast muscle fiber type distributions

between individuals can also exist, dependent upon gender, age, genetic, and health influences. Assuming the electrical activation of motor neuron axons by the relatively intense and spatially broad electric field discharges used in this study to be relatively non-selective with respect to axon size (as has been seen in some applications of electrical stimulation for therapeutic purposes), it is possible then that probe positioning and separations in our study could also have introduced additional variations in measures of muscle mass activation (lactate) and damage (CK) based upon underlying skeletal muscle fiber-dependent abilities to produce and maintain force.[18] Lastly, the exposure duration in this study is short. The physiological changes with longer exposures may be different. Some changes may be expected to be more significant, such as with lactate and CK. Some, such as respiration, may actually show improvement with longer exposures. In prior studies, it was the experience of the authors that subjects often held their breath for the first 5-7 seconds due to a pain response and then began a more regular breathing pattern.

CONCLUSION

In our small sample size, five-second, simultaneous, multiple exposures to the TASER Shockwave device did not appear to have significant deleterious effects on human physiology, except for moderate increases in CK and elevations in lactate that are less than maximal exertion regimens, and possibly a trend towards decreased minute ventilation with large spread simultaneous exposures. Our study suggests that this device may have a reasonable risk/benefit ratio when used to protect an area from a threat. We recommend further study in this area to validate our results.

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Fatal Dysrhythmia Following Potassium Replacement for Hypokalemic Periodic Paralysis

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We present a case of fatal rebound hyperkalemia in a patient with thyrotoxic periodic paralysis (TPP) treated with potassium supplementation. Although TPP is a rare hyperthyroidism-related endocrine disorder seen predominantly in men of Asian origin, the diagnosis should be considered in patients of non-Asian origins presenting with hypokalemia, muscle weakness or acute paralysis. The condition may present as a life threatening emergency and unfamiliarity with the disease could result in a fatal outcome. Immediate therapy with potassium chloride supplementation may foster a rapid recovery of muscle strength and prevent cardiac arrhythmias secondary to hypokalemia, but with a risk of rebound hyperkalemia. [West J Emerg Med. 2010; 11(1):57-59.]

INTRODUCTION

Hypokalemic paralysis is a rare cause of muscle weakness and cardiac arrhythmias that primarily affects male patients of Asian descent. Because it is rare in non-Asians[1] it can be misdiagnosed. Thyrotoxic periodic paralysis (TPP) is caused by a sudden shift of potassium into cells, leading to hypokalemia and muscle weakness and can lead to near-fatal or fatal arrhythmias. Immediate therapy with potassium chloride supplementation may foster a rapid recovery from weakness and prevent arrhythmias but risks rebound hyperkalemia.[1,2] We present a case of fatal rebound hyperkalemia in a patient with TPP treated with potassium.

CASE REPORT

A 40-year-old Hispanic woman called 911 for worsening chest tightness, generalized weakness and vomiting of two days. On arrival, paramedics performed an EKG that revealed sustained monomorphic ventricular tachycardia at 160-180 beats/minute. Blood pressure and oxygen saturation were normal. She was treated with 40 mg intravenous lidocaine after which she converted to normal sinus rhythm. In the emergency department (ED), she was alert and complained of weakness of all four extremities. She denied shortness of breath. She had a history of hyperthyroidism and hypertension but took no medicines. Vital signs were blood pressure of 126/70 mm of Hg, pulse of 90 beats/minute and respiratory rate of 18 breaths/minute. She was afebrile, and oxygen saturation was 96% in room air. Cardiac and lung examinations were normal. There was no thyromegaly. Neurological examination showed 2/6 strength and hypoactive reflexes in all four extremities. Cranial nerves and sensations were normal. Initial laboratory tests showed potassium of 2.3 mEq/L (normal: 3.5-5.5mEq/L) with normal anion gap. Magnesium, chloride, calcium and creatinine were normal. Urinary toxicology screen was negative. A 12-lead electrocardiogram showed normal sinus rhythm.
In the ED the patient received 40 mEq of oral potassium chloride, and intravenous (IV) potassium was started at 20 mEq/hour. Repeat laboratory testing after three hours showed potassium of 1.9 mEq/L. Thyroid-stimulating hormone was low (0.01µunit/ml; normal: 0.5-5.0 µunit/ml) with high free thyroxine (7.77 ng/dL; normal: 0.75 to 1.8 ng/dL). The patient complained of worsening weakness in her legs. She was given additional 40 mEq of oral potassium. Potassium was increased to 30 mEq/hour IV, and the patient was admitted to medical intensive care unit.

A diagnosis of TPP was made based on clinical presentation and laboratory results. Blood drawn after eight hours showed potassium of 6.6 mEq/L. Intravenous potassium was stopped, and intravenous dose of 1 gm calcium, 50% solution of 50 ml dextrose, and 10 units of insulin were given urgently to correct hyperkalemia. Despite these, the patient

developed episodes of ventricular fibrillation and despite several attempts at electrical cardioversion, she died. Her potassium level was 10.1 mEq/L at the time of her death.

DISCUSSION

In the United States, the incidence of TPP in the non-Asian population is 0.1-0.2%.[3] It occurs mostly during summer and winter and with increased consumption of sweet drinks, outdoor activities and exercise. TPP primarily occurs in persons aged 20-40, and the most common symptoms are leg muscle weakness, aching cramps and stiffness. Although most patients with thyrotoxicosis are female, men with TPP outnumber women approximately 20:1.[1] While TPP is associated with hyperthyroidism, personal or family history of hyperthyroidism may be absent. As in the case of our patient, nearly half of patients with TPP have no obvious symptoms related to hyperthyroidism during an attack.[1-5]

Differential diagnosis of TPP includes familial periodic paralysis (FMPP), barium intoxication, hypochloremic metabolic alkalosis and hyperchloremic metabolic acidosis.[1,2] In contrast to TPP, FMPP occurs most often in Caucasians and early in life (rarely after age 25).[6] And also in contrast to FMPP, TPP does not occur during exercise but in a period of rest after exercise.[1] Barium intoxication should be considered and could result from the ingestion of contaminated food causing hypokalemia by blocking the potassium channels in the cell membrane that normally allow cellular potassium to diffuse into the extracellular fluid.[7]

In the ED, a diagnosis of TPP should be considered in men of Asian or Hispanic descent who present with hypokalemia, muscle weakness or paralysis and cardiac arrhythmias. Leg weakness, which usually begins proximally, is most commonly symmetrical and can progress to flaccid quadriplegia.[1] Deep tendon reflexes are decreased or absent, but ocular, bulbar, and respiratory muscles are usually spared, as are sensation and level of consciousness, although ventilator impairment has been reported.[6] The EKG findings are those of hypokalemia with increased P wave amplitude, prolonged PR interval, widened QRS complexes, and prolonged QT and U waves. These EKG findings were absent in our patient. Life-threatening intraventricular conduction abnormalities and ventricular fibrillation also have been reported.[8] Urgent blood investigations in the ED should include a thyroid function test, and patient should have continuous EKG monitoring.

Although the pathogenesis of TPP remains unclear, it is believed to be related to increase in sodium-potassium-adenosine triphosphate (Na/K-ATPase) pump activity. Thyroid hormone coupled with enhanced beta adrenergic response in thyrotoxicosis state increases Na/K-ATPase activity, leading to influx of potassium into the intracellular space causing hypokalemia.[9] High carbohydrate diet in the setting of a hyperadrenergic state in TPP stimulates insulin release from pancreatic beta cells, which in turn stimulates N/K-ATPase activity.[1] The chemical structure of thyroxine is similar to catecholamines and exerts its cellular effect via catecholamine receptors. This may explain the usefulness of nonselective beta blockers in the treatment of TPP-associated hypokalemia.[1,10,11]

A patient with a serum potassium concentration of 2 mEq/L may have a 400 to 800 mEq potassium deficit.[12] The serum potassium concentration can rise acutely by as much as 1 to 1.5 mEq/L after an oral dose of 40 to 60 mEq, and by 2.5 to 3.5 mEq/L after 135 to 160 mEq.[13] Our patient had received approximately 240 mEq of potassium (oral and IV) in eight hours. We expected our patient would have a potassium level of 3.5-4.5 mEq/L after receiving 200 mEq of potassium after eight hours. But due to rebound hyperkalemia, potassium levels increased to 10.1 mEq/L. This discrepancy between the expected calculated potassium and the real potassium is in part caused by the fact that during the recovery phase of TPP, potassium release from muscle occurs at the rate of up to 15 mEq/hr.[14]

Body potassium stores are normal in patients with TPP.[12] A few studies have looked at potassium replacement in TPP. In a case-controlled study by Lu et al.,[15] average recovery time was cut in half in patients with intravenous potassium chloride supplementation at the rate of 10 mEq/h vs controls (6.3±3.8 vs 13.5±7.5 hr). Rebound hyperkalemia occurred in 70% of patients 2-3 hours after recovery from TPP treated with IV potassium chloride while rebound hyperkalemia was rarely seen with potassium supplementation of 50 mEq or less as a total dose. In a retrospective study, Manoukian et al.[16] reported that rebound hyperkalemia occurred in approximately 40% of patients with TPP, especially if more than 90 mEq of potassium chloride was given within 24 hours.[16]

An alternative approach focusing on treating the adrenergic drive has been reported using beta blockade. Both oral and IV propranolol appear to be effective in reversing TPP without risk of rebound hyperkalemia.[10,11,17] Controlled studies are needed to document the effectiveness of combined nonselective beta-blockers and low-dose potassium.

