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Chart Smart: A Need for Documentation and Billing Education Among Emergency Medicine Residents?

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Objective: The healthcare chart is becoming ever more complex, serving clinicians, patients, third party payers, regulators, and even medicolegal parties. The purpose of this study was to identify our emergency medicine (EM) resident and attending physicians' current knowledge and attitudes about billing and documentation practices. We hypothesized that resident and attending physicians would identify billing and documentation as an area in which residents need further education.

Methods: We gave a 15-question Likert survey to resident and attending physicians regarding charting practices, knowledge of billing and documentation, and opinions regarding need for further education.

Results: We achieved a 100% response rate, with 47% (16/34) of resident physicians disagreeing or strongly disagreeing that they have adequate training in billing and documentation, while 91% (31/34) of residents and 95% (21/22) of attending physicians identified this skill as important to a resident's future practice. Eighty-two percent (28/34) of resident physicians and 100% of attending physicians recommended further education for residents

Conclusion: Residents in this academic EM department identified a need for further education in billing and documentation practices. [West J Emerg Med. 2010;11(2): 116-119.]

INTRODUCTION

"If it isn't in the chart then it wasn't done," is often heard from attending physicians, department heads, administrators, and coders alike. Documentation has been important as a means of communicating to future providers what was done for the patient; over time the chart has evolved to serve additional purposes. Many academic physicians lament this progressive growth in charting as required by the Centers for Medicare and Medicaid Services [CMS, or as it was previously known, the Health Care Financing Administration (HCFA)] and believe that it detrimentally impacts both patient care and resident teaching.[1-3] The medical chart is now used to justify reimbursement from third-party payers, and is an important medicolegal document. Each of the chart functions has separate requirements and considerations that the physician must master to be successful in today's healthcare environment. The Accreditation Council for Graduate Medical Education (ACGME) has recognized the importance of teaching residents these skills by including a requirement in its six core competencies for "systems-based practice" and for "professionalism."[4-6]

In 1992, the Medicare fee schedule became "resource based," and the new Current Procedure Terminology (CPT) codes developed by the American Medical Association were implemented by the HCFA. The Evaluation and Management (E/M) codes under this system are site specific, indicating where [clinic, nursing home, emergency department (ED)] the service was performed. These codes are further divided into as many as five different levels, reflecting the amount of work required by the physician. E/M levels are designed to reflect separate elements of every visit, most importantly the patient's history, physician's examination, and medical decision-making. Under this system there are graduated requirements for each level of service and each of the three elements. A problem arises when the physician evaluates a patient for a problem that is eligible to be billed at a certain level but cannot be billed due to inadequate chart documentation. Although the physician may have performed the work they

Table 1. Resident Survey Responses

Resident Survey Responses (All PGY Levels) n=34						
Question		Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
1	I complete the majority of my charts while I see the patient or immediately after leaving the patients room.	9%	29%	9%	29%	24%
2	I complete the majority of my charts after the shift is over but before leaving the hospital.	15%	29%	6%	21%	26%
3	I complete the majority of my charts at some point after my shift is over and I have left the hospital or department.	41%	35%	6%	6%	9%
4	I received specific and targeted training in medical school regarding current billing and documentation practices in healthcare.	44%	44%	3%	9%	0%
5	I have received adequate education in billing and documentation practices to prepare for my future job.	12%	35%	26%	26%	0%
6	I understand the role that Medicare reimbursement has on billing and documentation practices in emergency medicine.	3%	35%	21%	35%	3%
7	I understand what an E/M code is and how it is determined.	21%	41%	24%	15%	0%
8	I feel confident in my ability to determine the appropriate E/M code for patients I see.	18%	56%	18%	9%	0%
9	I know the documentation requirements for each level of chart.	3%	47%	26%	24%	0%
10	I adjust the amount of documetation based upon the anticipated E/M level.	24%	44%	15%	15%	3%
11	I know the basic charges for each E/M level.	35%	47%	12%	6%	0%
12	I know the charges for many of the frequently performed ED procedures.	32%	50%	12%	3%	3%
13	Knowledge of billing and documentation practice will be important after I graduate residency and start my first job as an attending.	0%	6%	3%	35%	56%
14	Further formal education should be provided to residents regarding billing and documentation practices as they relate to Emergency Medicine.	0%	3%	15%	35%	47%

will be reimbursed at the lower level, a practice referred to as "downcoding."

Current didactics in billing and documentation at this academic ED include a lecture during intern orientation, a focus on documentation in monthly morbidity and mortality conference, chart reviews and a "billing overview" meeting during third-year administration month. We created a survey to document our resident and attending physicians' attitudes and knowledge regarding billing and documentation practices under our current educational system. Our hypothesis was that our physicians would identify lack of adequate knowledge in this area.

METHODS

All protocols were reviewed and approved by the University Medical Center Institutional Review Board.

Study design

We gave a 15-question survey using a Likert scale to 34 EM residents (study authors were excluded) from a single accredited three-year residency, with 12 first-year, 13 second-year, and 11 third- year residents. The ED has an annual census of about 70,000 and is in a rural tertiary care hospital. The purpose of the resident survey was to evaluate residents' knowledge of and attitudes towards billing and documentation practices. We gave a similar 22-question survey using a Likert scale to all 22 EM attending physicians from the same EM residency. The attending physician survey asked similar questions regarding knowledge of billing and documentation practices, as well as their opinions about the residents' knowledge.

Data Analysis

Responses were recorded in a database and response percentages were calculated and reported.

RESULTS

For the purposes of analysis an affirmative response was considered to be agree or strongly agree, while a negative response was disagree or strongly disagree. While significant findings are discussed below, complete survey questions and results by percentage are provided in Tables 1 (for residents) and Table 2 (for attendings).

We obtained completed surveys from both 100% (34/34) of EM residents (excluding two study authors) and 100% (22/22) of EM attending physicians.

Table 2. Attending Survey Responses

Attending Survey Responses n=22						
Question		Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
1	Residents should complete charts when they see the patient or immediately after leaving the patients room.	5%	27%	5%	36%	27%
2	Residents should not leave the hospital before their charts are complete.	9%	5%	9%	27%	50%
3	I received formal training in billing and documentation practices in my residency	36%	18%	5%	36%	5%
4	I received formal training and/or communication on my billing and documentation practices as a private physician.	14%	21%	0%	36%	29%
5	Residents in this program receive adequate training in billing and documentation practices to prepare them for private sector jobs.	0%	57%	14%	24%	5%
6	Many of todays jobs in emergency medicine will require the physician to be skilled in biling and documentation practices.	5%	0%	0%	36%	59%
7	I understand the role that Medicare reimbursement has on billing and documentation practices in emergency medicine.	0%	9%	0%	41%	50%
8	Our residents understand the role that Medicare reimbursement has on billing and documentation practices in emergency medicine.	5%	50%	32%	14%	0%
9	I understand what an E/M code is and how it is determined.	0%	14%	5%	43%	38%
10	Our residents understand what an E/M code is and how it is determined.	5%	38%	43%	14%	0%
11	I feel confident in my ability to determine the approriate E/M code for patients I see.	5%	23%	5%	45%	23%
12	Our residents are able to determine the apropriate E/M codes for patients they see.	14%	55%	27%	5%	0%
13	I know the documentation requirements for each level of chart.	9%	18%	5%	50%	18%
14	Our residents know the documentation requirements for each level of chart.	5%	59%	27%	9%	0%
15	I adjust the amount of documentation based upon the anticipated E/M level.	10%	14%	0%	48%	29%
16	Our residents adjust the amount of documentation based upon the anticipated E/M level.	18%	55%	23%	0%	5%
17	I know the basic charges for each E/M level.	5%	32%	9%	41%	14%
18	Our residents know the basic charges for each E/M level.	9%	59%	32%	0%	0%
19	I know the charges for many of the frequently performed ED procedures.	23%	41%	14%	18%	5%
20	Our residents know the charges for many of the frequently performed ED procedures.	36%	45%	18%	0%	0%
21	Our residents' documentation practices need improvement.	0%	0%	0%	36%	64%
22	Further formal education should be provided to residents regarding billing and documentation practices as they relate to emergency medicine.	0%	0%	0%	45%	55%

Regarding current residency training, only 26% of our residents and 29% of our attendings reported adequate education in billing and documentation in the residency program to prepare the residents for their future jobs. Both residents (91%) and attendings (95%) agreed that current or future jobs will require this knowledge.

Understanding of evaluation and management (E/M) codes was poor among residents, with 15% reporting that they understood what an E/M code is and how it is determined. While 81% of attending physicians reported that they themselves understood the E/M code and how it is determined, only 14% thought that residents understood this aspect of billing.

Regarding future education on billing and documentation, 82% of our residents and 100% of our attendings agreed that further education on this topic should be provided. Furthermore, 100% of our attendings reported that resident documentation needs improvement.

DISCUSSION

In our EM residency a recent change in our documentation system underscored that resident education in billing and documentation requirements may be inadequately addressed. Previously, EM residents and their programs have identified documentation criteria for various E/M codes and the concept and use of RVUs as an area in which they lack adequate knowledge and skill, even after graduation.[7] More recently, an abstract presented at the 2006 American College of Emergency Physicians Research Forum reported more frequent downcoding from one billable level of chart to a lower level among EM residents, compared to midlevel providers and attending physicians.[8] Not only do EM residents identify this as an area needing improvement, but a recent Schumacher Group survey of ED administrators reported they felt EM physicians were not well prepared for the current pay-for-performance setting.[9]

This appears not to be an isolated issue for EM, as several other residency groups including internal medicine, surgery, and obstetrics and gynecology have all identified billing and documentation by residents as an area that needs improvement.[10]

Further training in documentation would be helpful to EM residents on more than one level. In today's EM job environment, there seems to be a move towards more pay-for-performance jobs. This is likely to continue if reimbursement rates from third parties stay stagnant or decline. Preparing EM residents for this job climate requires proficiency in billing and documentation.

Given the growing trend toward reporting of "core measures," quality initiatives, and hospital ratings, it is likely administrators will continue to place emphasis on the medical chart to ensure compliance. We should be preparing EM residents to meet these aspects of their future careers.

In 1999 a survey given to all EM residents as part of the annual American Board of Emergency Medicine In-training examination reported that residents across the nation identified billing and documentation practices as an area in which they needed more training.[7] Our survey confirms that our current residents continue to identify this as an area in which they believe they lack adequate education. A focused educational offering on billing and documentation offered during residency, rather than at the beginning and end, might help meet this perceived deficit. Future areas of study could include developing and testing the outcome of an educational program, using the metric of RVUs generated before and after the program to document change.

LIMITATIONS

Our study was limited to one EM program with a small sample size. We did not measure actual resident or attending performance or detailed knowledge of billing and coding documentation requirements.

CONCLUSION

EM residents and attending physicians in this academic department continue to identify billing, coding and documentation requirements as an area in which resident physicians need further training.

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The Chief Resident Role in Emergency Medicine Residency Programs

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Study Objectives: Although other specialties have examined the role of the chief resident (CR), the role and training of the emergency medicine (EM) CR has largely been undefined.

Methods: A survey was mailed to all EM CRs and their respective program directors (PD) in 124 EM residency programs. The survey consisted of questions defining demographics, duties of the typical CR, and opinions regarding the level of support and training received. Multiple choice, Likert scale (1 strong agreement, 5 strong disagreement) and short-answer responses were used. We analyzed associations between CR and PD responses using Chi-square, Student's T and Mann-Whitney U tests.

Results: Seventy-six percent of CRs and 65% of PDs responded and were similar except for age (31 vs. 42 years; p<0.001). CR respondents were most often male, in year 3 of training and held the position for 12 months. CRs and PDs agreed that the assigned level of responsibility is appropriate (2.63 vs. 2.73, p=0.15); but CRs underestimate their influence in the residency program (1.94 vs. 2.34, p=0.002) and the emergency department (2.61 vs. 3.03, p=0.002). The majority of CRs (70%) and PDs (77%) report participating in an extramural training program, and those CRs who participated in training felt more prepared for their job duties (2.26 vs. 2.73; p=0.03).

Conclusion: EM CRs feel they have appropriate job responsibility but believe they are less influential in program and department administration than PD respondents. Extramural training programs for incoming CRs are widely used and felt to be helpful. [West J Emerg Med. 2010; 11(2):120-125.]

INTRODUCTION

The position of chief resident (CR) has been long regarded as important in physician residency training, with references as early as the late 1800s.[1,2] The CR position is often seen as a bridge between the faculty and resident physicians, and individuals selected for chief are seen as resident leaders based upon their accomplishments, teaching skills, and overall personalities. The CR often balances multiple responsibilities, ranging from administrative duties, such as scheduling junior residents, to patient care, research and teaching medical students and fellow residents.[1-4] Published reports from several sources suggest that although the administrative duties of the CR comprise a relatively large percentage of the CR's time, the least amount of satisfaction is derived from these duties.[5,6] Furthermore, recent trends may indicate that administrative duties are taking up a larger percentage of a CR's time.[6]

The role of CR and its relation to academic medicine

has been recognized in prior research. The position is often regarded as a stepping stone into an academic career in medicine and surgery. Despite the fact that it is an integral part of most training programs throughout the medical and surgical specialties, surprisingly little research is available regarding the CR position, especially within emergency medicine (EM) literature.[7] EM CRs are appointed positions and do not simply reflect the last year of a resident physician's training, as they do in some surgical specialties.[7] Perhaps because EM is a relatively young specialty, little has been published on the CR's role. While EM has unique practice characteristics and relies heavily on off-service rotations for completing training of its trainees, we assume that the roles and responsibilities of the EM CR may resemble those of other training specialties. With this in mind, we sought to define the current demographics as well as the training and responsibilities held by EM CRs throughout residency programs in the United States. We also explored the concordance of the CR's and PD's viewpoint of the training, expectations and influence of the position.

Table 1. Survey population demographics and residency program characteristics

	Chief Resident Respondents (n=151)	Program Director Respondents (n=81)
Gender		
Male	73%	77%
Mean Age		
Years	31 (range: 26-48)	42 (range: 32-56)
Residency Program Length (years)		
1-3	73%	78%
1-4	13%	11%
2-4	11%	7%
Other	3%	4%
Length of Chief Resident Term (months)		
12	92%	96%
4	4%	2%
1-3	4%	2%
Chief Resident Post-Graduate Year		
3	72%	77%
4	27.5%	23%
5	0.5%	0%
Median Annual Number of Chief Residents		
	3 (range: 1-8)	2 (range: 1-8)
Median Annual Number of EM Residents		
	10 (range: 6-20)	10 (range: 6-18)
Medical Degrees of Respondents		
MD	92%	88%
DO	8%	12%

METHODS

Study Design and Population

A structured anonymous written survey was mailed to each of the 124 Residency Review Committee-approved EM programs for 2002. To compare and contrast opinions between populations, we distributed a parallel survey of CRs (up to four per program) and their PDs. The catalog of EM residencies provided by the Society for Academic Emergency Medicine (SAEM) was the source of the correspondence addresses. This study was reviewed and approved by our local Institutional Review Board prior to initiation.