CONCLUSION

TPP appears to present a problem in potassium distribution rather than potassium deficiency; hence, we believe that in most patients potassium supplementation is not indicated, unless the patient is having life-threatening arrhythmias due to hypokalemia or is experiencing respiratory insufficiency. The risk of life-threatening arrhythmias caused by the potential of rebound hyperkalemia outweighs the morbidity of the temporary paralysis. If potassium supplementation must be used, as in the case of unstable arrhythmias due to hypokalemia, very low doses should be given (less than 10 mEq/ hr) with close monitoring of potassium level to reduce the risk of rebound hyperkalemia.[15]

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Emergency Department Septic Screening in Respiratory Syncytial Virus (RSV) and Non-RSV Bronchiolitis

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Objective: To identify factors associated with culture-proven serious bacterial infection (SBI) and positive emergency department septic screening (EDSS) tests in children with bronchiolitis and to identify factors associated with the performance of EDSS.

Methods: We reviewed an existing study database of patients with bronchiolitis. We defined a positive EDSS as urine with ≥10 WBC per high power field or cerebrospinal fluid (CSF) with ≥10 WBC per high power field (>25 WBC in neonates), or if organisms were identified on gram stain. We defined SBI as significant growth of an accepted pathogen in blood, urine or CSF. Our composite endpoint was positive if either of these was positive. The decision to perform testing was modeled using modified Poisson regression; the presence of the combined outcome was modeled using logistic regression modified for rare events.

Results: We studied 640 children. Testing was performed in 199/640 (31.1%). These tended to be younger than two months RR 2.69 (95% CI 2.11, 3.44), febrile RR 2.01 (95% CI 1.58, 2.55), more dehydrated RR 1.50 (95% CI 1.28, 1.75) and had more severe chest wall retractions RR 1.54 (95% CI 1.22, 1.94). Only 11/640(1.7%) had a positive EDSS or SBI. Younger age (OR 0.67 per month; 95% CI 0.45, 0.99) and a negative RSV antigen test (OR 6.22; 95% CI 1.30, 29.85) were associated with the composite endpoint.

Conclusion: Testing was more likely to be performed in children younger than two months of age, and in those who were febrile, dehydrated, and had more severe chest wall retractions. A positive EDSS or SBI was rare occurring in younger infants with non-RSV bronchiolitis.
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INTRODUCTION

The detection of respiratory syncytial virus (RSV) decreases the probability of a concurrent bacterial illness in infants with fever without source.[1-3] The clinical presentation of RSV is highly variable. It causes more than half of all cases of bronchiolitis.[4,5] Other viruses are responsible for almost all of the remainder.[4,6-9]

Bronchiolitis itself is a clinically recognizable viral illness; consequently, a low prevalence of culture-proven serious bacterial illness (SBI) would be anticipated.[10-12] This raises the question whether bronchiolitis caused by RSV as distinct from bronchiolitis caused by other viruses has a different prevalence of bacterial co-infection and therefore warrants a different emergency department (ED) evaluation.

The primary purpose of this study was to identify those clinical factors most likely associated with SBI and positive ED screening tests in children with bronchiolitis. The secondary purpose was to identify factors associated with obtaining these screening tests and cultures.

METHODS

Underlying assumptions

We made the following assumptions about emergency physicians' (EP) risk tolerance: (1) a positive screening test for SBI would prompt a change in management regardless of subsequent outcomes (since these cannot be known ahead of time); (2) EPs would not want to miss an infant who had a positive culture despite a (false) negative screening test.

We made the following assailable but unavoidable assumptions about bacterial illness in these patients. Firstly, we assumed that if both screening tests and cultures were negative that SBI was absent. Secondly, we assumed if no screening was performed without any adverse clinical outcomes three days post-ED visit, then SBI was absent. We anticipated that the outcomes we were seeking would be sufficiently rare that our primary analysis would require a combined endpoint rather than separate analyses of several single endpoints.

Study Design

Our Institutional Review Board approved this study. We conducted a retrospective review using existing patient records and an existing database of ED patients prospectively enrolled into an RCT over three bronchiolitis seasons.[5]

Setting and Population

The parent study was conducted at two centers; this study used data only from the primary study site. The primary study site was a county teaching hospital ED with an annual census of 53,000 (23% children less than 14 years) serving a mixed urban, suburban, and rural population.

Bronchiolitis was defined as clinical evidence of lower airway obstruction (physical findings of wheezing and chest wall retractions) following an upper respiratory tract infection. The eighteenth month of life was chosen as the upper age limit. This represents a compromise between competing views as to an appropriate definition of the diagnosis.[5,10]

Neonate was defined as age up to 28 days. Dehydration and retraction severity were each described using scales from a validated bronchiolitis severity assessment tool.[13] The inter rater reliability of these individual variables and that of the severity of illness tool been described elsewhere.[14] Fever was defined as rectal temperature ≥38.0°C.

Patients were enrolled consecutively. Those with bronchiolitis so mild as to not require bronchodilator treatment and those with illness so severe as to require immediate intubation were excluded. These criteria reflect the design of the parent study, a randomized controlled trial of bronchodilators in bronchiolitis. We restricted this study to patients from that study to ensure the quality of data collected. Patients who received bronchodilators in the ED prior to screening for the parent study were excluded from that study and also from this. Although the patients included in this study reflect the parent study design, it is difficult to imagine an EP prescribing antibiotics in infants with bronchiolitis so mild as to not be eligible for the original trial, or withholding them in patients intubated for bronchiolitis.

Patients were recruited between November 1, 2003 and May 1, 2006. Potentially eligible children were identified by trained research assistants, residents and faculty. Diagnosis was made by an attending physician or midlevel provider. Clinical findings, including prior antibiotic and steroid use, were recorded on a specifically designed data collection.Laboratory testing was ordered at the physician's discretion.

Laboratory tests

We performed RSV antigen detection on nasal aspirates samples using the BD Directigen™ RSV Test Kit (Becton, Dickinson and Company, Franklin Lakes, NJ).

We performed urinalysis and cultures on catheterized specimens. Urinalysis was performed with an Iris iQ200 Automated Urine Microscopy Analyzer (Iris Diagnostics, Chatsworth, CA). Urine culture was performed using the calibrated-loop method on well-mixed, uncentrifuged specimens on blood agar and MacConkey agar plates. Low colony count plates (recommended if the child has received antibiotics prior to the sample being obtained) were used if specified by the physician. Results were reported after 48 hours of incubation. Cerebrospinal fluid (CSF) specimens were processed for protein, glucose, red and white blood cell counts (RBC, WBC), gram stain (GS) and cultures. Blood cultures were processed using the BacT/ALERT system (bioMérieux, Marcy l'Etoile, France), and their results were generally available after 48 hours.

Study Protocol

We obtained clinical data from the study database. Testing results were obtained from the hospital laboratory database. The clinical record was reviewed by first and second authors to determine whether positive cultures were treated by the physician.

Outcome measures:

An ED septic screen (EDSS) was considered positive if urine or CSF analysis showed ≥10 WBC per high power field (>25 WBC in neonates) or organisms were identified on gram stain regardless of subsequent culture being positive or negative. CSF WBC counts were corrected assuming one

Table 1. Demographic and clinical information by RSV status

	RSV Positive (N = 334)	RSV Negative (N = 271)	RSV Equivocal/Not Done (N = 35)
Mean age, months	5.3	6.5	7.4
(Median , IQR)	(4.4, 5.6)	(5.0, 6.7)	(7.0, 7.8)
Male (%)	193 (57.8)	163 (60.2)	15(42.9)
Premature, (%) (<37 wks gestation)	62 (18.6)	52(19.2)	5 (14.3)
Admission rate, (%)	167 (50.0)	80(30.0)	7 (20.0)
Median respiratory rate	45	43	42
Days ill before ED visit Mean	4.8	4.1	6.0
(Median, IQR)	(3, 3)	(3, 3)	(3, 6)
Temp, (°C)	37.8	37.7	37.9
Mean Pulse oximetry, (%)	97	97	98
Febrile, (%)			
38.0°C-39.0 °C (%)	78/334 (23.4)	46/271 (17.0)	7/35 (20.0)
39.0°C-40.0°C (%)	24/324 (7.4)	24/271 (8.9)	3/35 (8.6)
>40°C, (%)	13/334 (3.9)	9/271 (3.3)	2/35 (5.7)
Normal Hydration, %	287/327 (87.8)	232/265 (87.6)	32/33 (97.0)
5% Dehydrated, (%)	27/327 (8.3)	27/265 (10.2)	1/33 (3.0)
10% Dehydrated, (%)	12/327 (3.7)	6/265 (2.3)	0/33 (0.0)
15% Dehydrated, (%)	1/327 (0.3)	0/265 (0.0)	0/33 (0.0)
Retraction Severity			
None	24 (7.8)	17 (6.8)	4 (13.3)
Mild	148 (48.2)	129 (51.2)	14 (46.7)
Moderate	120 (39.1)	94 (37.3)	12 (40.0)
Severe	15 (4.9)	12 (4.8)	0 (0.0)
Community antibiotic use	34/328 (10.5)	31/266 (11.8)	6/35 (17.1)
Steroid use (%)	15/334 (4.5)	10/271 (3.7)	2/35 (5.7)

RSV, Respiratory Syncytial Virus; *IQR*, *interquartile range*; *ED*, emergency department.

additional WBC to be normal for every 500 RBCs present.

We defined culture-proven SBI as a significant growth of a known bacterial pathogen in urine (10,000 or more colony-forming units per milliliter of a single pathogenic organism on a catheterized specimen), CSF or blood regardless of initial urine or CSF WBC results. When more than one organism was detected in a urine culture the specimen was considered contaminated. We considered blood cultures contaminated if they grew organisms commonly not accepted as pathogens (such as coagulase-negative *staphylococcus*, diphtheroids, and alpha- or gamma-hemolytic *streptococcus*).

We created a composite endpoint comprised of either a positive EDSS or a culture-proven SBI, or both. Patients who did not have laboratory tests and were alive 72 hours post-ED discharge (as assessed by telephone follow-up) were assumed not to have had either an SBI or the composite endpoint. In cases where both telephone and written follow-up failed, and a review of hospital medical records showed no further contact with the patient, the county coroner's records were used to determine vital status.

We did not address the possibility of pneumonia as an SBI because of the inability to differentiate a viral from a bacterial cause on chest x-ray.

Data analysis

We compared the prevalence of outcomes between RSV-positive and RSV-negative groups using Fisher's exact test for categorical data. We analyzed the importance of age, gender, presence of fever, clinical exam findings, and prior community antibiotic use on outcomes using logistic regression multivariate analysis. A modified multivariate Poisson analysis[15] was performed to determine factors associated with having an EDSS performed or not performed. We used logistic regression modified for rare events to account for biased standard logistic regression estimates in the case of a rare outcome.[16,17] We performed model diagnostics on the standard

Table 2. Details of infants with a positive outcome.

ID	AGE	RSV	Sex	Blood Culture	Urine WBC units	Urine Culture	CSF WBC units	Classification for Analysis	Comments
7	43 days	+	M	Coag neg *staphylococcus*	9	*Klebsiella* coag neg *staphyloccus E. faecalis*	0	EDSS - SBI -	Clinician considered blood culture significant and treated but analyzed as negative.
2	19 days	-	M	Coag neg *staphylococcus*	1	No growth	12	EDSS - SBI -	Treated initially as meningitis. CSF Protein 93 but analyzed as negative
3	23 days	+	F	none	0	Gamma hemolytic *streptococcus*	0	EDSS - SBI -	Febrile. Considered a real SBI by the treating clinician but analyzed as negative.
4	27 days	-	F	none	51	No growth	0	EDSS + SBI -	
5	35 days	-	F	none	405	*E.coli*	0	EDSS + SBI +	
6	43 days	+	M	Group B *streptococcus*	Not done	No growth	0	EDSS – SBI +	
1	13 days	-	M	None	0	Contaminant	40	EDSS + SBI -	CSF culture negative. Analyzed as EDSS only +
8	48 days	-	M	none	2	*Klebsiella pneumoniae*	0	EDSS- SBI+	SBI positive urine culture. Subsequently had two more UTIs.
9	51 days	-	M	none	46	*Candida glabrata*	0	EDSS+ SBI+	*C. glabrata* considered significant by clinician.
10	59 days	-	F	none	12	Not done	0	EDSS+ SBI-	
11	56 days	-	M	none	5	*E.coli*	0	EDSS- SBI+	SBI Positive urine culture.
12	87 days	+	F	Coag neg *staphylococcus*	21	Coag neg *staphyloccus*	0	EDSS+ SBI-	Clinician considered cultures significant and treated but analyzed as EDSS + SBI-
13	4 months 12 days	-	M	Not Done	12	Not done	0	EDSS+ SBI-	
14	7 months 3 days	-	F	*Staphylococcus aureus*	Not done	Not done	0	EDSS- SBI +	

RSV, Respiratory Syncytial Virus; *WBC*, white blood count; *CSF*, cerebrospinal fluid; *EDSS*, emergency department septic screening; *SBI*, serious bacterial infection.

logistic regression model as described in other medical literature using this technique.[18] Tests reached statistical significance at $p \leq .05$. We used Stata 9.2 statistical software, (Statacorp LP, College Station TX), for all analyses.

RESULTS

Data were available for 640 patients. RSV antigen testing was performed in 608 (95%) of these 640. The ED ordered RSV testing in 553 cases, the admitting pediatric service ordered it in 55. Three hundred thirty-four patients (54.9%) tested positive for RSV antigen, 271 (44.6%) tested negative and in 3 (0.5%) results were equivocal.

The median age of patients was 4.8 months. Patients' clinical and demographic characteristics are grouped by RSV status in Table 1.

ED testing to rule out bacterial illness was performed in 199/640 (31.1%) of patients. There were differences between children in whom physicians did and did not perform testing for bacterial illness. Those investigated were more likely to be younger than two months RR 2.69 (95% CI 2.11, 3.44), be

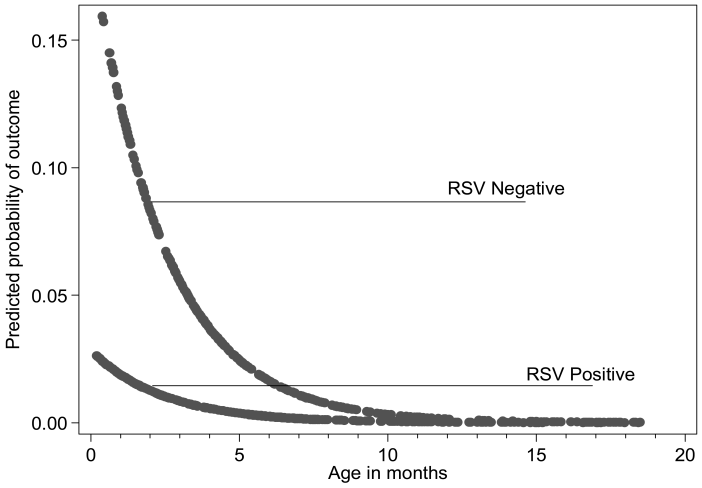

Figure. Predicted probability of a positive emergency department septic screening or serious bacterial infection (SBI) by age and respiratory syncytial virus (RSV) testing results.

Table 3. Prevalence of Respiratory Syncytial Virus (RSV) and serious bacterial infection (SBI) or emergency department septic screening (EDSS) by age.

Age (months)	RSV positive (%)*	SBI (%)	EDSS (%)	Combined (%)
<1	31/41 (76)	0/43 (0)	2/43 (4.7)	2/43 (4.7)
1-2	57/95 (60)	5/96 (5.2)	3/96 (3.1)	6/96 (6.3)
2-3	46/76 (61)	0/80 (0)	1/80 (1.3)	1/80 (1.3)
3-4	18/50 (36)	0/52 (0)	0/52 (0)	0/52 (0)
4-5	32/55 (58)	0/60 (0)	1/60 (1.7)	1/60 (1.7)
5-6	33/54 (61)	0/57 (0)	0/57 (0)	0/57 (0)
6+	117/234 (50)	1/252 (0)	0/252 (0)	1/252 (0.4)
Total	334/605 (52)	6/640 (0.9)	7/640 (1.1)	11/640 (1.7)

*Excludes cases where RSV testing was equivocal or not performed.

febrile RR 2.01 (95% CI 1.58, 2.55), be more dehydrated RR 1.50 (95% CI 1.28, 1.75), and have more severe chest wall retractions RR 1.54 (95% CI 1.22, 1.94). RSV antigen results did not dissuade physicians from testing, RR 0.82 (95%CI 0.65, 1.04).

Although 14 patients were treated as having a positive EDSS or SBI by their treating physicians, our study definitions led us to discount three cases. These are shown in Table 2. Using study definitions, the combined endpoint of a positive septic screen, culture-proven SBI, or both occurred in 2/334 (0.6%, 95% CI 0.1% to 2.1%) and 9 of 271 (3.3%, 95% CI 1.5% to 6.2%) in RSV and non-RSV bronchiolitis, respectively (two sided Fisher's exact, p=.02).

Using logistic regression modified for rare events, younger age (OR 0.67 per month; 95% CI 0.45, 0.99) and a negative RSV antigen test (OR 6.22; 95% CI 1.30, 29.85) were associated with the composite endpoint. These results are presented graphically in the Figure. Using ordinary logistic regression, age (OR 0.63 per month; 95% CI 0.43, 0.94) and a negative RSV antigen test (OR 7.77; 95%CI 1.61, 37.56) were associated with the primary or composite endpoint. The results were similar (age OR 0.57, RSV negative OR 4.81) when we analyzed the treating physicians' clinical impressions rather than study definitions of which infants had a positive EDSS or SBI.

The results were similar for the individual components (EDSS and SBI) of the endpoint. The prevalence of a positive EDSS was 7/605(1.1% 95% CI 0.4%, 2.2%); 1 of 334 (0.3%, 95% CI 0.0%, 1.7%) in the RSV group and 6 of 271 (2.2%, 95% CI 0.8%, 4.8%) in non-RSV bronchiolitis (two sided Fisher's exact, p=.049). Prevalence of a culture-proven SBI was 6/640 (0.9% 95% CI 0.3% to 2.0%). One of 334 (0.3%; 95% CI 0.0% to 1.7%) had RSV-positive and 5 of 271 (1.8%, 95% CI 0.06% to 4.3%) had RSV-negative bronchiolitis, (two-sided Fishers exact p=0.095).

Of the individual EDSS components, blood cultures were the most frequently obtained. However, urinary studies were the most likely to yield positive findings. Urine microscopy was performed in 95/640 (14.8%), urine cultures in 71/640 (11.0%), blood cultures in 183/640 (28.6%) and lumbar punctures in 10/640 (1.5%). Six out of 95 (6.3%) patients had >10 WBC in on urine microscopy, 2/10 (20%) had >10 WBC (corrected) in the CSF, and 7/71 (9.9%) had a positive urine culture. Twenty-one of 183 blood cultures grew organisms; of these, only two were recognized pathogens.

Prior antibiotic use did not seem to alter outcome; low colony count plates were not used in some children who had had prior antibiotics. The prevalence of SBI and EDSS in each age group is shown in Table 3.