Survey Content and Administration

Because no prior survey of EM CRs has been performed, the authors developed the survey instrument. The survey consisted of a 28-question CR instrument and a 27-question PD instrument, focusing on the demographics, training and responsibilities of the current CRs. Residency program faculty and former CRs reviewed the instruments for face validity, and we then we revised for clarity. The survey utilized multiple-choice, Likert scales (1, most positive; 5, most negative) and open-ended questions. No survey questions were strictly open-ended, as they reflected additional information provided by respondents for an "other" response in a multiple- choice format question. We reviewed these answers, and if by investigator consensus we discerned a distinct pattern, an additional answer category was reported. Subjects also occasionally provided unsolicited comments to questions. We attempted to incorporate these into our results whenever logically possible. A follow-up mailing was sent six weeks after the first to those programs that had not initially responded. We sent several reminder e-mails to the CRs who used the Emergency Medicine Residents' Association (EMRA) CR e-mail list serve, and to the PDs using the published SAEM e-mail listing. Each survey was filled out anonymously and returned in a postage-paid envelope to the investigators. We encoded the surveys with a randomly generated study identification number that corresponded to each specific EM program, allowing reminder letters to be mailed without compromising anonymity.

Demographic queries included age, gender and educational background. EM residency program demographics included the length of the program, program type (PGY 1-2-3, 1-2-3-4 or 2-3-4), number of annual CRs, the annual number of accepted resident physicians and the length of the CR term. We also queried about the process for choosing and training CRs, as well as which PDs had served as CRs and found the position beneficial.

Data Analysis

We analyzed responses using SPSS v11.0 (SPSS Inc., Chicago IL), and used descriptive statistics to summarize demographic data. Associations between CR's and PD's

Table 2. Selection and evaluation of the chief resident

	Chief Resident* (n=151)	Program Director* (n=80)
Chief resident chosen by:		
Combination of Faculty, Program Director & Residents	56%	59%
Faculty & Program Director Only	26%	23%
Program Director Only	5%	7%
Residents Only	4%	2%
Faculty Only	3%	2%
Rotation Based Position	2%	1%
Other	4%	6%
Chief resident evaluated by:		
Program Director	48%	56%
Program Director & Department Chair	25%	23%
Department Chair	1%	0%
Other	26%	21%

responses were sought using the Chi-Square test, student T-test and Mann-Whitney U test for nominal, ordinal and interval variables, respectively. We defined statistical significance as $p<0.05$. We also conducted a content analysis of open-ended questions.

RESULTS

One hundred fifty-one CRs (representing 76% of total U.S. EM programs) and 81 PDs (representing 65% of total U.S. EM programs), returned completed surveys. Sixty-four programs (51.6% of total U.S. EM programs) had responses from both the PD and a CR. When we compared individual demographic factors and program characteristics of the CR and PD respondents, no significant demographic differences existed aside from age (Table 1). Most CRs are between the ages of 26 and 35 (mean age 31), while most PDs are between 36 and 50 (mean age 42). The majority of PDs (77%) and CR respondents (73%) were men. The majority of EM CRs complete their duties during the last year of their EM residency, with a few programs requiring additional training time. EM residency programs appoint one or more CRs for a term of 12 months, and rotating positions are rare (2% of CR respondents, 4% of PD respondents). Eighty-six percent of CR and PD respondents had MD degrees (Table 1). Fifty-six percent of CRs and 59% of PDs reported that they filled the CR position based on a combination of faculty, program director and resident input (Table 2).

Significant differences were reported in the training experiences for CRs between CRs and their PDs. Forty-four percent of CRs reported that they received a formal written job description, while 58% of PDs reported distributing one ($p=0.045$). Of CRs, only 11% reported participating in a formal intra-institutional training program, while 23% of the PDs reported offering one ($p=0.02$). The majority of CRs (70%) and PDs (77%) reported participation in a formal extra-institutional training program prior to assuming the CR role. The most common extra-institutional training program was the EMRA Chief Resident Forum, a one-day didactic and interactive forum held annually during the American College of Emergency Physician (ACEP) Scientific Assembly. The majority of intra-institutional training reported was a formal job orientation, most often conducted by residency faculty and the PD. Both groups felt that a job description and training was beneficial, and that overall CRs were prepared for the position (Table 3). When responses were stratified by orientation and training, CRs who received a written job description reported feeling more prepared for their position than those who did not (mean Likert scale 2.23 vs. 2.53, $p=0.047$). Those CRs that had received extra-institutional training reported feeling better prepared for the position compared to those who had not participated in such a program (mean Likert scale 2.26 vs. 2.73, $p=0.03$). PDs also reported that residents participating in extra-institutional training were more prepared for CR duties (mean Likert scale 2.08 vs. 2.56, $p=0.01$).

PDs and CRs agreed that the level of responsibility given to the CR was appropriate (2.63 vs. 2.73, $p=0.15$). However,

Table 3. Chief residency job description and training

	Chief Resident (n=151)	Program Director (n=81)	p value
Chief resident received a formal written job description	44%	58%	0.045
How beneficial is a formal written job description?*	2.80	2.61	0.3
Chief resident received formal in-house training	11%	23%	0.02
How beneficial is formal in-house training?*	2.35	2.27	0.9
Chief resident is funded for outside training	70%	77%	0.4
How beneficial is funded outside training?*	2.51	2.21	0.1
How well prepared is the chief resident for the job?+	2.40	2.19	0.19

***** Likert scale 1 to 5; 1 = Very beneficial, 5 = Not beneficial at all; + Likert scale 1 to 5; 1 = Very prepared, 5 = Not prepared at all

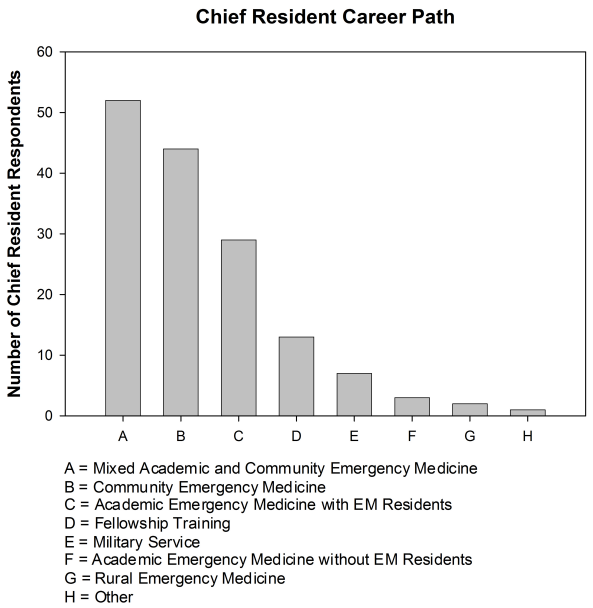

Figure 1. Career Plans of Chief Residents

PDs found the position more influential than the CRs in effecting change in the residency program (mean Likert scale 1.94 vs. 2.34, p=0.002) and the ED (mean Likert scale 2.61 vs. 3.03, p=0.002). Both groups agreed that fellow residents and faculty are supportive of the CR, but that university and hospital administrators are not helpful.

Gender did not affect responses in the majority of the survey questions. However, a few important distinctions exist. Female CRs felt significantly less prepared to perform the duties than their male counterparts (mean Likert score 2.77 vs. 2.28, p=0.001). Female CRs also found PDs to be less helpful than their male counterparts (mean Likert score 1.7 vs. 1.4, p=0.03). Female PDs also reported the faculty was less supportive of the CRs, as compared to male PDs (mean Likert score 2.38 vs. 1.85, p=0.02).

Most CRs receive a benefit for holding the position, with fewer shifts and increased salary/stipend as the most commonly offered. PDs and CRs had similar estimations of time spent on each duty of the CR (13-15 hours per week on average); however, PDs underestimated CRs' time spent on patient care (44.1 vs. 37.5 hours/week, p=0.001) (Table 4). The majority of CRs would recommend the job to fellow residents, believe that the position is helpful to their career and would choose to be CR again. Those PDs who had at one time held a CR position felt stronger than current CRs that they would choose the job again (mean Likert score 1.35 vs. 1.87; p=0.007). Most CRs responded that they planned on pursuing careers in an academic, mixed academic and community hospital, or a community medicine setting (Figure 1).

DISCUSSION

After compiling data from the participating CRs and PDs, we are able to describe the general demographics of EM CRs and their position requirements. Most chiefs are male, with an allopathic medical degree, and generally hold the position for 12 months during the last year of their training. They are required to perform multiple academic and administrative duties, and usually receive some form of benefit for the 13-15 hours per week this requires. In general, the CR position is filled by a combination of faculty, PD and resident input; however, the PD is usually the sole evaluator of the CR. This is consistent with previous reports from the published literature of other medical specialties.[3,6-8]

By surveying both the CRs and PDs, a comparison between their opinions is offered on a variety of issues. While we found consistencies between the two groups, we discovered that several differences also exist. Although CRs and PDs perceive different amounts of job description and formal training given, both agree that chiefs receiving formal extra-institutional training are better prepared to perform the assigned duties compared to those who do not. This finding is mirrored in previous CR literature from other medical specialties as well, and other authors have proposed formal training programs in other specialties.[9,10] Kim et al.[11] noted in a survey of former pediatric CRs that only 37% had received some form of an orientation with 54% in the form of a workshop or seminar, while others had verbal training from outgoing CRs, chairpersons or PDs. In a survey of family practice CRs, 70% received no formal training and 19% participated in an extra-institutional training program.[12] The most common venue for EM CR extra-institutional training reported was the EMRA Chief Resident Forum, offered annually at the ACEP Scientific Assembly.[13] The daylong workshop offers training in conflict resolution, leadership training, bedside teaching, and tips from former CRs. The workshop uses formal didactic lectures, small groups and panel discussions. While a causative relationship cannot be determined by this type of research methodology, these responses suggest that should further development of extra-institutional formal training programs occur, the time and funding to send residents to these programs is important.

Table 4. Duties of chief residents

	Chief Resident (n=145)	Program Director (n=73)	p value
Hours spent per week:			
Schedule creation	3.7	4.5	0.31
Administrative tasks	4.2	4.5	0.66
Teaching	3.6	3.8	0.90
Research	3.1	2.2	0.51
Total Time for chief resident duties	**14.6**	**15.0**	**0.27**
Patient care	**44.6**	**37.6**	**0.0001**

If validated, the development of extra-institutional formal training programs may help to unify the CR position among EM residency programs, as well as other medical specialties.

CRs and PDs have varied opinions regarding the level of influence held by the CR. In general, CRs perceive themselves as less influential than PDs do in effecting change throughout the residency program and the ED, although both agree that the CR has power to make changes in program policies. While reasons for this difference are unclear from this survey, this may represent a need for better communication and feedback between PDs and CRs. Despite the differences in perceived influence, both CRs and PDs felt that the university and hospital administration are not as supportive as they could be. While the importance of this deficit is not known, there may also be an opportunity for improved communication between PDs, department chairs and administrators.

Little research exists regarding the CR position as a whole,[1,2,4-9,11] and even less for EM;[7] however, many of our survey points reinforce previous findings. The majority of respondents indicated that the EM CR position is incorporated into the standard EM residency and no additional training time is allocated. Although limited medical specialty studies exist, this pattern is similar to reports from family practice [12] and pediatrics.[14] EM CRs spent over 15 hours per week on chief duties and also had to perform similar academic and clinical duties as their peers. Previous surveys have noted similar trends in CR workloads and the desire for more time devoted to teaching and research and less time allotted for scheduling and administrative duties.[11,12] PDs who had previously been a CR, as well as current CRs, found the position satisfactory enough to do it again if given the opportunity. Although follow-up data is unavailable, many of the respondent CRs were planning on pursuing a career in an either academic or mixed academic and community medicine setting, suggesting that a CR position prepares individuals for an academic emergency medicine career, an opinion supported in the literature of other specialties.[14]

Gender differences in other specialty CRs appear to exist as well in EM. Female EM CRs report less preparedness and PD support. Interestingly, female PDs recognize this and feel less faculty support of CRs as well. Consistent with other limited published findings among psychiatry CRs, this suggests further obstacles for women in EM, especially in academic careers.[15] Further research is warranted in exploring gender differences in EM training programs and academic emergency medicine.

LIMITATIONS

This study has some limitations worth noting. We achieved a limited response rate (CR responses represented 76% of U.S. EM residency programs and PD responses represented 65% of U.S. EM residency programs); therefore, our reported results may not reflect those of the non-respondents. No data could be collected on survey non-responders to identify any differences with survey responders. In addition, not all surveys were completed in their entirety. This survey is also subject to recall bias, especially when attempting to quantify time spent performing specific duties or the amount of support felt from administration and faculty. Using an EM CR list serve to identify potential participants could have introduced selection bias, as these individuals may have been different from those not represented on the list serve. Because no previously validated survey of CRs had been compiled, the survey was developed by the study's authors. Although the study was tested for face validity and clarity by resident faculty and former CRs, it was not formally assessed for performance of the questionnaire. Survey results were analyzed using aggregate CR and PD populations, and data were not linked to specific programs or individuals. While these results give a general overview of the EM CR position, they may not be applicable to individual locations. The results of this survey reflect a cross-sectional descriptive overview of the CR position in EM. The associations noted in this study do not reflect a causative relationship, as multiple additional variables and confounders may be responsible. Further research with different methods would be required to determine causation of these findings. Finally, gender differences noted may be influenced by prior social and academic events experienced outside of the role of CR or PD.

CONCLUSION

CRs in EM most often represent male allopathic physicians appointed in the last year of residency training by a combination of the PD, faculty and residents, for a term of 12 months. Resident physicians who undergo formal training, particularly from an extra-institutional source, feel more prepared for the role of CR. Most would recommend the position and would choose to be CR again. Further research into why female CRs and PDs sense less support in their field of academic EM is indicated.

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The Association Between Money and Opinion in Academic Emergency Medicine

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Objectives: Financial conflicts of interest have come under increasing scrutiny in medicine, but their impact has not been quantified. Our objective was to use the results of a national survey of academic emergency medicine (EM) faculty to determine if an association between money and personal opinion exists.

Methods: We conducted a web-based survey of EM faculty. Opinion questions were analyzed with regard to whether the respondent had either 1) received research grant money or 2) received money from industry as a speaker, consultant, or advisor. Responses were unweighted, and tests of differences in proportions were made using Chi-squared tests, with $p<0.05$ set for significance.