DISCUSSION

In children up to their eighteenth month of life with bronchiolitis, an EDSS was more likely to be performed in those who were less than two months old, febrile, dehydrated, and had more severe chest wall retractions; in short, those who appeared sicker. This evaluation was more likely to be positive in those who were younger and had a negative RSV antigen test. Once the decision to screen was made, neither fever nor the height of the fever was associated with SBI or positive EDSS. The paucity of positive outcomes despite relatively large sample size resulted in broad confidence intervals for our estimates of these effects.

Studies of febrile children have shown that when a viral etiology can be demonstrated, typically by RSV or influenza antigen testing, concurrent bacterial infection is rare.[1-3,11,19] Despite this, RSV status did not significantly affect the decision to obtain these tests in our study (RR 0.82 95% CI 0.65-1.04). Perhaps with larger numbers this

trend would have reached significance. Similarly, in the presence of a recognizable viral illness concurrent bacterial infection is also unlikely.[11] We anticipated, and found, very low rates of culture- proven bacterial illness (0.9%) or EDSS (1.1%) in infants with bronchiolitis. One might reasonably expect, therefore, that RSV antigen testing would add little information in the risk stratification of these children. But it did, with a negative RSV test increasing the odds of EDSS or SBI by 6.22.

Why the prevalence of either a positive EDSS or SBI should differ in RSV as distinct from non-RSV bronchiolitis is a matter of conjecture. Although clinically indistinguishable, the inflammatory profile of RSV bronchiolitis differs from that of other viruses.[20-23]

A weakness in this study is that EDSS was variable in its components. Some children had blood, CSF and urine cultured, and some, typically older infants, only had urine cultured. This is inherent in the retrospective use of even prospectively collected research data. Even if a purely prospective design were employed, it would not be ethical to subject children to investigations that the treating clinician did not believe were indicated.

A related limitation is the possibility of a missed SBI in those not screened and who did not have an adverse outcome within three days of enrollment in the parent study. The most likely source in these cases would be urinary, and the most likely pathogen *Escherichia coli*, (*E. coli*). Where the infection is confined to the urinary tract it is possible that some infants would have cleared the infection spontaneously. Sepsis in conjunction with UTI occurred in 31% of neonates, 21% of infants aged 1 to 2 months, 14% of those aged two to three months, and 5.5% of infants over three months of age in one series.[24] Mortality rates as high as 45% to 73%, depending on the underlying prognosis, have been reported in children growing *E. coli* in blood cultures.[25] As there was only one death within 30 days of enrollment (in a severely co-morbid ex-premature infant), a clinically important miss rate for SBI in unscreened patients seems unlikely.

Another limitation is the use of RSV antigen rather than PCR testing. The sensitivity and specificity of the test we used is modest, 78 % and 67% respectively.[26] Whether and how PCR testing would have changed our results is speculative.

We chose our combined endpoint as the primary outcome for several reasons. Culture- negative SBI can occur, with diagnosis hinging on screening tests and clinical judgment. Our necessarily practical definition of EDSS in this study included only tests with a turnaround time short enough to impact ED management. Dropping "screen positive culture negative" cases does not help an EP who cannot know beforehand what cultures will grow.

Including screening tests alone would be incomplete. Although infants with urinary WBC<10 are less likely to have a urinary tract infection,[27,28] culturing is nonetheless recommended for all urine specimens obtained in this age group.[29] While CSF pleocytosis is suggestive, its absence in a neonate does not preclude meningitis.[30] Consequently, we felt that neither culture nor screening tests alone were a satisfactory outcome for emergency medicine.

Finally, when studying rare events, using a sensible combined outcome measure may allow insights to be obtained with smaller sample sizes than would otherwise be possible. The rarity of our outcome means that despite a sample size of 640 patients our confidence intervals are wide.

Our study definitions sometimes conflicted with the treating physicians' clinical impression of a coexisting bacterial illness. Two neonates who were treated based on CSF results were ultimately felt not to have an SBI. We categorized one of these cases as having a positive EDSS but negative SBI. One case was treated by the clinician as having a real UTI based on urine culture of gamma hemolytic *streptococcus*. We analyzed a case of *Candida glabrata* as having an EDSS and SBI in one patient who had pyuria. Though *C. glabrata* is often nosocomially acquired, it can be considered a non-trivial finding; this patient was treated.[31] Some have questioned whether urinary bacterial colony counts less than 50,000 in the presence of low urine WBC are significant. We had only one case where this may have been an issue; however, this infant has had two subsequent UTIs. While reluctant to discount the judgment of the treating pediatrician, we felt obliged to analyze the data according to our study definitions. Reassuringly, when we analyzed the data based on the physicians' clinical impressions the results were similar.

We were surprised that community antibiotic usage did not appear to affect the results. This may in part be because of the low prevalence of their use (11%). We were also surprised that blood cultures were ordered more frequently than urine cultures. They appear to have been ordered reflexively as part of the admission process in some cases.

Our overall prevalence of SBI was lower than some previous studies, which report a prevalence of SBI in bronchiolitis of 11.4%.[1] In RSV bronchiolitis specifically, the prevalence rates range from none to 7.0 %.[1,32] Children with RSV negative bronchiolitis have also been found by most though not all others to have a higher prevalence of SBI.[1,34-36] These studies excluded afebrile infants. We found that while the presence of fever influenced the decision to work up an infant, once that decision was made, neither the presence nor height of the fever was associated with a concurrent bacterial illness. Had we excluded infants who were afebrile on presentation we would not have been able to demonstrate this point. This approach also allowed us to capture the practice of experienced clinicians who occasionally perform an EDSS in infants without a fever yet look unwell.

Unlike prior work[2,31,34-36]we included children older than

three months of age; this allowed us to prove the importance of age as a predictor of concurrent bacterial infection.

There are some differences between our findings and those of others that bear examination. In Liebelt et al 211 infants aged 90 days or younger with clinical bronchiolitis, no case of SBI was found. Of note, 82% of that study's patients had RSV-positive bronchiolitis.[33] Given that SBI is more likely in RSV negative patients and the CIs for 0/38 overlap with our findings, this apparent difference is likely artifactual. Antonow et al studied 282 infants less than two months of age with clinical bronchiolitis and found a SBI prevalence of 1.8%. In that study two-thirds of patients were febrile and RSV rate was 83 % (34). In our study, 32% were febrile on ED presentation (42% febrile in Liebelt and 65% in Antonow) and 55% were RSV-positive.

Most children, even the very young, will have neither a positive EDSS nor an SBI. Among those who do, a UTI is the most common diagnosis.[1,2,19,32,36] For individual patients, clinical judgment, which may be more cost effective than using "clinical rules,"[37] remains necessary. This study provides a measure of the underlying prevalence to help inform that judgment. We have not attempted to provide specific thresholds at which EDSS may be withheld. Instead we have provided our results in a way that we believe informs individual physicians' risk tolerance for what is a rare but important outcome.

Future work establishing the prevalence of concurrent bacterial lung infection in children with bronchiolitis is needed.

CONCLUSION

In those children with bronchiolitis in whom ED testing for bacterial illness was performed, younger age and a negative RSV antigen test was associated with a positive EDSS or SBI.

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Necrotizing Fasciitis of the Paraspinous Muscles

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Necrotizing fasciitis (NF) is a rare and lethal soft tissue infection that requires urgent surgical intervention. It is most often found in the extremities occurring with precipitating trauma or in immunocompromised states. Signs and symptoms are often vague or missing making early diagnosis very difficult. Our patient presented with flank pain and altered mental status but no known precipitating factors. Computed Tomography showed gas within and around the right paraspinous muscle suspicious for NF. Given NF's high lethality, early suspicion by emergency physicians of NF in patients with soft tissue infections or with systemic findings of unknown etiology is necessary. [West J Emerg Med. 2010; 11(1):68-70.]

INTRODUCTION

Necrotizing soft tissue infections (NSTIs) encompass a rare but highly lethal spectrum of infections of the subcutaneous tissue and fascia. NSTIs are often associated with trauma or immunocompromised but can be seen in previously healthy people. Given the high mortality, reported at 25% in recent years[1,2] and up to 76% with involvement of the perineum or trunk[1], early recognition and consultation for debridement is essential to decrease mortality.

CASE REPORT

A previously healthy 54-year-old man presented to the emergency department (ED) with a chief complaint of altered consciousness. Over the preceding five days, the patient's wife reported that he had worsening back and right-flank pain. He also had a productive cough and was seen by a physician three days prior and diagnosed with bronchitis and a lumbar strain. He was prescribed ciprofloxacin, baclofen, and hydrocodone 5mg/acetaminophen 500mg. Despite this, he worsened and developed fever to 39.2°C. On the day of presentation, he became confused and his wife brought him to the ED. Review of systems from the wife was otherwise negative.

Past medical history included hypertension and a brain angioma as a child. He had a 60 pack-year smoking history but denied intravenous (IV) or illicit drugs, recent trauma or illness. Physical exam showed temperature of 37.3°C, pulse 130 beats per minute, blood pressure 110/70 mm Hg and respiratory rate 16 breaths per minute. He appeared tired, diaphoretic, and older than stated age. His head and neck exam was noncontributory. Cardiac exam revealed tachycardia with normal S1 and S2. His lung exam was significant for diffuse rhonchi. The abdomen was soft and non-tender to deep palpation. His skin exam, from his right flank to right paraspinal lumbar region, showed erythema and brawny edema with minimal elevation of the epidermis. This area was moderately tender and without crepitance. His mobility was limited by pain. Extremities were dry but skin was warm. There were no gross motor or sensory deficits. The patient was confused with speech limited mainly to incomprehensible sounds. He was easily aroused and complained of pain when he was turned to examine his back.

A metabolic panel revealed a blood urea nitrogen of 41 mg/dL (normal 8-22), creatinine 2.1 mg/dL (normal 0.5-1.3) and serum sodium 136 mEq/L**.** A complete blood count showed white blood cells (WBC) of 30.3 K/mm^3 with a manual differential of 27.9 K/mm^3 neutrophils. Serum lactate was 2.1 mmol/L (normal <2). The remainder of the laboratory results was unremarkable. An ECG showed sinus tachycardia without ST changes. No HIV test was done.

The patient's resuscitation included two liters IV normal saline without improvement in mental status or blood pressure. Given the area of skin elevation in his back and the clinical presentation of presumed sepsis, computed tomography (CT) scans of the head, chest, abdomen and pelvis were ordered. The CT of the head and chest were unremarkable; however, the CT scan of the abdomen and pelvis showed gas within and around the right paraspinous muscles with an adjacent large abscess measuring 28 (cranial to caudal) x 15 x 5 cm that extended from the gluteus muscle to the mid-thoracic level of the back concerning for necrotizing fasciitis (Figure). General surgery was immediately consulted and the

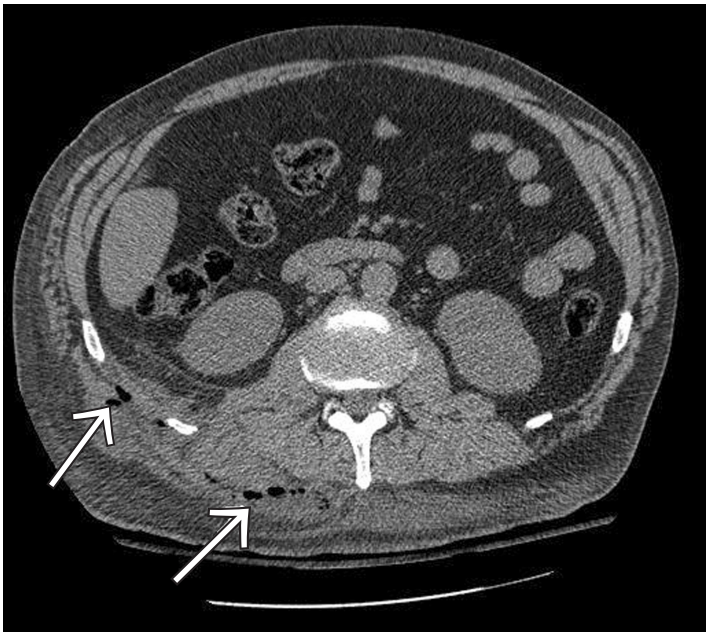

Figure. Computed tomography scan of the abdomen demonstrating gas (arrows) in the right paraspinous muscles.

patient was given broad-spectrum IV antibiotics. Despite this, the patient became hypotensive with systolic blood pressure 92 mmHg. After the patient's surgical evaluation, he was intubated to protect his airway and for his impending surgery.

In the operating room (OR), extensive necrosis of the trapezius, quadratus lumborum, and paraspinous muscles from the base of the neck to two centimeters above his buttock were debrided. Involvement extended into portions of the retroperitoneum at the lumbar triangle. There was also bony involvement of the twelfth rib, cervical spine, lumbar spine, and iliac crest requiring removal of the twelfth rib, with no spinal canal or cord involvement. In total, an estimated 9% of total body surface area was affected without involvement of the perirectal area. Wound cultures grew *Streptococcus viridans,* peptostreptococcus and porphyromonas species.

The patient returned to the OR the next day for more debridement and wound vac placement. Through his 17-day hospitalization, he had four additional debridements and wound vac changes, with continuous IV antibiotics. The patient recovered and was discharged home in stable condition. He was seen in general surgery clinic with no complications or need for additional surgical or medical interventions.

DISCUSSION

Necrotizing fasciitis (NF), a NSTI that has invaded fascial planes, is a rare but potentially fatal infection that requires early diagnosis and surgical intervention due to its rapid progression and high mortality. The incidence of NF in the United States is estimated at 500-1500 cases per year with mortality of 20-60%.[1-6] The pathophysiology of NF involves release of bacterial toxins and enzymes resulting in rapidly progressing soft tissue necrosis.[2,7] Pathogens further block the lymphatic and vascular systems, impairing the immune system and antibiotic delivery.[2] Ultimately, if untreated, extensive inflammation and coagulation necrosis results in pathogen spread along fascial planes with eventual muscular and bony involvement. Mortality results from overwhelming sepsis and multiple organ failure.

Table. Location of necrotizing soft tissue infections in recent prospective studies

Study	Extremity (%)	Perineal[a] (%)	Other location[b] (%)
Ogilvie 2006[3]	88 (57.9%)	58 (38.1%)	6 (4%)
Frazee 2008[1]	90 (73.7%)	23 (18.9%)	30 (24.6%)
Anaya 2005[14]	96 (57.8%)	37 (22.3%)	33 (19.9%)
Wong 2003[12]	71 (79.8%)	n/a	18 (20.2%)
Sudarsky 1987[13]	33 (67%)	8 (24%)	3 (9%)

[a]Perineal includes buttock and upper leg in all studies.
[b]Other includes trunk only with exception of Frazee, which also includes shoulder, and Anaya, which includes head and neck.

There are many classification systems for distinguishing various types of NF, based on type of pathogen, location and/or extent of tissue involvement. While classification can be useful for refining antibiotic treatment or documentation purposes, there are no obvious distinguishing clinical features separating the various types, and initial treatment in the ED should be the same in all suspected cases of NF.[2,5]

While many risk factors have been identified, including diabetes mellitus, chronic kidney disease, IV drug use and immune suppression,[3,9] up to 50% of NF cases occur in otherwise healthy patients of all age ranges.[2,3] Many cases have a precipitating factor, usually trauma. However, as in our patient, >20% present with unknown etiology.[4,10]

NF is primarily a clinical diagnosis with a wide spectrum of presentations, making early diagnosis difficult. The high rate of initial misdiagnosis in the ED, reported at 42.6%- 86.4%, has been attributed to lack of systemic and/or cutaneous findings.[5,9,11] The most common misdiagnoses are cellulitis or abscess,[9,11] but NF can also present similarly to erysipelas, phlebitis, arthritis, deep vein thrombosis and viral illness.[4] While NF most often affects the extremities, itcan affect any part of the body with the perineal area and trunk being the next most common (Table).[1,10,12-15]

Initial symptoms are vague and onset occurs over several hours to days.[1,5,10] Symptoms include tenderness, swelling, erythema and pain at the affected site.[3,10] Skin changes are usually heterogeneous[5,9] and can mimic cellulitis [4,5] or abscess.[1,7] Pain out of proportion to exam is the most specific early manifestation of NF,[5,6,10] while presence of bullae is a specific late finding indicating tissue necrosis.[5] These findings are fairly specific but insensitive (10-40%).[4] Systemic findings may include fever, tachycardia, diaphoresis, hypotension, extreme anxiety and vomiting/diarrhea.[2,5]

Laboratory results associated with poor outcomes from NF are WBC counts >14,000 cells/mm3, serum sodium <135 mEq/L and a BUN >15-18 mg/dl.[2,11] Given the lack of definitive clinical presentation, Wong et al.[16,17] developed the Laboratory Risk Indictor for Necrotizing Fasciitis (LRINEC) that uses six predictive factors to distinguish NF from other soft tissue infections, which in one prospective study was shown to have a negative predictive value of 95% and a positive predictive value of 40%. Wong et al.[18] thus argued that the LRINEC should be used to limit and target use of radiographic imaging rather than as an independent diagnostic tool for NF. However, utility of this instrument has not been validated in ED patients.

CT and magnetic resonance imaging (MRI) are most commonly used and studied. While MRI is more sensitive than CT for soft tissue infections, availability often limits its use. Findings on CT suspicious for NF include asymmetric deep fascial thickening, fat stranding and presence of fluid or gas.[18] Plain films have a high specificity but low sensitivity in identifying subcutaneous gas.[4] Imaging should be an adjunct to diagnosis and not delay operative treatment if suspicion for NF is high, since an open look by a surgeon is the criterion standard for diagnosis and allows for immediate treatment.[5]

Our patient initially presented to his primary medical doctor with low back pain and a productive cough that later progressed to fever and delirium. While these initial symptoms were vague, we suspected NF given the redness and exquisite tenderness of the back and right flank. Unusual features of this case include atypical location, lack of trauma and apparent previous healthy state of this patient. The emergency physician (EP) should consider NF even in these circumstances. In this, the diagnosis was made expeditiously with CT and early exploration.

Initial treatment in the ED for NF includes aggressive resuscitation, broad spectrum IV antibiotics, and immediate surgical consult.[10] The criterion standard of treatment is repeated surgical debridement to ensure removal of all necrotic tissue along with deep incisional biopsy, wound cultures and antibiotics.[2-4] Hyperbaric oxygen and IV immunoglobulin have also been used with mixed results and are seen as possible adjuvants, especially if risk of mortality is high.[4,6,19]

CONCLUSION

As in this patient, NF can occur in any location without precipitating factors and with vague symptoms, making early diagnosis difficult. Misdiagnosis can lead to delay in surgical debridement, which is the only identified modifiable factor that decreases mortality.[1,6] Although NF is rare, the rapid progression and lethality warrants high clinical suspicion, early diagnosis by the EP and prompt treatment.