Results: We received responses from 430 members; 98 (23%) received research grants from industry, while 145 (34%) reported fee-for-service money. Respondents with research money were more likely to be comfortable accepting gifts (40% vs. 29%) and acting as paid consultants (50% vs. 37%). They had a more favorable attitude with regard to societal interactions with industry and felt that industry-sponsored lectures could be fair and unbiased (52% vs. 29%). Faculty with fee-for-service money mirrored those with research money. They were also more likely to believe that industry-sponsored research produces fair and unbiased results (61% vs. 45%) and less likely to believe that honoraria biased speakers (49% vs. 69%).

Conclusion: Accepting money for either service or research identified a distinct population defined by their opinions. Faculty engaged in industry-sponsored research benefitted socially (collaborations), academically (publications), and financially from the relationship. [West J Emerg Med. 2010; 11(2):126-132.]

INTRODUCTION

With healthcare spending now 15% of the United States (US) economy, it is no surprise that pharmaceutical companies are spending in excess of seven billion dollars annually to market their products to physicians.[1,2] The topic of physician-industry relations has been debated in depth over the years in countless articles and, although still a controversial issue, academic medical societies have published guidelines with regard to the activities of their members.

This trend has been amplified by recent media coverage of

unprincipled activities involving some of the most prestigious medical societies in the US. The American Heart Association and the American College of Cardiology, for example, recently were criticized for their revisions of guidelines outlining increased use of statins. It was discovered that seven of the nine members who drafted the guidelines had personal financial arrangements with drug manufacturers.[3] These financial relationships result in an appearance of impropriety that undermines the public's trust in medicine as an institution.[4,5]

Although the effects of industry-physician relations on professional behavior and prescribing patterns have been addressed by both opinion surveys and commentary, the impact of money has not been objectively studied.[6-11]

The reporting of financial conflicts of interest has become commonplace in all areas of academic medicine, although the exact meaning of those conflicts remains to be understood. This study utilizes the results from a recent survey of the Society of Academic Emergency Medicine (SAEM) membership to determine if an association between money and personal opinion exists.

METHODS

Study Design

We designed a survey instrument using a web-based format and implemented it during a three-week period in 2007. The instrument was based on a *New England Journal of Medicine* article outlining physician-industry relations based on specialty and was adapted for use by the SAEM.[12] After adaptation the survey was reviewed in a small focus group setting comprised of faculty from a single institution. The instrument was then reviewed further by 10 representatives from different academic institutions for validity and aptness (Industry Relations Committee, SAEM, 2007). After appropriate changes were made to the questionnaire, we submitted it to the Board of Directors of SAEM for final approval. The study protocol met criteria for exemption from review by the Institutional Review Board at the first author's institution.

Setting/Selection of Participants

The data source for this study was the national membership of SAEM, 3,183 individuals. Via e-mail we contacted those who had previously provided their information to the society. If they expressed interest in participating, the e-mail routed them to the appropriate web-based questionnaire. We sent follow-up e-mails requesting participation for three weeks after the initial mailing.

Data Collection and Processing

The questionnaire collected demographic information on the participants, including personal and professional characteristics. Personal characteristics included gender and race. Professional characteristics included number of years in practice and role as a peer reviewer, editor, or clinical guidelines contributor. Additional professional characteristics included degrees held, current leadership positions within their program, and academic rank. Highest leadership position was reported as senior (chair, vice-chair or equivalent, program director or research director), or midlevel (all others). The final demographic recorded dealt with practice characteristics and included the location (urban, suburban, or rural), type of hospital (private or public), emergency medicine (EM) departmental status, and academic affiliation. Finally, respondents included if residents (EM, other, neither) and medical students trained in their departments.

The next part of the survey asked 17 yes/no questions dealing with specific faculty-industry relationships. The data was directly linked to fields in a Microsoft Excel spreadsheet compiled by the SAEM administrative offices. The website did not close the HTML page after the respondent clicked "submit." For this reason, some duplicate questionnaires were identified. We used a structured data-cleaning algorithm to count the number of unique and repeat answers.[13]

Outcome Measures/Primary Data Analysis

Research Grants

Participants were asked what, if any, percentage of research funding they received from public, private, industrial, or intramural sources in the preceding year. Those who reported a percentage for any of these sources were classified as having received research funding; otherwise they were classified as not having received funding.

Fee-for-service

The second category included respondents who accepted monies for intellectual-based services. Participants were asked whether they had received payments from industry within the preceding year for consulting work or for serving as a speaker or on an advisory board. An affirmative response in any of the three categories was sufficient to classify respondents as having accepted fee-for-service money from industry.

On a number of opinion questions (see Tables 2 and 3) a Likert scale was used. For conciseness, responses to each of these questions were then split into two categories, either strongly agree or agree vs. all other responses. We then compared the percentages in the affirmative category between the groups of people receiving research funding or not and the groups of people receiving fee-for-service money or not. Then we calculated chi-squared tests of differences in the proportions, and reported a p-value on the difference. There were no corrections made for multiple testing.

RESULTS

A total of 655 surveys were completed after a three-week period in 2007. Of these, 225 responses were discarded due to duplication, leaving viable responses from 430 members who represented 14% of the 3,183 active members

Table 1. Survey Respondent's Characteristics Categorized by Type of Monies Accepted (research grants, fee-for-service, or none) (n=430)

Characteristics	Percent Reporting			Characteristics	Percent Reporting		
	Research n=204	Fee-for-Service n=145	None n=184		Research n=204	Fee-for-Service n=145	None n=184
Personal				**Practice**			
Gender				Primary Practice Location			
Male	82	89	83	Urban	81	81	73
Race				Suburban	13	15	23
White	89	87	84	Rural	4	4	4
African-American	2	0	2	Primary Hospital			
Hispanic	2	3	5	Private	53	51	48
Asian	6	8	5	Public	47	49	52
Other	1	2	4	ED Role in Hospital			
Professional				Department	86	82	90
Number of Years in Practice				Division	13	16	7
<10 yr	42	37	54	Neither	1	2	3
11-19 yr	35	35	25	Residents Trained in ED			
20-29 yr	19	22	25	EM	82	74	75
≥30 yr	5	7	6	Other Specialty	17	22	18
Professional Degree				Neither	2	4	7
MD	64	71	79	Medical Students Trained in ED	100	98	93
DO	4	2	4	Hospital-University Relations			
Advanced (MS, MPH, MBA, PhD)	32	27	17	Affiliated	38	37	47
Highest Leadership Position Held				Attached	57	55	42
Senior	37	41	33	Neither	5	7	10
Midlevel	24	22	11				
None	40	37	56				
Academic Rank							
Professor	20	20	7				
Associate Professor	32	41	15				
Assistant Professor	37	30	41				
Instructor	7	2	12				
None	5	7	25				
Peer Reviewer for Medical Journal	74	78	38				
Editorial Board Member of Medical Journal	34	32	11				
Involved in Creating Clinical Practice Guidelines	68	75	52				

of SAEM. There was no difference between duplicate and unique responses in our sample. Respondent demographics are in Table 1. In our sample, 51% of respondents reported receiving research funding from any source; 23% reported receiving research grants from industry, 31% from private sources, 35% from public funds, and 25% from intramural sources within the last year. One-third of respondents (34%) reported money coming from industry for fee-for-service work in the preceding year.

The results of our chi-squared test for respondents receiving research grants are summarized in Table 2. Respondents who received research money from any source were more likely to be comfortable accepting gifts (OR 1.6, 1.05-2.3) and acting as paid consultants (OR 1.7, 1.1-2.5). They were also more likely to agree that SAEM should accept educational grant money from industry (OR 2.3, 1.5-3.6), that the annual meeting

Table 2. Unweighted responses from Society of Academic Emergency Medicine faculty conditioned on whether they did or did not receive funding for research from any source.

Statement	Respondents with Research Funding (%) n=204	Respondents without Research Funding (%) n=226	p value
I would feel comfortable talking to an industry representative in a non-clinical setting.	60	56	0.38
I would feel comfortable accepting nominal gifts: i.e. meals from an industry representative in the clinical setting.	30	29	0.95
I would feel comfortable accepting nominal gifts: i.e. meals from an industry representative in the non-clinical setting.	40	29	0.02
I would feel comfortable acting as a paid consultant for industry.	50	37	0.01
I would feel comfortable if SAEM accepted unrestricted educational grants from industry.	33	18	0.0005
The annual meeting for SAEM would benefit from the addition of industry sponsored Satellite Symposia.	65	48	0.0003
An industry sponsored CME lecture can be presented in a fair and unbiased way.	52	29	<0.0001
Direct person-to-person marketing through representatives has an influence on my medical decision making.	31	25	0.13
My participation in industry sponsored research has provided financial support for other research endeavors.	41	11	<0.0001
My participation in industry sponsored research has introduced me to collaborators within EM.	42	16	<0.0001
My participation in industry sponsored research has introduced me to collaborators outside of EM.	40	14	<0.0001
My participation in industry sponsored research has resulted in publications.	38	10	<0.0001
Industry has no influence on my clinical decision making.	32	32	0.99
Industry sponsored research produces biased results.	53	59	0.24
The SAEM annual meeting has remained an unbiased forum because it has not permitted Industry sponsorship.	45	53	0.10
Industry representatives should have restricted access to residents and students.	67	61	0.18
Honoraria for speakers introduces bias when provided by industry.	58	67	0.08

would benefit from satellite symposia (OR 2.0, 1.4-3.0), and that industry-sponsored continuing medical education (CME) could be fair and unbiased (OR 2.4, 1.6-3.6). These findings held true even when only respondents holding research grants from industry were analyzed against all others. The responses from faculty with research grants from industry were the same as those with research grants from all other sources. The one exception was that respondents with research money from industry agreed that industry-sponsored research was biased only 38% of the time, as opposed to 66% of the time for respondents receiving research grants from all other sources.

Respondents who accepted fee-for-service money from industry for activities other than research had similar opinions to those who received research money (Table 3). Additionally, these respondents were more likely to agree that industry-sponsored research produces fair and unbiased results (OR 0.51, 0.34-0.77). Conversely, they were less likely to believe that industry-provided honoraria introduce bias for speakers (OR 0.43, 0.28-0.65) and that industry representatives should have restricted access to residents and students (OR 0.62, 0.41-0.94).

Faculty who received funding for either research or fee-for-service activities were more likely to agree that their participation in industry-sponsored research has allowed them to receive financial support for other research endeavors, introduced them to collaborators within and outside EM, and has resulted in publications (OR 2.5, 2.3–2.8).

DISCUSSION

We demonstrate that industry interactions with a medical society (SAEM) are viewed more favorably by members receiving funds for research, as well as industry-sponsored

Table 3. Unweighted responses from Society of Academic Emergency Medicine faculty who did or did not receive fee-for-service money.

Statement	Respondents with Fee-for-Service Money (%) n=145	Respondents without Fee-for-Service Money (%) n=285	p-value
I would feel comfortable talking to a pharmaceuticalindustry representative in a non-clinical setting.	68	53	0.002
I would feel comfortable accepting nominal gifts: i.e. meals from an industry representative in the clinical setting.	27	31	0.45
I would feel comfortable accepting nominal gifts: i.e. meals from an industry representative in the non-clinical setting.	56	24	<0.0001
I would feel comfortable acting as a paid consultant for industry.	52	39	0.01
I would feel comfortable if SAEM accepted unrestricted educational grants from industry.	38	20	<0.0001
The annual meeting for SAEM would benefit from the addition of industry-sponsored satellite symposia.	70	50	<0.0001
An industry-sponsored CME lecture can be presented in a fair and unbiased way.	57	33	<0.0001
Direct person to person marketing through representatives has an influence on my medical decision making.	28	28	0.99
My participation in industry-sponsored research has provided financial support for other research endeavors.	46	16	<0.0001
My participation in industry-sponsored research has introduced me to collaborators within EM.	53	17	<0.0001
My participation in industry-sponsored research has introduced me to collaborators outside of EM.	51	14	<0.0001
My participation in industry-sponsored research has resulted in publications.	43	15	<0.0001
Industry has no influence on my clinical decision making.	32	32	0.92
Industry-sponsored research produces biased results.	45	61	0.001
The SAEM annual meeting has remained an unbiased forum because it has not permitted industry sponsorship.	43	52	0.10
Industry representatives should have restricted access to residents and students.	57	68	0.02
Honoraria for speakers introduce bias when provided by industry.	49	69	0.0001

fee-for-service activities. It is important to note that the source of research money was unimportant; with the exception of whether or not the respondents believed industry-sponsored research to be biased. The same observation cannot be made for fee-for-service activities since our survey did not specifically include any fee-for-service activities not sponsored by industry.

Although causality cannot be determined from our sample, the association we find between money and opinions can be interpreted in a variety of different ways. One way to view these findings is that money buys influence, and the exchange of money for service imparts a more favorable view of the client (industry) on the provider. The problem with this view is that differences in opinion do not extend beyond the societal level to individual physician-industry interactions in our sample. The opposing viewpoint may ascribe the differences seen in our survey to lack of money rather than the presence of it. Perhaps faculty without compensation or funding are not so by choice, and are motivated more by resentment in their view of industry interaction. A more moderate way to explain our findings is that experience with the requirements and expectations of a financial relationship to industry results in a familiarity and acceptance of the process. Faculty who accept payment or funding from any source might be expected to be comfortable with the ramifications of such an interaction at the societal level. Regardless of why it exists, it is clear that accepting payment or funding defines a distinct subset of faculty members with regard to their opinions.

Our study centered on the relationship that exists when payment is provided for intellectual service or research, as opposed to the gift-recipient relationship. Social theory holds that the act of gift giving creates a social bond with an obligation to reciprocate on the part of the recipient. A recent

study by Halperin et al.[6] found that radiation oncologists who accepted gifts of high value from industry representatives were more likely to be sympathetic toward this practice. The obligatory relationship of the gift relationship with regard to physician-industry interactions has been explored even for trivial gifts, but little has been said about whether an independent contractor relationship produces similar obligations.

It seems clear from our survey that faculty-industry interactions involve more than just money. In our sample, roughly 40% of faculty receiving research funding agreed that industry-sponsored trials resulted in publications, financial support for other research activities, or professional collaboration. This number is even higher for faculty participating in fee-for-service activities with industry, with more than half receiving a benefit beyond just money. These are tangible benefits that make industry interactions an important component of academic advancement, and should not be dismissed as imparting insignificant influences on academic faculty. A recent survey published in the *Journal of the American Medical Association* showed that more than half of department chairs with ties to industry believed that a positive relationship exists and the support received from industry plays "an important role in the education and research missions of academic centers."[14]

Although it is reassuring that those who conduct industry-sponsored trials are no more likely than their faculty counterparts to believe that industry sponsored is biased, it is concerning that those who participate in fee-for-service activities (speakers, consultants, or advisors) are less likely to believe that their participation may bias their perception (45% vs. 61%). It is also not surprising that those who receive fee-for-service money from industry are more likely to feel that industry-sponsored CME can be presented in a fair and unbiased manner. This may be due to unrecognized bias or increased knowledge of the process.