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Small Bowel Obstruction from Capsule Endoscopy

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Over the past decade, capsule endoscopy has become the accepted modality for small bowel imaging in the United States. It is very helpful in making the diagnosis of Crohn's disease; however, this patient population is also at an increased risk of small bowel obstruction secondary to capsule impaction. We present the case of a 60-year-old female with undiagnosed Crohn's disease who presented to the emergency department with small bowel obstruction after capsule ingestion. She was successfully disimpacted with diatrizoate upper gastrointestinal (GI) series with small bowel follow-through and intravenous steroids. Review of the endoscopic video images revealed findings consistent with Crohn's disease. [West J Emerg Med. 2010; 11(1):71-73.]

INTRODUCTION

Patients with recurrent abdominal pain of unclear etiology present a challenging problem for even the most seasoned emergency physician. Many patients have had extensive workups and are merely seeking pain relief. Patients with inflammatory bowel disease limited to the small bowel have traditionally been a diagnostic dilemma. With the advent of capsule endoscopy, a comprehensive endoscopic view of the entire gastrointestinal (GI) tract is now possible. Small bowel obstruction secondary to capsule impaction is a serious risk of the procedure, and to our knowledge it has not been reported in the emergency medicine literature. We present the case of a patient with undiagnosed Crohn's disease presenting with small bowel obstruction after undergoing capsule endoscopy.

History

A 60-year-old female presented to the emergency department with abdominal distension and peri-umbilical pain. She described the pain as intermittent, cramping, and associated with nausea and vomiting. She denied dysuria, fevers, or chills. Over the past year, the patient had had an extensive negative workup for recurrent episodes of abdominal pain and diarrhea, including comprehensive blood and stool studies, computed tomography (CT), abdominal ultrasound, esophagastroduodenoscopy (EGD), colonoscopy, barium enema, and upper GI with small bowel follow-through. A tentative diagnosis of irritable bowel syndrome was made. Five days prior to presentation, the patient underwent capsule endoscopy – the results of which were still pending. Her past medical history included gastroesophageal reflux disease and a 3cm abdominal aortic aneurysm. The patient's surgical history was significant for multiple abdominal surgeries including hysterectomy, cholecystectomy, and three Caesarian sections. Her home medications were a proton pump inhibitor and hormone replacement therapy.

Physical Exam

The patient appeared in mild discomfort. Vital signs were heart rate 72, respiratory rate 18, blood pressure 135/71, and temperature 36.4°C. The head and neck exam were normal. The lungs were clear. The heart was regular with no murmurs. The abdominal exam revealed a mildly distended abdomen with hyperactive bowel sounds. The percussion note was tympannitic. There was no localizing tenderness or evidence of peritonitis. The rectal exam was normal with brown heme negative stool. The extremities were warm and dry with symmetric pulses in the upper and lower extremities.

DIAGNOSTIC TESTING

The complete blood count included a white count of 10,300 cells/mcL and hemoglobin of 13.7 g/dL. Electrolytes, hepatic function panel, lipase, renal function, and urinalysis were normal. An acute abdominal series showed multiple air fluid levels, distended small bowel, and a retained capsule endoscope in the terminal ileum

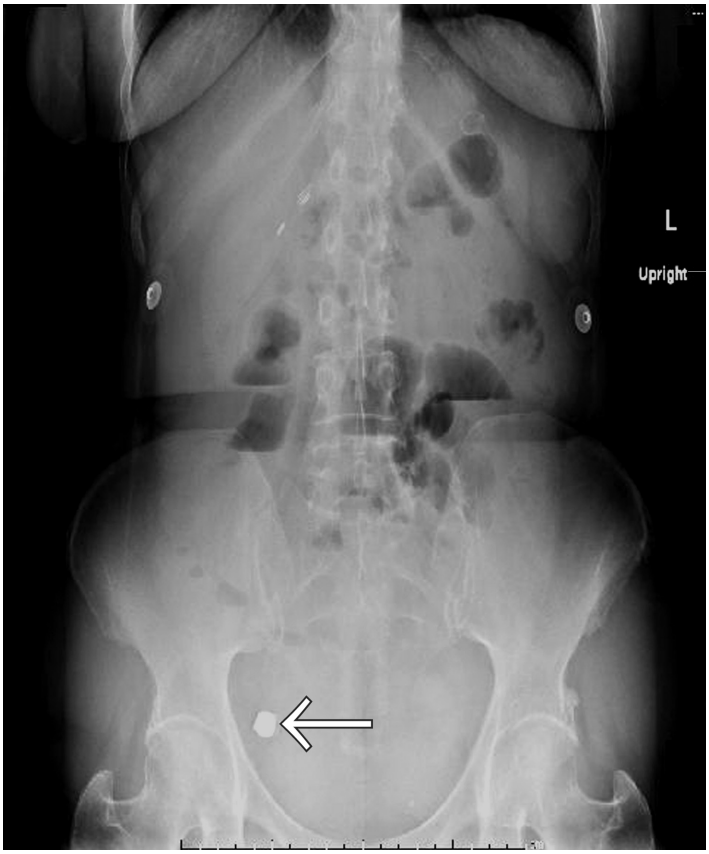

Figure 1. Upright (left) and supine (right) abdominal radiographs demonstrating retained capsule endoscope.

consistent with a small bowel obstruction (**Figure 1**).

A nasogastric tube was placed and the patient was admitted. The patient was treated with IV steroids and antibiotics. The primary team performed a diatrizoate (Gastrografin) upper GI series with small bowel follow-through 12 hours after admission. Delayed films three hours later showed that the capsule had passed into the colon. Review of the endoscopic video images revealed erythema, granularity of the mucosa, friability, and edema of the small bowel, consistent with the diagnosis of Crohn's disease.

DISCUSSION

After its approval by the Food and Drug Administration in 2001, capsule endoscopy has gained widespread acceptance as an important imaging modality for small bowel pathology. Included in the 1 cm x 2.5 cm ingestible endoscope are a wireless video camera, illumination system, batteries, and an image transmitter (**Figure 2**). Images are recorded by a sensing system worn on the patient's trunk, which is removed for image download approximately eight hours after capsule ingestion. Seventy-five percent of capsules enter the colon during the eight-hour acquisition time.[1] Subsequently, the disposable plastic-covered capsule is excreted in the stool 10-48 hours later.[2,3]

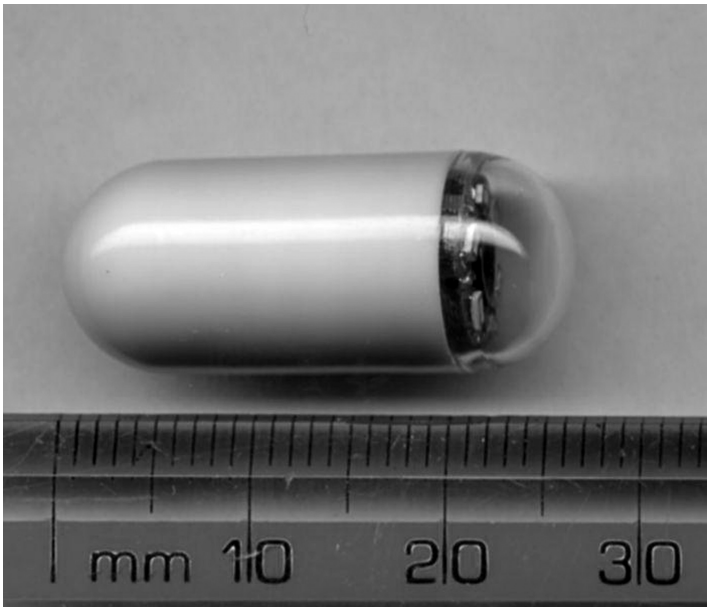

Figure 2. Capsule endoscope. Image courtesy of Wikimedia Commons.

In preparation for capsule endoscopy, a patient typically fasts or maintains a clear liquid diet for 10-24 hours prior to the procedure. Several bowel preparation regimens (polyethylene glycol, simethicone, and/or sodium phosphate) have been studied, but there is no current consensus for whether bowel preparation is necessary or beneficial. Some clinicians administer promotility agents, including erythromycin and metoclopramide, during capsule passage. Evidence is controversial to support their use.[4]

Indications for capsule endoscopy include obscure GI bleeding, suspected Crohn's disease, malabsorptive syndrome, or small intestinal tumors, and surveillance for patients with polyposis syndromes. The list of relative contraindications includes patients with known or suspected GI obstruction, stricture, fistula, or motility disorders, patients with cardiac pacemakers or other implanted electro-medical devices, dysphagia, and pregnancy.[2,5]

One of the common risks of the procedure is capsule retention. Capsule retention is defined as a capsule remaining in the gastrointestinal system for longer than two weeks, requiring directed medical, endoscopic, or surgical intervention to retrieve or pass the capsule.[1] The most common causes of retention are Crohn's disease, strictures caused by chronic non-steroidal anti-inflammatory drug (NSAID) use, small-bowel tumors, radiation enteritis, and surgical anastomotic strictures. The incidence of capsule retention ranges from 0% to 13%, with the most common site of detainment in the ileum, similar to our patient.[1,6] Capsule retention occurs frequently in patients with known Crohn's disease, 13% in one large study.[7] Capsule retention rarely causes symptoms but can potentially cause small bowel obstruction or perforation.[8-12]

Asymptomatic capsule retention may be treated with medical, endoscopic, or surgical intervention.[1,6] Capsule retrieval is not emergent in asymptomatic retainers. In one large study, early elective laparotomy or double-balloon endoscopy was performed to retrieve the capsule and treat the underlying cause for the stricture (small-bowel tumor, Crohn's disease, ischemic bowel) in 34% of patients with asymptomatic capsule retention. The remainder (66%) underwent medical therapy for their underlying disease. Spontaneous capsule passage occurred in 52% of the medical therapy group. The rest underwent laparotomy for emergent obstructive symptoms (24%) and failure of medical treatment (24%).[6] Medical therapies include steroids, infliximab, prokinetics, or cathartics. Their efficacy is controversial. The longest reported case of capsule retention is 2.5 years.[1]

Small bowel obstruction and perforation are rare but serious results of capsule retention. They may occur as early as several hours after capsule ingestion or after a prolonged period of capsule retention.[8,9] Patients with abdominal pain, distension, and nausea after capsule endoscopy should be evaluated for impaction and small bowel obstruction or perforation. Diagnosis may be aided by interpretation of capsule images. There may be evidence of an obstructing lesion, repetitive images of the same area of mucosa, or inability to visualize the colon. Abdominal radiography or CT will typically demonstrate a radioopaque density in the small bowel.[1]

Cases of capsule retention with signs and symptoms of small bowel obstruction or perforation are managed operatively or non-operatively, depending on the clinical scenario. Non-surgical interventions include enemas and enteroscopy with snare retrieval.[8,9] Surgical interventions may be open or laparoscopic with capsule recovery via enterectomy or intraoperative manual bowel manipulation and digital rectal retrieval.[8,11,12] Surgical intervention can remove both the obstructing lesion and the retained capsule. This case report describes successful disimpaction with IV steroids and diatrizoate upper GI series with small bowel follow-through.