The recent media spotlight on medical societies, as well as individual physicians' relationships with the pharmaceutical and biotechnology industry, has forced some to take a closer look at current practice guidelines and question the nature of these interactions.[2,3,8-11] With the traditional physician guise of nonmaleficence, fidelity, justice, and self-improvement at stake, professional associations have moved to update their guidelines regarding the acceptance of money from industry. However, in a paternalistic system where physicians often believe that their peers are susceptible to the influences of industry and they themselves are invulnerable, discussing financial relationships and opinions remains a delicate topic with causality difficult to establish.[2,14]

An article published in the *Canadian Medical Association Journal* outlined particular interactions between physicians and the pharmaceutical industry, including CME conferences.[9] They concluded that industry-sponsored CME events could be biased and influence physicians even after conforming to guidelines designed to prevent such occurrences. It is of interest to note that this study came out after SAEM, the American College of Physicians, and the American Medical Association implemented updated physician-industry relations guidelines, including appropriate industry support for CME conferences.[15-17]

LIMITATIONS

The sampling strategy used was less than ideal and created a potential for sampling bias. The survey was administered to all active SAEM members, so that they could provide input to the Board of Directors for future interactions between SAEM and industry. As such, we were more likely to receive responses from members who had formed opinions. The demographics of our responding faculty are in line with previously reported physician survey samples and suggest that we received responses from an academically diverse selection of members.

The poor sample response rate of 14%, linked with a broad, non-random sampling strategy, resulted in a survey response that was deemed inadequate for representing the opinions of SAEM as a whole. This is why the current manuscript emphasizes the relationship between opinion and the self-reported receipt of monies, as opposed to the opinions in and of themselves. In this case, having a sample split evenly between those who did and did not receive funding is ideal for the analysis. This still remains subject to self-selection bias, as the response rate further emphasizes that the respondents were not random.

It is not possible from our survey design to determine if respondents' opinions were a result of either their research grants or fee-for-service activities, or if respondents merely participated in those activities because their pre-formed opinions allowed them to do so. It is beyond the scope of this survey to determine which came first, opinion or money. The important point from our work is that the mere fact that a faculty member has received money for any reason defines a distinct subset with regard to their personal opinions. We only assessed opinions regarding bias and the intrinsic value of various relationships. The survey instrument was not derived to show the existence of actual bias in clinical or academic decision-making, only the perception of bias.

CONCLUSION

In our sample, receiving money for either service or research identified a distinct group of faculty defined by their opinions. Our results also point out that faculty engaged in industry- sponsored research were likely to benefit socially (via collaborations), academically (via publications), and financially from the relationship. The pharmaceutical and biotechnology industry is a business, and as such it imparts these benefits to physicians with expectations of fiscal returns. Academic faculty must carefully consider the impact of these benefits when weighing the pros and cons of physician-

industry interactions and realize the impact that they may have on opinions.

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Identification and Risk-Stratification of Problem Alcohol Drinkers with Minor Trauma in the Emergency Department

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Background: Brief alcohol intervention may improve outcomes for injury patients with hazardous drinking but is less effective with increased severity of alcohol involvement. This study evaluated a brief method for detecting problem drinking in minor trauma patients and differentiating hazardous drinkers from those with more severe alcohol problems.

Methods: Subjects included 60 minor trauma patients in an academic urban emergency department (ED) who had consumed any amount of alcohol in the prior month. Screening and risk stratification involved the use of a heavy-drinking-day screening item and the Rapid Alcohol Problems Screen (RAPS). We compared the heavy-drinking-day item to past-month alcohol use, as obtained by validated self-reporting methods, and measured the percentage of carbohydrate-deficient transferrin (%CDT) to assess the accuracy of self-reporting. The Alcohol Dependence Scale (ADS) was administered to gauge the severity of alcohol involvement and compared to the RAPS.

Results: Eighty percent of the subjects endorsed at least one heavy drinking day in the past year, and all patients who exceeded recommended weekly drinking limits endorsed at least one heavy drinking day. Among those with at least one heavy drinking day, 58% had a positive RAPS result. Persons with no heavy drinking days (n=12) had a median ADS of 0.5 (range 0 to 3). RAPS-negative persons with heavy drinking days (n=20) had a median ADS of 2 (range 0 to 8). RAPS-positive persons with heavy drinking days (n=28) had a median ADS of 8 (range 1 to 43).

Conclusion: A heavy-drinking-day item is useful for detecting hazardous drinking patterns, and the RAPS is useful for differentiating more problematic drinkers who may benefit from referral from those more likely to respond to a brief intervention. This represents a time-sensitive approach for risk-stratifying non-abstinent injury patients prior to ED discharge. [West J Emerg Med. 2010; 11(2):133-137.]

INTRODUCTION

Heavy alcohol consumption is the major preventable cause of injury resulting in an emergency department (ED) visit; however,many alcohol-related injuries occur in people who drink in a hazardous manner without meeting criteria for alcohol dependence.[1,2] Because such hazardous drinkers are excellent candidates for a brief intervention (BI) aimed at decreasing future alcohol-related problems, screening and BI has been recommended for ED patients.[2,3] This brief counseling process typically involves feedback about alcohol use, an emphasis on responsibility to change drinking, advice on drinking goals, suggestions on how to achieve drinking goals, empathy on the part of the provider, and support of the patient's self-efficacy.[4] While BI is effective for hazardous drinking, persons with more severe alcohol involvement are less likely to respond to BI alone, and may benefit from

referral to an addiction treatment facility or self-help group.[5] Implementing efficient methods for detecting hazardous drinking and assessing the severity of alcohol problems would thus improve the quality of care for patients with alcohol-related ED visits. This is particularly true for patients with minor trauma who do not require hospitalization. Their relatively short ED stay represents an opportune time to detect and start treatment for problem drinking.[6]

The Rapid Alcohol Problems Screen (RAPS) is a four-item instrument that has been validated in EDs for the detection of alcohol use disorders (i.e., alcohol abuse and dependence by American Psychiatric Association criteria).[7] An extended version, which includes two alcohol use quantity-frequency (QF) items, is referred to as the RAPS-QF.[8] The QF items note the presence of heavy drinking days during the past year, and the presence of at least monthly drinking during the past year. This instrument has good sensitivity and specificity for hazardous drinking and for alcohol use disorders, with a positive response to both QF items indicating hazardous use, and any positive RAPS items suggesting an alcohol use disorder. The National Institutes of Health (NIH), in recognition of the value of brief screening in medical settings, has recommended the use of a heavy-drinking-day item alone for initial screening in healthcare settings, with additional assessment for those with one or more heavy drinking days in the past year.[9] The same heavy-drinking-day item, using a three-month rather than 12-month time horizon, has been studied in ED settings, and has good sensitivity and specificity for detecting hazardous drinking or alcohol use disorders in combination, but not for differentiating between these conditions.[10] We undertook this study to further evaluate the use of the NIH-recommended heavy-drinking-day screening item, followed by the RAPS in minor trauma patients. Our main hypothesis was that patients with positive heavy drinking days but a negative RAPS would have a low severity of alcohol problems, while those with heavy drinking days and a positive RAPS would have a greater severity of alcohol problems. If so, this would further support the combined use of these brief screens as a tool for detecting hazardous drinkers most likely to respond to BI, while also determining who may benefit from referral for additional alcohol assessment as a component of their discharge planning.

Table 1. Screening Instrument

1)	How many times in the past year have you had 5 or more drinks in a day (4 or more for women)? _____ (Enter # days)
2)	During the last year have you had a feeling of guilt or remorse after drinking? *Yes* *No*
3)	During the last year has a friend or family member ever told you about things you said or did while you were drinking that you could not remember? *Yes* *No*
4)	During the last year have you failed to do what was normally expected of you because of drinking? *Yes* *No*
5)	Do you sometimes take a drink in the morning when you first get up? *Yes* *No*

A positive response to item 1 (i.e., the NIH-recommended heavy drinking day item) indicates "hazardous" drinking. A positive response to any of the remaining 4 items (i.e., the Rapid Alcohol Problem Screen) indicates an increased probability for serious alcohol problems.

METHODS

Recruitment

Subjects included a convenience sample of minor trauma patients age ≥ 18 presenting to an academic urban ED for treatment. Most subjects were recruited during the work week between 8 AM and 6 PM when part-time research staff were available. Minor trauma was defined as an acute injury not resulting in hospitalization. Potential subjects were asked by healthcare personnel if they had consumed any alcohol in the past month and, if so, were they interested in hearing about a research survey for which they would receive $25 for participating, if eligible. Patients who had consumed any alcohol in the past month, who were not currently intoxicated (i.e., blood alcohol content <0.08 mg/dL as estimated by breathalyzer, alco-Sensor FST, Intoximeters, St. Louis, Missouri), who could converse in English, and who expressed interest in participating were approached by research staff for additional study description and to obtain informed consent. In those providing consent, all data were collected prior to ED discharge. The protocol was approved by the university human subjects committee.

Description of the screening instrument

The screening instrument consisted of five items (Table 1). Subjects were provided with the definition of a standard drink before completing the screen. The initial item was the NIH- recommended screen for hazardous drinking, and is similar to the heavy-drinking-day item in the RAPS-QF.[8,9] Regardless of their response to the heavy-drinking-day item, all subjects then completed the four RAPS items.[7] We considered a positive response to the heavy-drinking-day item (i.e., ≥ 1) indicative of hazardous drinking, and any positive response on the RAPS indicative of more severe alcohol problems.

Reference standard for estimating current hazardous drinking

Past 30-day alcohol use was assessed using Alcohol

Timeline Followback methodology. This calendar-based method uses memory cues to obtain a daily drinking log from patient recall.[11] Hazardous drinking is defined by the World Health Organization as drinking that increases risks for adverse health events.[12] While there is no specific cutoff for defining hazardous drinking, it is often operationalized as drinking in excess of health-related guidelines. Based on United States dietary guidelines, women who averaged more than one drink per day during any seven-day period in the past month, or consumed more than three drinks on any drinking day, were considered hazardous drinkers.[13] For men, the cutoff was averaging more than two drinks per day during any seven-day period or consuming more than four drinks during any drinking day. A "drink" was defined as 14 grams of ethanol, and was calculated from the amount and type of beverage consumed. For example, this is the amount of ethanol in 12 fluid ounces of beer containing 5% ethanol, or 8 fluid ounces of malt liquor containing 8% ethanol.

Reference standard for estimating severity of alcohol involvement

The severity of alcohol problems was estimated with the Alcohol Dependence Scale (ADS).[14] This 25-item survey includes questions for estimating elements of an alcohol-dependence diagnosis, including tolerance and withdrawal, impaired control, and compulsivity of drinking behavior. The possible scoring range is 0 to 47, with higher scores correlating with increasing severity of alcohol problems.[14,15]

Estimating the accuracy of alcohol self-report

Percent carbohydrate-deficient transferrin (%CDT) was used to assess the accuracy of self-reported alcohol consumption, and particularly heavy consumption. Averaging roughly 50 to 60 grams of ethanol or more per day (about four drinks or more as defined for this study) can result in an alteration in the glycoprotein transferrin, which normally has three to six terminal sialic acids on two carbohydrate side chains. Percent CDT consists of the less sialylated isoforms divided by total transferrin, and a level $\geq 2.6\%$ is approximately 65% sensitive and more than 90% specific for heavy drinking within the past 2-3 weeks.[16] We measured %CDT in plasma using the Bio-Rad %CDT assay at the Clinical Neurobiology Laboratory of the Medical University of South Carolina.[17]

Analysis

All analyses were completed with SAS statistical software v. 9.1 (SAS Institute Inc., Cary, NC).

Estimating utility of the screening instrument

We compared the heavy-drinking-day screening results to the alcohol timeline followback, and the RAPS to the ADS. Specifically, we assessed agreement between the heavy-drinking-day item and a hazardous drinking categorization from the timeline followback using Fisher's exact test. The sensitivity and specificity of this item for hazardous drinking were also estimated. We compared ADS scores between groups with a negative heavy-drinking day and negative RAPS, a positive heavy-drinking day but negative RAPS, and a positive heavy-drinking day and positive RAPS using the Kruskal-Wallis test.

Estimating the validity of alcohol self-report

Using the Wilcoxon rank sum test, we compared the total number of drinks on the 30-day timeline followback, and total number of past-year heavy-drinking days from the screening item, between those with and without a positive %CDT. We also calculated Spearman correlation coefficients between these drinking measures and %CDT.

RESULTS

Research staff approached 166 potential subjects over a four-month period to recruit the 60 (36%) study participants. The major reasons for non-participation included no reported drinking in the past month (n=46), not interested in participating without providing a specific reason (n=39), and blood alcohol concentration above 0.08 mg/dL (n=8). The characteristics of the 60 participants are listed in Table 2. The majority of the patients were less than 35 years of age, with males and females equally represented. Most endorsed at least one heavy-drinking day in the past year, and roughly half of the sample had a positive RAPS result.

Percent CDT findings supported the accuracy of self-reported alcohol consumption. We correlated % CDT with the total number of drinks in the past month ($r=0.38$, $p=0.003$)

Table 2. Subject Characteristics

Characteristic	Sample result (n=60)
Male	30 (50%)
Ethnicity	
African-American	28 (47%)
non-Hispanic white	28 (47%)
other ethnicity	3 (6%)
Age category	
18 to 25	26 (43%)
26 to 35	12 (20%)
36 to 45	11 (18%)
46 to 55	9 (15%)
> 55	2 (4%)
Positive heavy-drinking day response	48 (80%)
Positive Rapid Alcohol Problems Screen (RAPS)	29 (48%)
Hazardous drinking past month	41 (68%)
Median Alcohol Dependence Scale (ADS) interquartile range	3 (1-8)
Positive carbohydrate-deficient transferrin (%CDT)	18 (30%)

and total number of heavy-drinking days in the past year (r=0.48, p<0.001). In addition, those with a positive %CDT (n=18, 30%) consumed a median of 164 drinks in the past month, while those with a negative %CDT (n=42) consumed a median of 13 drinks in the past month (Wilcoxon rank sum test p<0.001). Individuals with a positive %CDT reported a median of 209 heavy-drinking days in the past year, while those with a negative %CDT reported a median of six heavy days (Wilcoxon rank sum test p<0.001).

The heavy-drinking-day item was predictive of hazardous drinking (Fisher's exact test p<0.001), with a sensitivity of 100% and specificity of 85%. The imperfect specificity reflected past-year heavy-drinking days on the screening item in patients without past month hazardous drinking on the timeline followback. The median ADS score in patients with a negative heavy-drinking day item (n=12) was 0.5 (interquartile range 0 to 2); in patients with a positive heavy-drinking day item but negative RAPS (n=20), median ADS was 2 (interquartile range 1 to 3); in patients with a positive heavy-drinking day item and positive RAPS (n=28), median ADS was 8 (interquartile range 5 to 15). These scores were significantly different (p<0.001). Pairwise comparisons were also significantly different (for comparing the heavy-drinking item negative group to the heavy-drinking positive/RAPS negative group p=0.027; p<0.001 for the other pairwise comparisons).

DISCUSSION

This study evaluated the use of the NIH-recommended heavy-drinking-day item and the RAPS for detecting minor injury patients with potentially problematic alcohol use, and subsequently estimated their severity of alcohol problems. Results support the use of the heavy-drinking-day item for detecting hazardous drinking, and the utility of the RAPS in identifying patients who merit additional assessment for alcohol problems.

The utility of the heavy-drinking-day screen has been supported in prior ED-based research, and the RAPS has been clinically validated as a screen for alcohol dependence in ED patients.[7,10] In addition, the RAPS-QF includes two items on heavy-drinking days and frequency of drinking, rendering it appropriate for both hazardous drinking and alcohol dependence screening.[8] Our results support the use of the RAPS-QF, or RAPS with the heavy-drinking-day item alone, in those endorsing any alcohol use for identifying hazardous drinkers and estimating the severity of their alcohol problems. Since any heavy-drinking day identifies drinking in excess of health-related guidelines,[13] patients with a positive heavy-drinking-day item should receive a brief intervention. This may be sufficient treatment given a negative RAPS, although additional study is needed to confirm this hypothesis. Prior research in large probability samples found that a positive RAPS was 87% specific for alcohol dependence in ED patients.[7] Results of this study are consistent with this finding, indicating a relatively low level of alcohol problems in RAPS negative patients, and a relatively higher level of problems in those with a positive RAPS. For these patients, referral for additional diagnostic assessment and possible treatment may be indicated, although additional study is also needed in this regard.

LIMITATIONS

Strengths of this study include assessment of a gender-balanced group at high risk for alcohol problems, who require accurate risk stratification during a relatively brief exposure to the healthcare system. The main limitation is the assumption that RAPS negative persons are appropriate for BI alone, while RAPS positive persons require additional assessment and possibly treatment. While this is a reasonable approach to implement in the ED, stronger evidence would require a controlled trial. An additional limitation was our reliance on self-reported consumption, the accuracy of which can be threatened by intentional underreporting or other sources of bias.[18] However, the validity of self-reported consumption was objectively supported by %CDT results. Finally, the recruitment process may have biased our results. The subjects were not chosen at random or explicitly selected to provide a representative sample, and it is possible that results would differ for the general population of minor trauma patients. Also, some hazardous or even dependent drinkers may have been excluded if they had not consumed any alcohol during the month preceding their ED visit.

CONCLUSION

Brief alcohol interventions are effective in individuals who drink too much at times but are not alcohol dependent, and constitute an important component of care for ED patients. The current study suggests that the use of the NIH-recommended heavy-drinking-day screen, followed by the RAPS in those with heavy-drinking days, is a time-sensitive means for detecting hazardously drinking patients who merit BI, and also risk stratifying these patients to gauge who should be referred for evaluation by an addiction specialist.

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Sonographic Scoring for Operating Room Triage in Trauma

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Objective: The focused assessment with sonography for trauma (FAST) exam is a routine diagnostic adjunct in the initial assessment of blunt trauma victims but lacks the ability to reliably predict which patients require laparotomy. Physiologic data play a major role in decision making regarding the need for emergent laparotomy versus further diagnostic testing or observation. The need for laparotomy often influences the decision to transfer the patient to a trauma center. We set out to derive a simple scoring system using both ultrasound findings and immediately available physiologic data that would predict which patients require laparotomy.

Methods: We conducted a prospective observational study of victims of blunt trauma who presented to a Level 1 Trauma Center. We collected FAST findings, physiologic data, and lab values. A previously-developed ultrasound scoring system was applied to the FAST findings. Patients were followed to determine if they underwent laparotomy. We used logistic regression analysis to determine which variables correlated with laparotomy and developed a new scoring system.

Results: We enrolled a convenience sample of 1,393 patients. A simple scoring system (range 0-6) was developed that included both FAST findings and vital signs (heart rate and blood pressure). Patients with a score of 0 or 1 had a less than 1% chance of requiring laparotomy.

Conclusion: The combination of FAST findings with vital signs in our scoring system predicted which victims of blunt trauma did not undergo laparotomy. Applying this to trauma patients who present to non-trauma centers could help prevent unnecessary patient transfers. This derivation set must be validated prior to use in patient care. [West J Emerg Med. 2010; 11(2):138-143.]

INTRODUCTION

The rapid identification of potentially life threatening intra-abdominal injury is critical for patients who sustain blunt abdominal trauma. Early definitive surgical care is crucial for improved survival. Emergency physicians (EPs) practicing in non-trauma center hospitals must often quickly decide whether to transfer a trauma patient to a trauma center or to fully evaluate and manage the patient at their hospital. The suspicion of a significant intra-abdominal injury requiring laparotomy greatly influences the decision to transfer.

Focused assessment with sonography for trauma (FAST) has become a routine part of the initial evaluation of victims of blunt abdominal trauma.[1,2] While it has limited ability to detect specific organ injury, its ability to rapidly and non-invasively assess for intra-abdominal hemorrhage makes it a useful diagnostic tool. It has gained widespread use in trauma centers throughout North America and Europe, and as increasing numbers of practicing EPs are trained in ultrasound, its use has expanded beyond urban trauma centers to community and rural hospitals.[3]

Multiple studies have attempted to derive a decision rule or scoring scale to predict the need for emergent laparotomy based on FAST findings and clinical presentation.[4-11] While this may be useful for patients who are evaluated in a trauma center, for patients in rural or community hospitals the question is not whether to take the patient to the operating room (OR), but rather whether or not to immediately transfer the patient to a trauma center. A tool that could reliably predict which patients had a very low likelihood of requiring an emergent laparotomy would be helpful.

Most previously developed decision rules use FAST findings with or without hypotension to predict the need

Table 1. Variables collected.

Variables Collected		
Sex (Male/Female)	945/446	
	n	mean (sd)
Age	1379	43 (20)
ED systolic blood pressure	1346	142 (27)
ED diastolic blood pressure	1314	79 (21)
ED pulse	1362	92 (20)
Lab results		
pH	1309	7.38 (0.10)
serum bicarbonate	1305	22.3 (5.4)
hemoglobin	1359	13.1 (1.9)
		median
Ultrasound Score	1390	0
Glasgow Coma Scale score	1340	15

sd, standard deviation; *ED*, Emergency Department

Table 2. Variables collected that were frequently unavailable or deemed unreliable, and therefore not included in the univariate analysis.

Unavailable or Unreliable Variables
Time of injury
Time of emergency department arrival
Transfer from another hospital
Prehospital SBP
Prehospital diastolic blood pressure
Prehospital pulse
Prehospital respiratory rate
Prehospital intravenous fluids received
Emergency department respiratory rate
Lowest Systolic blood pressure
Presence of pelvic fracture

Table 3. Huang FAST scoring system.[12]

Area	Fluid Visible	Points
Morrison's pouch	>2mm	2
	≤2mm	1
Douglas' pouch	>2mm	2
	≤2mm	1
Perisplenic space	Any	1
Paracolic gutter	Any	1
Floating intestinal loops	Any	2
	TOTAL	**= 0-8**

FAST, focused assessment with sonography for trauma.

for laparotomy.[7-9,11] We were interested in combining a larger number of physiologic findings and laboratory values with a previously developed FAST scoring scale to predict more accurately which patients would not require a laparotomy. Our study objective was to identify the combination of ultrasound findings, physiologic criteria, and laboratory values that reliably excluded patients from requiring an urgent laparotomy.

METHODS

This study was a prospective observational study of victims of blunt trauma who presented to our American College of Surgeons Level I Trauma Center with an annual emergency department (ED) census of 52,000. The study was approved by our local institutional review committee. A waiver of informed consent was granted since patient care was not altered.

Eligible study subjects included victims of blunt trauma who presented directly or were transferred to our trauma center for evaluation and required trauma team activation. The study population was a convenience sample, as enrollment occurred from 7am to 11pm when ED data collectors were present. Prisoners and patients with known ascites or with penetrating trauma were excluded. We made no effort to enroll patients who presented outside these hours, nor to determine if the nighttime population differed from those in our study.

Patients had routine trauma evaluations performed by both EPs and the trauma team (comprised of surgical residents and a trauma surgery attending). Either post-graduate year 3 emergency medicine (EM) residents or EM attendings trained in bedside ultrasound performed FAST exams. Locations of free intraperitoneal fluid on FAST exams were reported to the data collector by the treating physician. Physiologic data were also collected. (Tables 1 and 2) Patients had further evaluation and treatment at the discretion of the ED and trauma services. Study investigators scored FAST exam findings later, using a previously developed scoring system (Table 3).[12]

Subjects' medical records were subsequently reviewed to determine which patients had a therapeutic laparotomy within the first three days of hospital admission. Therapeutic laparotomy was defined by any of the following findings: grade 4 or 5 hepatic injury or splenic injury, greater than one liter of intraperitoneal blood, hollow viscus injury requiring repair, great vessel injury, left diaphragmatic rupture, pancreatic injury, or bladder rupture. Patients who had surgery other than laparotomy, such as craniotomy, thoracic, or orthopedic procedures were not considered positives.

The data were initially examined for reliability. Prehospital and ED respiratory rates were not included in the final data analysis due to a clear lack of variability that led us to believe they were not accurately measured. We excluded time of injury and prehospital intravenous fluid received in the analysis due to frequent missing data. For the remaining physiologic data and ultrasound scores (USs), we used

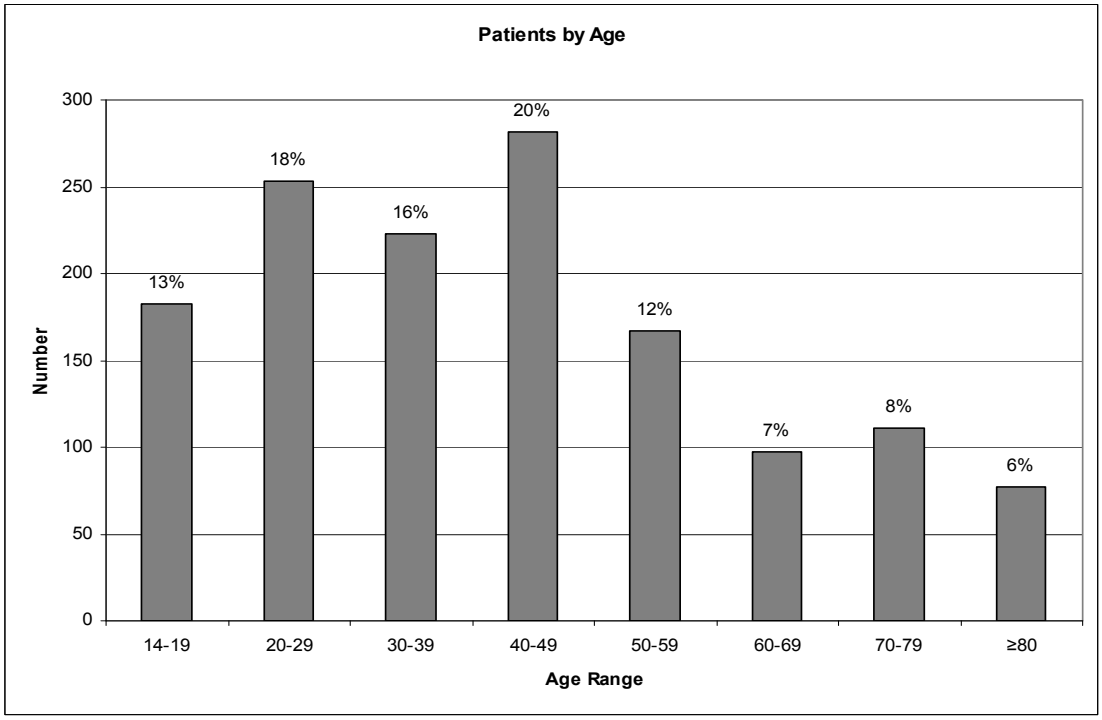

Figure 1. Subjects' age distribution.

logistic regression to determine which variables correlated with laparotomy. Using SAS (SAS 8.1, SAS Institute, Cary, NC), univariate models were fit with "laparotomy done" as the outcome to identify variables significantly (p-value < 0.05) associated with therapeutic laparotomy.

Once the associated variables were identified, multiple logistic models with stepwise selection procedures were tested using progressive cutoff points (heart rate every 5 beats/minute and blood pressure every 10 mm Hg). We chose the cutoff values based on these models, as well as physiologic parameters that represent class III hemorrhagic shock [pulse ≥ 120 beats/minute and systolic blood pressure (SBP) < 90 mm Hg].[2] From these models we developed a simplified score that used the combined variables associated with which subjects would not have urgent laparotomy. We called this the sonographic score for operating room triage in trauma (SSORTT) score.

RESULTS

We enrolled 1,393 patients, of whom 40 (2.9%) had urgent laparotomy. Subjects were 68% male. Age range was 14 to 94 years, with a median of 40 and an inter-quartile range of 25 to 55 (Figure 1). Of the 40 patients who had laparotomy, all were reported to have a therapeutic surgical intervention. Mean results for the reliably collected variables are demonstrated in Table 4. Time of injury, prehospital vital signs and fluid resuscitation volumes were not consistently available or accurately recorded (for example, pre-hospital respiratory rates showed little variability and were most often recorded as 20 breaths/minute). We analyzed the remaining variables for association with the need for laparotomy. Ultrasound score, initial ED SBP, and ED pulse were the only three variables associated with laparotomy.

A model using the variables ultrasound score, initial ED SBP, and ED pulse as continuous variables gave an area under receiver-operator characteristic

Table 4. Laparotomy versus no laparotomy patients.

	Laparotomy	No Laparotomy
n	40	1353
Sex (M/F)	22/18	923/428
Age (mean/sd)	42 (22)	43 (20)
ED SBP (mean/sd)	118 (29)	143 (27)
ED diastolic BP (mean/sd)	68 (24)	79 (20)
ED pulse (mean/sd)	107 (27)	91 (20)
GCS score (median)	15	15
Lab results (mean/sd):		
pH	7.32 (0.12)	7.38 (0.10)
bicarbonate	19.7 (3.8)	22.4 (5.4)
Hemoglobin	11.7 (2.2)	13.1(1.9)
US Score (median)	1	0
SSORTT Score (median)	3	0

SBP, systolic blood pressure; *SSORTT*, sonographic scoring for operating room triage in trauma; *US*, ultrasound; *ED*, Emergency Department; *sd*, standard deviation; *GCS*, Glasgow coma scale.