Of special note, patients with suspected capsule retention should not undergo magnetic resonance imaging.[2] Risk of capsule non-passage should be assessed in any patient who has undergone capsule endoscopy in the previous three years.

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Boerhaave's Syndrome

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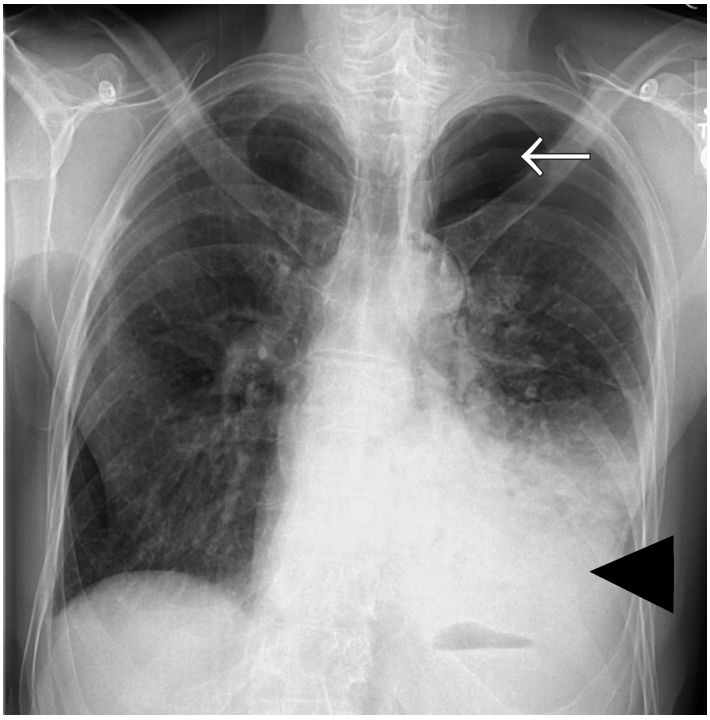

Figure 1. Radiograph of left-sided pneumo-hydrothorax, where the black arrowhead indicates the hydrothorax and the white arrow indicates the pneumothorax.

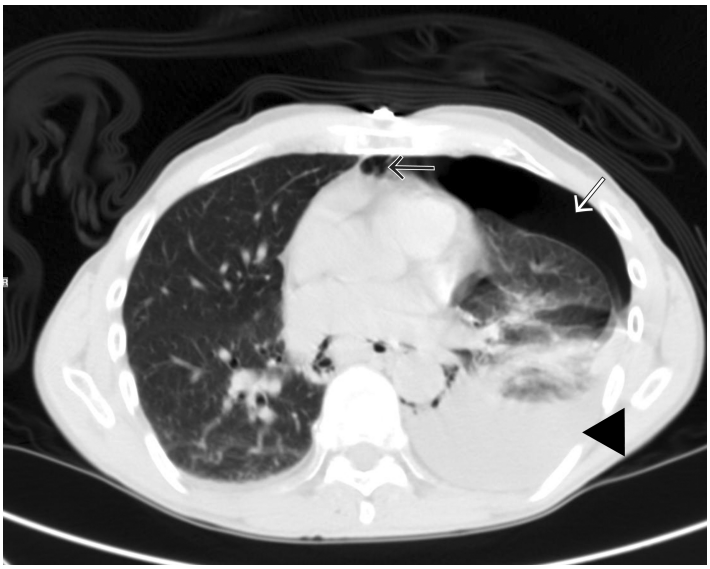

Figure 2. Computed tomography of the chest with pneumo-hydrothorax and mediastinal air, where the black arrowhead indicates the hydrothorax, the white arrow indicates the pneumothorax, and the black arrow indicates the mediastinal air.

A 66-year-old Caucasian male with no past medical history presented to the emergency department (ED) complaining of severe retrosternal pain, which began immediately prior to arrival following an episode of vomiting. The patient had symptoms including nausea, vomiting and generalized abdominal discomfort for three days prior. The patient had been evaluated by a primary care physician earlier the day of presentation and was diagnosed with gastroenteritis and possible early small bowel obstruction per computed tomography (CT) scan of the abdomen and pelvis. The patient was released home with anti-emetics. On presentation to the ED the patient was in moderate distress secondary to pain and hemodynamically stable. Physical exam was remarkable for absent breath sounds over the left hemithorax. Chest radiography revealed a left-sided pneumo-hydrothorax (Figure 1). Subsequent CT of the chest also demonstrated pneumo-hydrothorax, as well as mediastinal air (Figure 2). Laboratory studies showed normal comprehensive metabolic panel and coagulation profile; however, the CK-MB was elevated at 6.70 ng/ml (3.60-5.00), and a leukocytosis of 11.9 TH/ul (4.0-9.0). Electrocardiograph showed normal sinus rhythm with a ventricular rate of 87. A 28 French chest tube was inserted, draining 600 mL of dark blood-tinged fluid. Based on radiographic findings and clinical presentation, esophageal rupture was the primary diagnosis. The patient was transferred to a tertiary center where Boerhaave's was confirmed with a barium esophagram. Surgical repair was successfully performed.

Patients classically present with chest pain, vomiting and subcutaneous emphysema. Pain may radiate to the neck, arm or back and is aggravated by deep breathing or swallowing. A myriad of other findings may be present, including hoarseness,

JVD, and cyanosis. The Hamman crunch may be ascultated. A distinctive sound corresponding with each heartbeat is indicative of pneumomediastinum.[1] As time progresses, the clinical picture can be clouded by sepsis syndrome. Chest radiography is the preferred initial study and is most often abnormal, showing mediastinal or free peritoneal air. CT scan may reveal periesophageal fluid with possible air bubbles, pneumo-hydrothorax, esophageal wall edema, or widened mediastinum. Water-soluble esophagram is performed to confirm rupture; if negative, one should pursue a barium study treatment based on the location of the perforation. Thoracic esophageal perforations require surgical intervention within the first 24 hours involving mediastinal and chest drainage and esophageal repair. Cervical esophageal perforations can often be managed non-surgically.[2] Underlying esophageal disease may also influence the type of therapy, such that the treatment of the underlying process is included in the repair of the perforation. In one study morbidity and mortality of patients with underlying esophageal pathology were similar to patients without prior disease.[3] Concomitant therapies include antibiotics, acid suppression, nasogastric suction and supplementation, such as total parenteral nutrition or enternal feeding.

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in Emergency Medical Services and Disaster Medicine
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University of California, Irvine, Department of Emergency Medicine is seeking an HS Clinical Instructor for July, 2010. UC Irvine Medical Center is a Level I Trauma center with 2200 runs/year, 40,000 ED census. The fellowship in Emergency Medical Services and Disaster Medicine, beginning July 1, 2010, combines the traditional emphasis on EMS research with the disciplines of emergency management/ disaster medicine and public health. A key focus of the fellowship is health policy and health services systems research including mass casualty management and triage. Completion of American Council of Graduate Medical Education (ACGME) accredited Emergency Medicine Residency required prior to start. The two-year combined program, with an integrated Masters of Public Health, will be jointly administered by Director, EMS and Disaster Medicine. Salary commensurate with level of clinical work. Send CV, statement of interest and three letters of recommendation to:

Carl Schultz, MD
Department of Emergency Medicine, Route 128,
UC Irvine Medical Center,
101 City Drive, Orange, CA 92868.

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Emergency Medicine Education Fellowship
University of California, Irvine School of Medicine

University of California, Irvine, Department of Emergency Medicine (EM) is seeking a HS Clinical Instructor- Education Fellow for July, 2011. University of California, Irvine Medical Center is a Level I Trauma center with 2200 runs/year, 40,000 ED census with a three-year residency program since 1989. Fellowship concentration areas include education, medical school curriculum design, simulation, peer-reviewed journal editing and publishing. This two-year research fellowship includes a requirement for completion of a Masters in Education. Possibility exists for a one-year fellowship for candidates with a Masters degree or those starting one during their fellowship. Completion of an ACGME accredited EM Residency is required. Salary is commensurate with the level of clinical work.

Send CV and statement of interest to:

Dr. Shahram Lotfipour at SHL@uci.edu
or
Department of Emergency Medicine
UC Irvine Medical Center, Route 128-01
101 The City Drive
Orange, CA 92868
or
Call 714-456-5239

See the Department of Emergency Medicine's website available at http://www.emergencymed.uci.edu/ for more details.