Table 5. SSORTT scoring system.

Variable	Points
Ultrasound Score	
0 (no free fluid)	0
1 (fluid in one location)	2
>1 (fluid in more than one location or >2mm in Morison's or Douglas' pouch)	3
ED Pulse	
<120 beats/minute	0
≥120 beats/minute	2
ED Systolic Blood Pressure	
≥90 mm Hg	0
<90 mm Hg	1
TOTAL =	**0-6**

ED, Emergency Department

curve (AUC) of 0.852. These variables were then modeled using stepwise cutoffs to develop a mathematical scoring system. We condensed the US, which initially had a range of 0-8, into three categories (US score = 0, 1 or >1). This equated to either no free fluid (US score = 0), fluid in one location (US score = 1), or fluid in more than one location or more than 2mm of fluid in either Morison's or Douglas's pouch (US score >1). We condensed ED pulse and SBP into two categories (pulse<120 or ≥120 and SBP<90 or ≥90). The model with laparotomy necessary as the outcome and the variables categorized in this manner gave an AUC of 0.823. To develop a simple, useable scoring system we then weighted the variables based on their strength of correlation in the regression model and perceived clinical importance.

Table 5 illustrates our scoring system. Based on this system, a patient could achieve a score from 0 to 6. The breakdown of patients (laparotomy versus no laparotomy) for each SSORTT score is demonstrated in Table 6. Table 7 presents the sensitivity, specificity, positive and negative likelihood ratios, and positive predictive values for not requiring a laparotomy at different SSORTT score cutoffs. Patients with a score of less than or equal to 1 had a positive likelihood ratio of 2.974 (95% CI 1.852-4.776) and a positive predictive value of 0.990 (95% CI 0.983-0.995) for not requiring a laparotomy.

Table 6. Laparotomy versus no laparotomy for each SSORTT score.

SSORTT Score	Laparotomy (n)	No Laparotomy (n)
0	11	1190
1	1	17
2	7	106
3	9	30
4	5	6
5	4	3
6	3	1

SSORTT, sonographic scoring for operating room triage in trauma

DISCUSSION

The use of ultrasound in the initial evaluation of blunt trauma victims is routine within trauma centers in North America and Europe, and the American College of Surgeons now includes FAST as an adjunct to the primary survey in the Advanced Trauma Life Support course.[2] We set out to develop a simple scoring system that could help the treating physician decide how to proceed with patient management.

We developed a simple scoring system that, if validated prospectively, would predict which victims of blunt trauma have a very low probability of requiring laparotomy. Our score combines FAST exam findings with immediately available

Table 7. Sensitivity, specificity, + and - likelihood ratios, and positive predictive values for NOT requiring a laparotomy.

SSORTT Score	Sensitivity (95% CI)	Specificity (95% CI)	+ Likelihood Ratio (95% CI)	- Likelihood Ratio (95% CI)	Positive Predictive Value (95% CI)
0	0.879 (0.861-0.896)	0.725 (0.561-0.854)	3.198 (1.933-5.292)	0.166 (0.131-0.211)	0.991 (0.984-0.995)
≤1	0.892 (0.874-0.908)	0.700 (0.535-0.834)	2.974 (1.852-4.776)	0.154 (0.120-0.199)	0.990 (0.983-0.995)
≤2	0.970 (0.960-0.979)	0.525 (0.361-0.685)	2.043 (1.475-2.830)	0.056 (0.037-0.086)	0.986 (0.978-0.991)
≤3	0.993 (0.986-0.996)	0.300 (0.166-0.465)	1.418 (1.158-1.737)	0.025 (0.011-0.054)	0.979 0.971-0.986)
≤4	0.997 (0.992-0.999)	0.175 (0.073-0.328)	1.209 (1.048-1.394)	0.017 (0.005-0.055)	0.976 (0.967-0.984)
≤5	0.999 (0.996-1.0)	0.075 (0.016-0.204)	1.080 (0.989-1.180)	0.010 (0.001-0.093)	0.973 (0.964-0.981)

SSORTT, sonographic scoring for operating room triage in trauma

vital signs of pulse and SBP. The ability to rapidly and non-invasively determine that a trauma patient does not need urgent laparotomy may help the treating physician decide whether to transfer the patient to a trauma center.

A number of studies have used various types of FAST scoring systems to try to determine the need for a therapeutic laparotomy. A hemoperitoneum score developed by McKenney et al., combined the depth of the largest fluid collection with the number of sites of free intraperitoneal fluid. Based on their scoring system, 87% of patients with an US score ≥ 3 and all patients with hypotension (defined as SBP $\leq$90 mm Hg) and an US score ≥ 3 required a therapeutic laparotomy. Thirty-eight percent of their patients with scores of <3 and hypotension still required laparotomy compared with only 4% of patients who were normotensive with a score <3.9 However, their study was limited in that they only included patients with sonograms positive for free fluid, so predictions regarding patients who had negative sonograms could not be made. Huang, et al.[12] developed "A Simple Scoring System" for the evaluation of hemoperitoneum with ultrasonography based on free intra-abdominal fluid seen at specific sites. In their study, 96% of patients with an US score ≥ 3 required therapeutic laparotomy. While both of these studies showed that FAST findings can be used to help predict the overall probability that a given patient will require laparotomy, neither scoring system has been widely incorporated into practice. This is due in large part to the difficulty of applying broad percentages to individual patients, to the poor negative predictive values, and partly due to the complexity of their scoring systems. With the widespread availability of CT and the fact that traumatic intra-abdominal injuries are increasingly managed non-operatively, even patients with positive FAST exams rarely go directly to the OR, unless they are hemodynamically unstable.

In a recent study by Moylan et al., it has been demonstrated that there is a strong association between a positive ED FAST exam and therapeutic laparotomy in normotensive blunt trauma patients.[13] In their study, 37% of normotensive patients (defined as SBP > 100mm Hg) with a positive FAST exam required a therapeutic laparotomy versus 0.5% with a negative FAST exam. Their study excluded patients who were hypotensive during the initial ED evaluation. Our study builds upon this association by including hypotensive patients and by attempting to develop a useable scoring system to accurately predict which patients will likely not require laparotomy.

Recognizing that it is difficult to make clinical decisions based on a single test (FAST exam), we analyzed multiple clinical, laboratory, and US findings to determine how best to predict which patients would ultimately require therapeutic laparotomy. Interestingly, none of the laboratory values had a significant correlation with the need for laparotomy. This is most likely due to other traumatic injuries frequently causing significant lab abnormalities, such as hypoxemia, acidosis, coagulopathy, and anemia. Overall, in our study, a positive FAST exam was the single best predictor of laparotomy, but adding SBP and pulse strengthened the correlation.

The scoring system that we developed is simple and uses variables that are immediately and dependably available, as well as highly correlated with the need for surgery. It also allows the physician to easily calculate a score while at the patient's bedside with minimal information and without the aid of complex formulas. This score, if validated prospectively, can then be applied to reliably predict which patients would likely not require a laparotomy.

Blunt trauma patients evaluated at community and rural hospital EDs are often transferred to trauma centers early in the course of their evaluation. This is often done to hasten emergent laparotomy if it becomes necessary, as well as place decisions with those more experienced in trauma. However, this also consumes resources to transfer and manage patients at trauma centers who are increasingly treated non-operatively. It can also displace patients away from home and family support.

Although often times disregarded, there is both a significant cost (financial and personnel) as well as risk associated with an ambulance or helicopter transfer. As the demand on the emergency medical services (EMS) increases, unnecessary utilization of EMS places patients who truly need those services at risk. Also, patients who are transferred emergently via ambulance place both the crew and patient at increased risk of motor vehicle collision.[14,15]

Frequently lab and imaging are repeated at the receiving trauma center. In addition to financial costs, there is the risk of additional radiation exposure to the patient. Experts generally agree that CT scans are associated with an increase in the lifetime risk of cancer and that trauma patients generally have a significant radiation exposure as the result of diagnostic imaging.[16-18] Avoiding unnecessary transfers may limit the amount of repeat diagnostic imaging at the receiving facility, thereby decreasing radiation risk.

While victims of significant blunt trauma should be thoroughly evaluated by physicians experienced in trauma management, there are significant potential benefits of limiting unnecessary transfers to a Level I Trauma Center. SSORTT could better inform the decision to transfer for patients with a low likelihood of needing laparotomy.

LIMITATIONS

Some of our desired data were either unavailable or not reliably collected, especially by prehospital providers. For example, the amount of IV fluids received was often not documented and had the potential for lowering heart rate and increasing blood pressure. We also questioned the accuracy of some of our data, particularly the respiratory rates, which lacked the expected physiologic variability.

Relating to our data analysis, we used univariate models

to identify variables associated with therapeutic laparotomy. Variables that may help discriminate between laparotomy versus no laparotomy in a multivariate model may not have been identified.

Our data set was derived only from patients who were transported to a single Level I Trauma Center. The decision to operate on a patient is at the discretion of the trauma surgeon. It is possible our trauma surgeons are more or less likely to operate than surgeons at other centers, although our overall laparotomy rate of 2.9% is similar to rates noted in other studies.[13,19] Also, our patients are more likely to be severely injured than those seen in a non-trauma setting. Additionally, two of the variables (blood pressure and heart rate) are important factors that are considered as part of the decision-making paradigm by the trauma surgeon. As with any derived clinical decision rule, our score needs prospective validation in different settings and in non-trauma centers.

Finally, while all of our trauma FAST exams were performed by EPs trained to perform emergency ultrasound, we did not determine inter-rater reliability. Since ultrasound findings are highly operator dependent, this is another potential source of error.

CONCLUSION

FAST exams are part of the initial evaluation of victims of blunt trauma. Combining FAST findings with heart rate and SBP determines a simple score associated with a low likelihood of having therapeutic laparotomy. If prospectively validated, this score might prevent unnecessary or emergent transfers of blunt trauma patients to trauma centers. In an era of shrinking healthcare resources, this score could be of benefit.

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Pain in the Neck: the Enigmatic Presentation of an Embedded Acupuncture Needle

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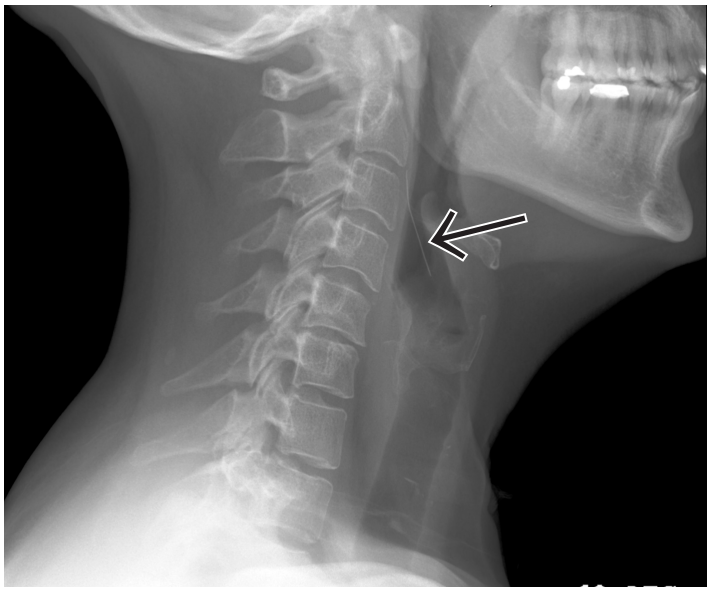

Figure 1. Lateral soft tissue neck radiograph revealing a needle-shaped foreign body.

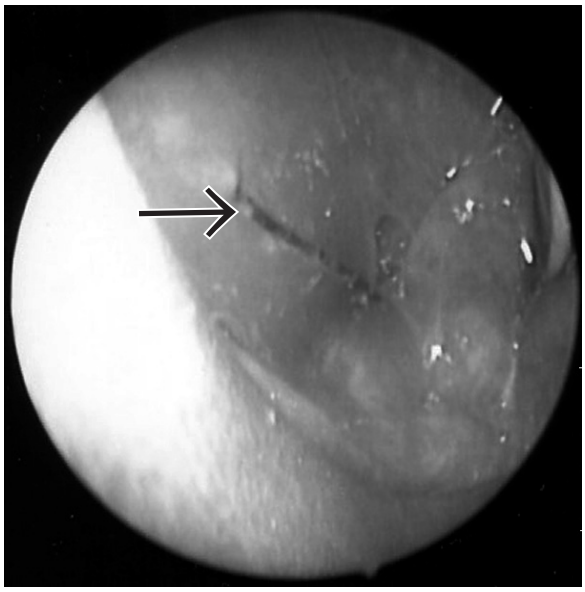

Figure 2 Fiberoptic laryngoscopy shows a 3.3 cm metallic foreign body in the esophagus.

A healthy 46-year-old female presented to the emergency department (ED) with the complaint of a foreign body sensation in her throat. Patient stated that she was eating a hamburger and chips for lunch when she acutely felt "a piece of a potato chip" lodge in her throat. Although she complained of difficulty swallowing, she was able to tolerate oral intake. She denied any shortness of breath or chest pain. On exam, the patient's vital signs were stable and she was well-appearing, in no distress. Soft tissue neck radiograph revealed a needle-shaped metallic foreign body. This raised a very concerning question of how the needle got there and whether it had been intentionally placed in the food by the patient or another party intending harm.

A bedside fiberoptic laryngsocopy performed by the on-call ENT surgeon showed an embedded 3.3 cm metallic foreign body lodged in her right piriformis sinus, and she was taken to the operating room for removal. Direct laryngoscopy confirmed that the foreign body was an acupuncture needle and that it had not been swallowed but extruded from the wall of the esophagus into the piriformis sinus.

Upon further questioning, the patient said she had acupuncture therapy in an alternative medicine clinic to treat whiplash-associated neck pain after a car accident. This therapy, in which the acupuncturist had placed needles in the back of her neck, occurred six months prior to her presentation to the ED. She did not recall whether one of the needles had broken, but after the procedure she continued to have pain in the neck. For six months until the ED diagnosis, she blamed the car accident for her chronic neck pain.

In general, acupuncture is considered safe. The most common reactions are bleeding, needle pain and skin infections, and vagally mediated systemic symptoms, such as nausea, vomiting and syncope.[1-3] In the literature, a few case

reports have described more serious complications associated with this practice of medicine, such as pneumothorax, cardiac tamponade and spinal cord injury.[2] Although these are significant adverse problems, it should be noted that these complications are rare. For example, pneumothorax occurred only twice in almost 250,000 treatments.

This case describes another rare, potentially hazardous complication associated with acupuncture, in which a broken part of the acupuncture needle was inadvertently left in the patient's skin and migrated through into her hypopharynx. If the needle had not been identified, it could have led to further complications, such as esophageal laceration, esophageal perforation, vascular injuries, mediastinitis[4] or pulmonary aspiration. This case represents a rare complication with acupuncture therapy.