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To apply please send a cover letter, CV and names of three references to:

Amin Antoine N. Kazzi, MD, FAAEM
Chief of Service & Medical Director, Emergency Department
AUB Faculty of Medicine and Medical Center
American University of Beirut
P.O.Box 11-0236 / Medical Dean's Office
Riad El-Solh / Beirut 1107 2020, Lebanon

For additional information, e-mail: ak63@aub.edu.lb

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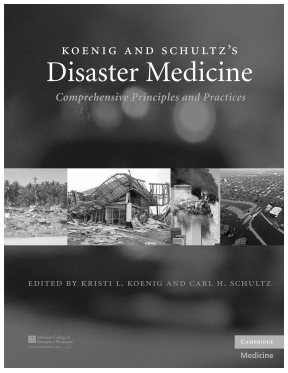
*West*JEM also seeks reviewers in all topics of emergency medicine.

Please send CV and letter of interest to Editor-in-Chief, Dr. Mark Langdorf at *West*JEM@gmail.com.

Newly Published Textbook Announcement



Koenig and Schultz's Disaster Medicine: Comprehensive Principles and Practices

As societies become more complex and interconnected, the global risk for catastrophic disasters is increasing. Demand for expertise to mitigate the human suffering and damage these events cause is also high. A new field of disaster medicine is emerging, offering innovative approaches to optimize disaster management. Much of the information needed to create the foundation for this growing specialty is not objectively described or is scattered among multiple different sources. Now, for the first time, a coherent and comprehensive collection of scientific observations and evidence-based recommendations with expert contributors from around the globe is available in *Koenig and Schultz's Disaster Medicine: Comprehensive Principles and Practices*. This definitive work on disaster medicine identifies essential subject matter, clarifies nomenclature, and outlines necessary areas of proficiency for healthcare professionals handling mass casualty crises. It also describes in-depth strategies for the rapid diagnosis and treatment of victims suffering from blast injuries or exposure to chemical, biological, and radiological agents.

- A fresh new approach to disaster preparedness and response, written for both emergency physicians and nurses
- Covers a wide range of disaster situations, with strategies for rapid diagnosis and treatment of victims, as well as scene management
- Contributed by experts from all over the world, supplemented with photos and diagrams of each aspect of disaster response

Available for purchase at the American College of Emergency Physicians bookstore, Cambridge University Press and Amazon.com.

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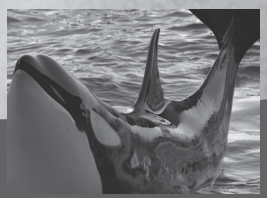
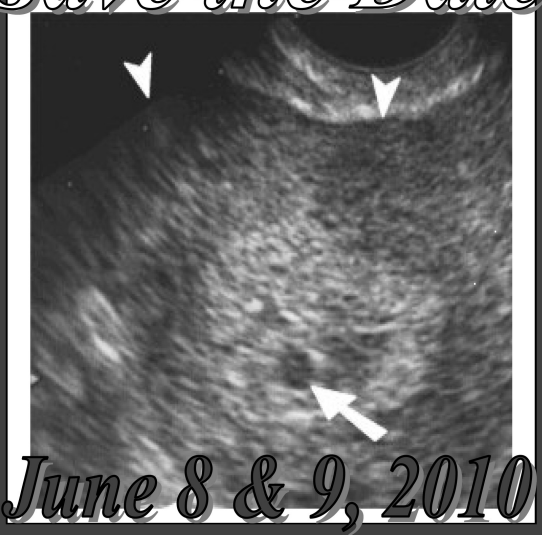


Giant Steps

Paradise Point Resort & Spa

Save the Date

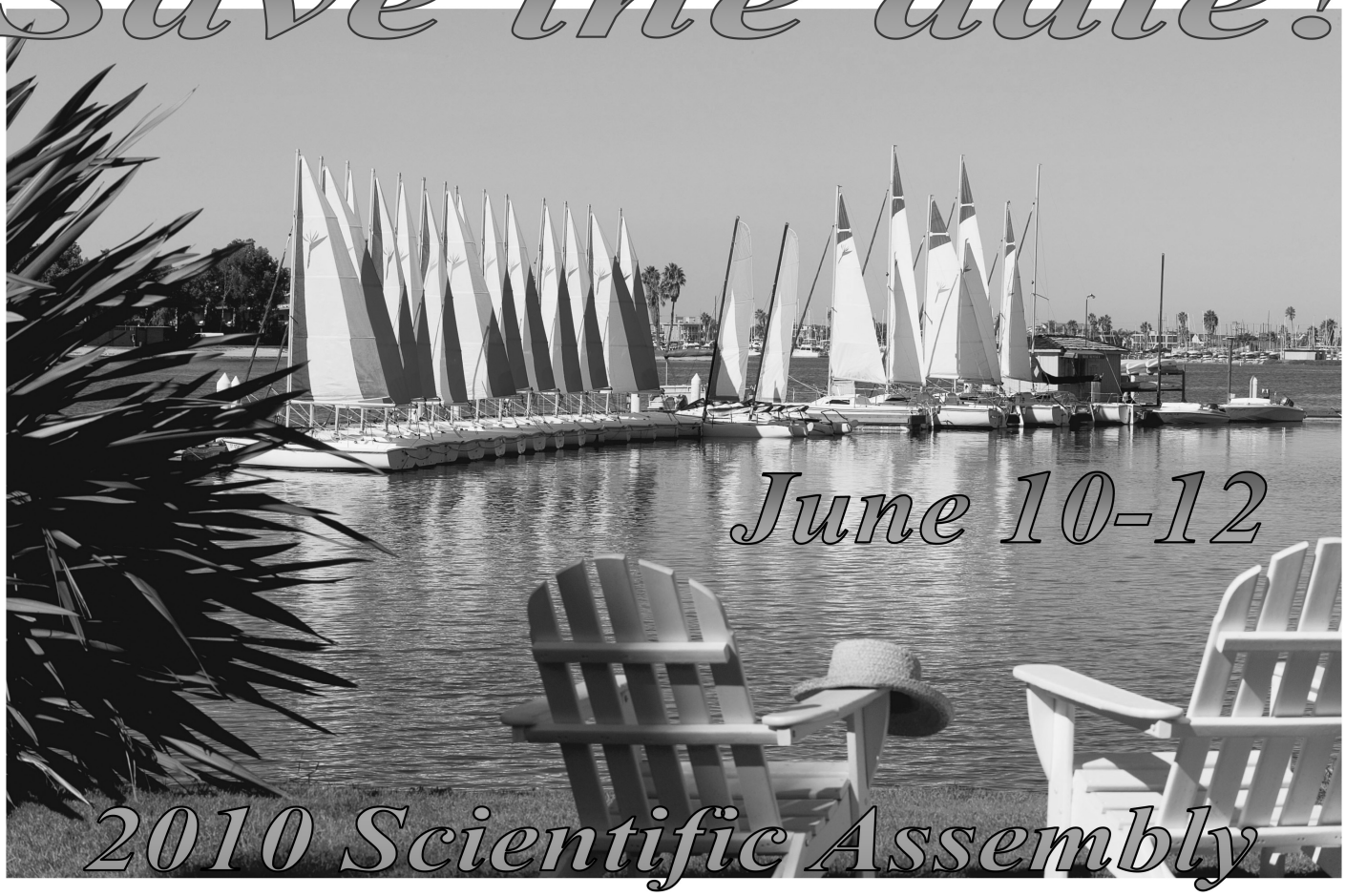


June 8 & 9, 2010

CAL/ACEP Emergency Medicine Ultrasound Workshop

Please call CAL/ACEP (1-800-735-2237) or E-mail: Deanna M. Janey • djaney@calacep.org.

Save the date!



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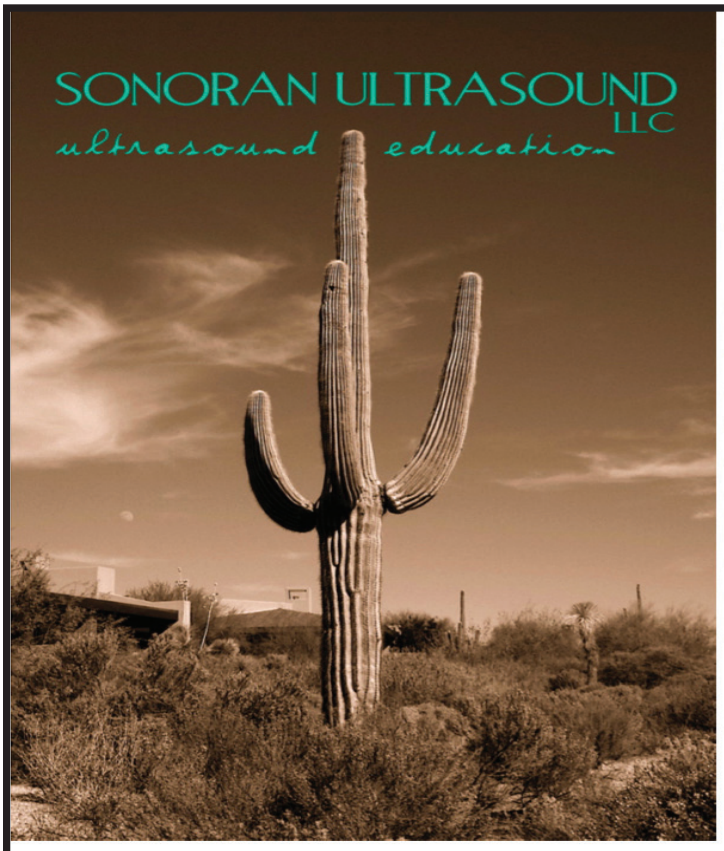

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