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Charcot Foot? Charcot Arthropathy Caused by Lisfranc Fracture-Dislocation in a Diabetic

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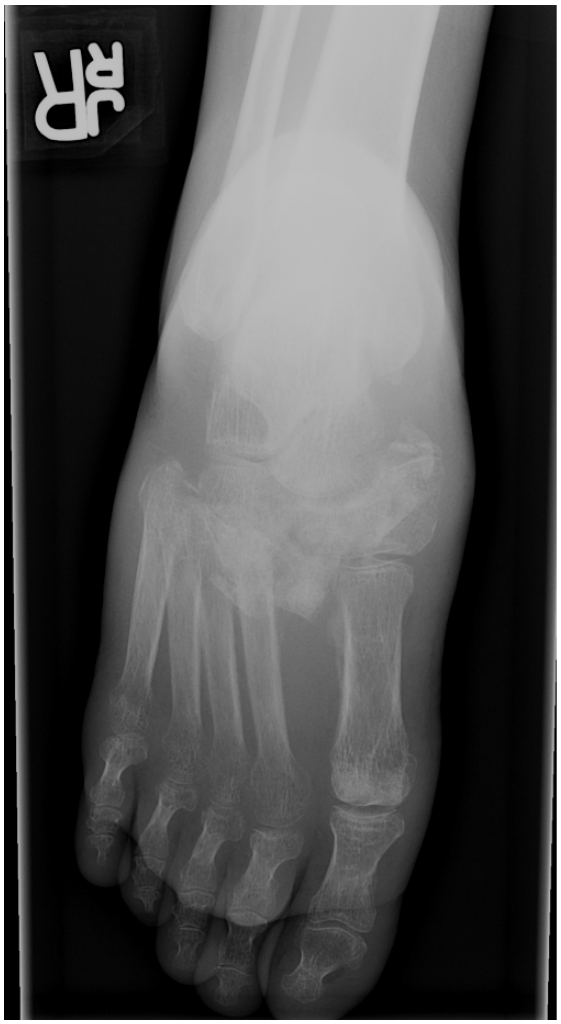

Figure. Dorsoplantar radiograph revealing a Lisfranc dislocation with fragmentation, disorganization and swelling consistent with Charcot foot.

A 48-year-old Hispanic male presented to the emergency department for medication refill for insulin-dependent diabetes mellitus. Upon presentation, the patient reported running out of insulin (Novolin) one month prior. The patient also noted increased swelling and pain in his right foot for approximately that same period of time. The patient denied any trauma to his right foot and reported pain with ambulation. He denied any other symptoms. On physical exam, the patient's right foot appeared mildly swollen with tenderness to palpation over the medial aspect. There appeared to be an ulcer over the mid-plantar surface, approximately 1cm by 1cm in size. There was no noted erythema, edema or purulent drainage. The patient had plain radiography of his right foot performed, including lateral, oblique and dorsoplantar weight-bearing views. The dorsoplantar weight-bearing view revealed a lisfranc dislocation with fragmentation, disorganization and swelling consistent with a charcot foot (Figure). There appeared to be lateral displacement between the 1st and 2nd metatarsals, with complete displacement of the 2nd – 5th metatarsals, consistent with a Type A Lisfranc injury. The patient was subsequently placed in a fracture boot, instructed to be non-weight bearing on the right lower extremity and provided with crutch teaching. He was referred to our diabetic foot clinic for further management and education.

Jacques Lisfranc de Saint-Martin, a field surgeon in Napoleon's army, first described the tarsometatarsal joint as a level for rapid forefoot amputation.[1] The term "Lisfranc" would later be used to describe a variety of injuries at the tarsometatarsal joint, including ligamentous, fracture-subluxation or fracture-dislocation. Lisfranc injuries are most commonly indirect and usually the result of axial loading or twisting on a plantar flexed foot.[2]

Charcot arthropathy, or neuropathic joint, is a progressive condition of bone and joint changes that occur secondary to sensory loss. It is characterized by joint dislocation, pathologic fracture and deformity.[3] It was first described by William Musgrave in 1703 as an arthralgia caused by venereal disease.[4] In 1868, Jean-Marie Charcot first described a hypertrophic process of destructive arthritis and it became known as "Charcot's disease."[5] It almost exclusively occurs in the foot and ankle and is most commonly caused by diabetes

mellitus.[6] The neurotraumatic theory of Charcot arthropathy is an unperceived trauma or injury to an insensate foot that is worsened by microtrauma with continued ambulation. In diabetic patients, the incidence of Charcot arthropathy of the foot and ankle ranges from 0.15 -2.5%.[7] The incidence of Lisfranc injuries is estimated at one per 55,000 and account for only 0.2% of all fractures. They occur more commonly in men and after the third decade of life.[8]

The treatment of Charcot arthropathy is primarily non-operative. In the acute phase, immobilization and non-weight bearing is key. Immobilization is typically accomplished by casting. Injuries with ulceration may require daily debridement and therefore benefit from removable immobilizers such as a walking boot or bivalve cast. Absolute non-weight bearing in the acute phase prevents continued joint destruction and should be instituted for 8-12 weeks.[9] Casting may be necessary for 3-6 months and is discontinued based on clinical and radiographic evidence of quiescence. Operative management is generally reserved for severely displaced or unstable ankle, hindfoot and forefoot injuries. Recalcitrant ulceration may also require surgical intervention. Lifelong protection of the involved foot includes custom footwear, such as extra-depth shoes with rigid soles and professional foot care on a regular basis.

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Radiographic Signs of Type 3A Schatzker Fracture of Lateral Tibial Plateau

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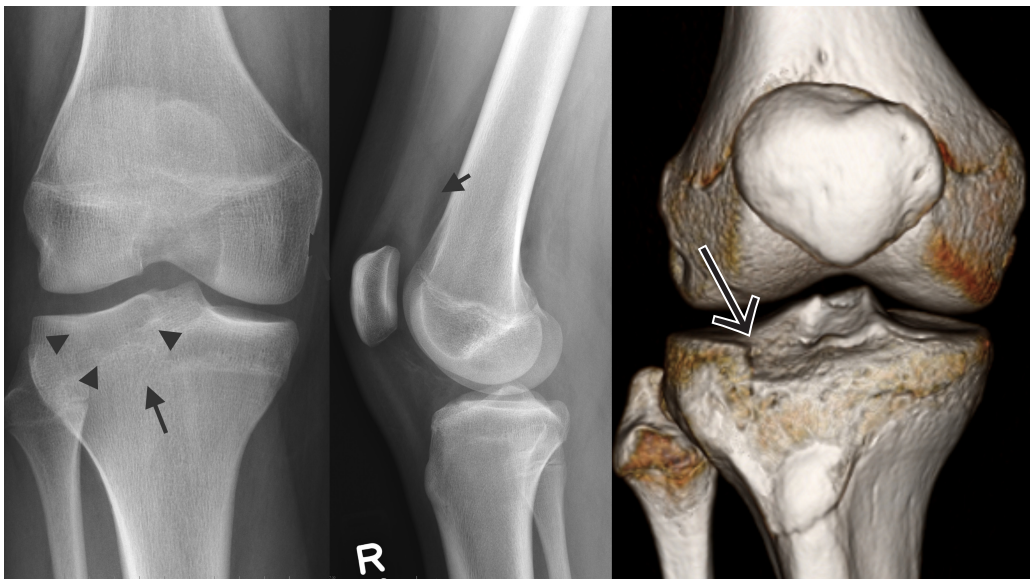

Figure. Both anterior and posterior margins of the medial tibial plateau are distinctly visible but the anterior aspect of the lateral plateau is not (arrowheads), a subtle indicator of the depressed fracture. Associated sclerosis (arrow) is noted. Lateral image demonstrates a small knee joint effusion (small arrow). Three-dimensional computed tomography confirms the fracture.

A 14-year-old boy developed immediate right knee pain and difficulty weight bearing after colliding with another baseball player. Knee radiographs and computed tomography knee confirmed type-3A Schatzker tibial plateau fracture. A depressed fracture may not be appreciated on plain radiographs and only clearly demonstrated at cross sectional imaging. Studies of tibial plateau fractures have shown that surgical plan based on radiographs are modified in 6-60% of cases after CT.[1] Furthermore, this fracture is more common in older age group with osteopenia rather than young patients. If left untreated, depression results in joint incongruity, valgus deformity and a sense of instability.[1]

We describe three signs of type 3A Schatzker fracture of lateral tibial plateau on radiographs, which include loss of visualization of the tibial plateau margin, associated increased sclerosis and effusion (Figure). In the setting of traumatic knee effusion, anterior and posterior margins of the tibial plateaus should be scrutinized. Management of the fracture centers on evaluating and repairing the articular cartilage and restoring the articular surface.[1,2] The patient underwent open reduction and internal fixation with elevation of the depressed fracture fragment and supported by allograft. Optimum outcome post treatment is obtained with an anatomic reduction, adequate rigid internal fixation and bone grafting of the depressed areas.[2]

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An Unusual Facial Impalement Injury in a 75-Year-Old Male

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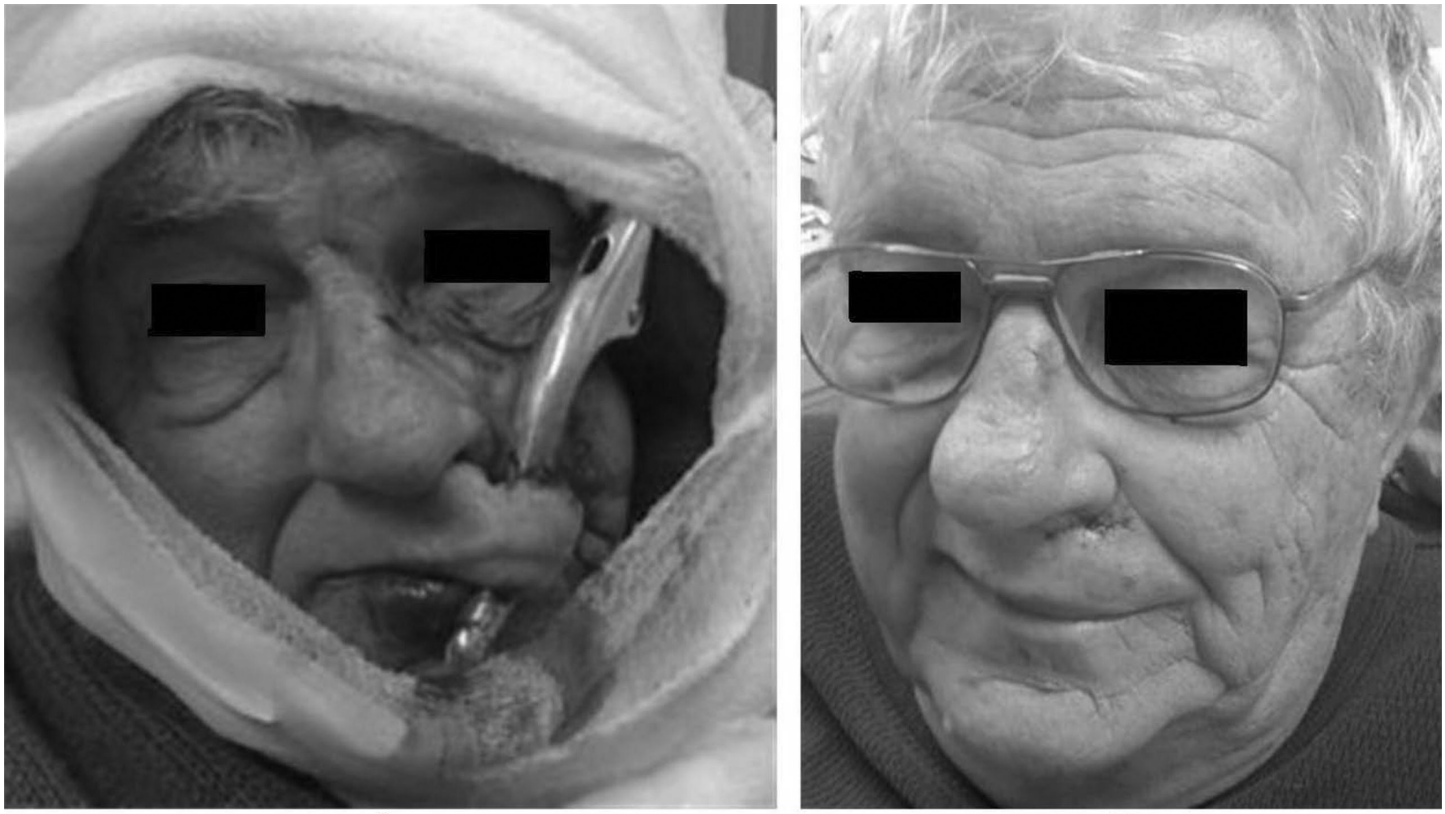

Figure 1. A 75-year-old male with bicycle brake handle impaled into his left upper lip (panel A), and following removal of the brake handle and complex suture repair of the resulting laceration (panel B).

A 75-year-old male presented to the emergency department (ED) following a fall from his bicycle. The patient fell face-first onto the handlebars, with the brake handle impaling his left upper lip. Paramedics were able to detach the handle from the bicycle and transport him to the ED. He denied loss of consciousness, neck pain, dental pain, or other injuries. Examination revealed the brake handle protruding through his upper lip just inferior to the nasal labial fold (Figure, panel A). No other intraoral trauma was noted, and bleeding was minimal. The ED physician carefully extracted the brake handle from the wound, revealing a 2.5 cm linear laceration. Regional anesthesia was accomplished using an infraorbital nerve block (1:1 mixture of lidocaine: bupivicaine). The wound was irrigated with sterile saline, and repaired using four subcutaneous 4.0 absorbable sutures followed by 6-6.0 nylon skin sutures

(Figure, panel B). The patient's tetanus immunization was updated, and he was discharged with instructions to return in seven days for suture removal.

Impalement injuries result from penetration by a rigid, blunt-tipped object that traverses a body area in a through-and-through fashion.[1] Facial impalement injuries are less common than injuries to the trunk or extremities due to the smaller target size of the face, and protective reflexes that tend to move the face away from coming objects.[2] In cases of oral impalement injuries, care must be taken in removing the foreign body in the event that the object is providing a tamponade effect and preventing significant bleeding, particularly if the labial artery is involved. Anesthesia of oral wounds should be accomplished using a regional nerve block (infraorbital nerve block for the maxillary lip) to prevent tissue distortion.[3] Through-and-through lip or oral lacerations should be closed using a layered approach.

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Chlorine Gas: An Evolving Hazardous Material Threat and Unconventional Weapon

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Chlorine gas represents a hazardous material threat from industrial accidents and as a terrorist weapon. This review will summarize recent events involving chlorine disasters and its use by terrorists, discuss pre-hospital considerations and suggest strategies for the initial management for acute chlorine exposure events. [West J Emerg Med. 2010; 11(2):151-156.]

INTRODUCTION

Once used as a chemical weapon in the World War I, chlorine gas has long been known for its pulmonary irritant properties. Many chlorine exposures are the result of accidents at swimming pools and mixing of household agents. However, recent events in the Iraq war, the war on terror and large-scale industrial incidents have demonstrated that chlorine represents a persistent hazardous material (HAZMAT) threat. Massive quantities of chlorine are stored and transported across the United States with minimal security. Chlorine has been successfully used as an unconventional weapon in Operation Iraqi Freedom. In this article, we will review the domestic threats of chlorine exposure, discuss its use as an unconventional weapon, review toxicologic principles, and examine treatment of chlorine-related casualties. We will also discuss some pertinent disaster management aspects of chlorine-related mass casualty (MASCAL) incidents.

Industrial production of chlorine in the U.S. exceeds 15 million tons annually. It is used in numerous industrial practices, including the manufacturing of paper, plastic and chemical products. It is also widely used in the municipal treatment of sewage and drinking water. Since chlorine production occurs in fewer than 20 states, it must be transported in large quantities to metropolitan centers. This large-scale transport and storage close to urban centers could make it an attractive target for extremist organizations. The use of chlorine could allow terrorists to deploy a chemical weapon in a highly populated area without having to manufacture or transport it themselves.[1] An intentional release of chlorine by terrorists, bombing of storage vessels, or an unintentional release from an industrial incident could produce thousands of casualties. In fact an intentional release of chlorine, included as one of the Department of Homeland Security's 15 "National Planning Scenarios," could result in over 17,000 fatalities and 100,000 injuries if it occurred in a highly populated area[2,3]. Despite this, many at-risk communities are unaware of the volume of chlorine that is transported through their area. The following events document recent incidents involving chlorine releases and highlight some of the risks posed by chlorine gas.

RECENT INCIDENTS

January 6, 2005, Graniteville, SC

One of the worst chlorine accidents in recent years occurred in Graniteville, South Carolina. A misplaced track switch resulted in a collision between a railroad tanker carrying chlorine and another train. The chlorine tank ruptured, venting 90 tons of chlorine gas into the surrounding area. The release resulted in nine fatalities. Eight were due to asphyxiation and occurred immediately. The ninth occurred within a day of admission to the hospital. There were also over 520 visits to local emergency departments (EDs) or primary care offices for-chlorine related symptoms.[4] Other non-medical effects included disruption of the local community, with over 5,400 of the town's 7,000 residents being evacuated for several days.[4,5]

February 12, 2007, Tacoma, WA

Due to technician error when transferring chlorine from a rail car to storage containers in a bleach factory, over 900 pounds of chlorine gas were released, forcing the closure of the Port of Tacoma.[6,7] Although there were no fatalities, 25 people required medical attention, including 12 first responders who were overcome after the wind shifted, placing

Table. Symptoms of chlorine exposure by concentration level

Concentration (PPM)	Symptoms
1-3	Irritation of eyes and oral mucus membranes
15	Onset of pulmonary symptoms
430	Fatal within 30 minutes

PPM, parts per million.

them directly in the path of the chlorine gas. Despite the relatively low number of casualties caused by this incident, closure of North America's seventh largest container port illustrates how a chlorine leak causes major disruption of transportation and shipping industries.

August 29, 2007, Las Vegas, NV

Operator error caused a Union Pacific tanker car full of chlorine gas to accidentally escape from the Arden train yard. Although no toxic gas was released, the tanker traveled 20 miles through densely populated areas before railroad workers and police were able to stop it. Based on prior estimates by the University of Nevada, the release of a full tanker of chlorine in such a populated area could have caused up to 90,000 fatalities.[8,9]

Operation Iraqi Freedom, 2007

Insurgents in Iraq have recently executed multiple attacks using chlorine tanker trucks. On February 20, 2007, a tanker truck carrying chlorine was outfitted with explosives and detonated in Taji. Five people were killed in the blast and over 140 others sought medical treatment for chlorine exposure.[10,11] The next day, another attack with chlorine resulted in two fatalities and over 30 treated at nearby hospitals for respiratory complaints.[12] On March 16, 2007, insurgents conducted three separate attacks using chlorine. The attacks occurred during a three-hour period in several different cities. Over 350 civilian casualties resulted from exposure, with hundreds requiring medical treatment.[13] On April 6, 2007, another incident involving a chlorine truck primed with explosives left 30 dead with over 50 seeking care at local hospitals for respiratory symptoms.[14] Most of these attacks utilized explosive-fit chlorine tanker trucks. These unorthodox delivery methods demonstrate a willingness by extremist groups to use chlorine in heavily populated areas, and highlight the relative ease in acquiring large quantities. Weaponized chlorine has clearly been shown to result in significant morbidity, mortality, and societal impact.

CLINICAL CONSIDERATIONS

General Toxicology

Chlorine is element number 17 on the periodic table. It exists as a yellow-green gas at temperatures above -34°C.

$$Cl_2 + H_2O \leftrightarrow HCl + HOCl \leftrightarrow 2HCl + O^-$$

Figure. Chlorine and water interact forming acid and oxidant byproducts

Because this gas has a density greater than air, it tends to settle along the ground.[15] All irritant gases have the potential to cause pulmonary injury, which is principally related to the duration of exposure. Irritant gases with high water solubility (e.g. ammonia) interact with oral, nasal and ocular mucosa rapidly causing discomfort. This warning property allows people to leave an area of exposure, limiting contact and thus reduces the likelihood of significant pulmonary damage. Irritant gases with low water solubility (e.g. phosgene) generate damaging caustic and oxidizing byproducts more slowly, resulting in very little warning properties. The absence of robust warning properties may result in prolonged exposures, allowing these agents to reach distal airways and produce greater pulmonary injury. Chlorine gas has an intermediate solubility, which gives it some warning properties, but may also allow for prolonged exposure and pulmonary damage.[16,17] At 1-3 parts per million (PPM), chlorine starts to cause irritation of the mucus membranes. Pulmonary symptoms begin at exposures greater than 15 PPM, and concentrations greater than 430 PPM are fatal within 30 minutes (Table 1).[18,19] In comparison, the Occupational Safety and Health Administration (OSHA) has set the permissible exposure limit (PEL) for an eight-hour time period at 1 PPM.[20]

Pathophysiology

Chlorine's toxic effects are due primarily to the production of hypochlorous and hydrochloric acid that occurs when elemental chlorine (Cl_2) reacts with water. These two acids then further react to produce oxygen free radicals (Figure 1). In large exposures, the acids and free radicals then damage cell walls and interact with sulfhydryl groups on various amino acids and enzyme systems.[16,18] Histologic findings of this damage include bronchial edema, desquamation of epithelial cells, erosions and localized necrosis.[2,21]

Clinical Effects

Local irritation from acid results in an inflammatory response of the upper and lower airways leading to bronchospasm, cough and dyspnea. Disruption of cell membranes and proteins by the acids and free radicals results in death of alveolar cells and endothelial cells of adjacent capillaries. Clinical manifestations of this damage include pulmonary edema and Acute Respiratory Distress Syndrome (ARDS).[16,22] Fortunately, most patients with mild to moderate exposures will have resolution of their acute symptoms within three to five days and will have normal pulmonary function

tests after several months.[15,23] Some patients, however, will have chronic respiratory problems, such as reactive airway disease (RAD). While there is no way to predict which patients will develop long term complications, patients with a history of smoking or a prior history of RAD may be at increased risk..[18]

Although the most serious clinical effects of chlorine toxicity tend to be pulmonary, it can also cause skin and eye injuries. While dermal manifestations include irritation and pain, in severe exposures, chemical burns, including blister formation, can take place. Ocular complications include irritation and conjunctivitis. Severe cases can result in corneal defects.[24] Chlorine also causes other non-specific symptoms, such as nausea, vomiting, rhinorrhea and headache.[25]

MANAGEMENT STRATEGIES OF CHLORINE EXPOSURE

Pre-hospital and Personal Protective Measures

The most important aspect of managing a chlorine release is identification of the prevailing wind direction in order to stage upwind while establishing scene safety. Personal protective equipment (PPE) for all first responders is paramount. The incident in Tacoma resulted in pre-hospital provider injuries due to limited utilization of PPE and an unexpected shift in wind direction. This event illustrates the importance of the use of appropriate PPE for all responders, which should include self-contained respirators as well as eye and skin protection.[19] According to OSHA standards, all personnel moving into high-risk areas must be issued positive pressure ventilation systems.[26] This level of protection best corresponds to OSHA level A or level B PPE since both consist of positive pressure self-contained breathing apparatuses with full face plates as well as protective over garments.[26] Per OSHA standard 910.120, if this type of system is not initially used, those conducting the preliminary assessment must be issued an escape breathing apparatus capable of operation for at least five minutes.[26] Military personnel working in a contaminated area or working on the decontamination line should be outfitted in mission-oriented protective posture (MOPP) level 4 equipment.[27] MOPP level 4 is roughly equivalent to OSHA level C PPE because it uses a chemical protective mask instead of a positive pressure breathing system. While this level of protection is insufficient to enter areas of high concentration, such as near a leaking chlorine tank, it does provide adequate protection for perimeter duty and work on the decontamination line. MOPP level 4 also represents the highest level of PPE that all U.S. soldiers are trained to use. Experience with higher levels of PPE, such as positive pressure respiratory systems, is reserved for specialized military HAZMAT teams.

Decontamination

Treatment of patients in the pre-hospital setting consists principally of decontamination and supporting the patient's breathing. Decontamination, as with most chemical exposures, involves evacuation of the patient from the area of exposure, removing clothing, and irrigating with copious amounts of water. Although the duration of decontamination has not been conclusively identified, three to five minutes of rinse time has been advocated.[19] While 0.5% chlorine solution is recommended for the decontamination of undifferentiated chemical exposures,[27] it is not expected to be relevant in cases of chlorine-related casualties. Patients complaining of ocular irritation should undergo copious eye irrigation. Contact lenses should be removed to ensure proper irrigation.[15,16] Unlike people exposed to liquid chlorine, patients exposed to only chlorine vapor represent no significant risk of contaminating rescue workers ("off gasing").[24] Patients exposed to gaseous chlorine probably will not require any decontamination other than removal of the clothing. However, if they are experiencing ocular or dermal symptoms, they should undergo decontamination.[2]

Treatment

Pre-hospital support of respiratory injuries involves removing patients from the source of exposure, providing supplemental oxygen, and administering inhaled beta-agonists for patients with bronchospasm. For patients in extreme respiratory distress, rapid sequence intubation (RSI) should be considered, but this type of resource-intensive procedure may not be feasible if there are multiple casualties and limited resources cannot support such an intervention. The use of a standardized triage system can help to sort patients based on the severity of their injuries and to guide resource allocation in such a situation.

ED care of patients is supportive. However, it is very important that the ED be prepared to decontaminate patients who arrive via private vehicles since these patients may not have been decontaminated prior to arrival. During the disaster in Graniteville, over 95% of the patients arrived via private vehicle.[4] After appropriate decontamination, skin wounds should be treated like other chemical burns, including: irrigation, tetanus prophylaxis, local wound care and analgesia. Eye irritation should prompt copious lavage and evaluation for corneal defects. Severe eye injuries, including any that result in a corneal defect, require ophthalmology consultation. If ophthalmologic consultation is not immediately available, patients with corneal defects should receive topical antibiotic prophylaxis to prevent bacterial superinfection. These patients also require ophthalmologic follow-up within the next few days.

Mild respiratory symptoms and bronchospasm can be treated with aerosolized beta-agonists. If a patient has a persistent cough but no respiratory distress, nebulized lidocaine (4 mL of a 4% solution) may provide symptomatic relief.[28] For patients with severe respiratory distress, RSI

should be considered. Patients may develop ARDS, with its characteristic bilateral infiltrates on chest x-ray and hypoxia that does not improve with increased inspired oxygen concentration. Therefore, when a patient is intubated after a chlorine exposure, low tidal volumes (5-8 mL/kg ideal body weight) are recommended.[29] The patient's inspired oxygen concentration and peak expiratory end pressure (PEEP) can then be adjusted to maintain the patient's oxygen saturation.

There is no specific antidote for chlorine exposures. Several studies have suggested that inhaled or parenteral steroids are effective at decreasing respiratory complications after chlorine exposure.[30,31] The proposed mechanism is decreased recruitment of inflammatory mediators and immune cells, as well as increased stimulation of surfactant producing pneumocytes.[32] One animal model showed a benefit of inhaled budesonide if administered within 30 minutes of exposure. This same study showed a significant decrease in improvement if treatment was delayed to 60 minutes, which suggests that steroids should be administered soon after an exposure when feasible.[33] Nebulized sodium bicarbonate may be another adjunctive treatment for chlorine pulmonary exposures. Theoretically, inhaled bicarbonate can neutralize hypochlorous and hydrochloric acids, decreasing severity of lung injury. One non-randomized, placebo-controlled study of chlorine exposure reported improved pulmonary function tests (PFT), but patient-oriented benefits and long-term outcomes were not determined.[34] Another study examining nebulized sodium bicarbonate revealed improved subjective symptoms, with no reported adverse effects.[35] In both studies patients received concomitant inhaled beta-agonists and intravenous steroids. Another case series utilized bicarbonate without beta-agonists or steroids in patients with mild chlorine exposures. All three patients subjectively improved after treatment with a 3.75% sodium bicarbonate nebulizer and no adverse effects were reported.[36] The utility of nebulized bicarbonate has not been firmly established, and the optimal dose has also not been delineated. A reasonable dose is 3.75-5% nebulized over 20 minutes and may be repeated. A 3.5% solution can be prepared by taking 2 mL of a 7.5% intravenous preparation of sodium bicarbonate solution (the concentration found in most cardiac "crash carts") and combining with 2 mL of normal saline. Because precipitates can form if combined, it is important that nebulized sodium bicarbonate be administered separately from nebulized albuterol sulfate.[37] Another theoretical treatment is the administration of an anti-oxidant such as N-acetyl cysteine (NAC). Although some data from animal models exists, there is currently not enough information to support the use of anti-oxidants in a clinical setting.[32,38]

Some patients will present with minimal or no symptoms. A small percentage who are minimally symptomatic on presentation may go on to develop delayed pulmonary edema over a period of several hours.[4] Therefore, patients with mild symptoms should be observed for eight to 24 hours for delayed onset of respiratory complications.[17] Patients who are asymptomatic after their exposure can be discharged after six hours of observation, but must be counseled on symptoms that should prompt a return for further care.

Disaster and Mass Casualty (MASCAL) Considerations

Personnel moving into areas of higher concentration or prolonged exposure time will need appropriate HAZMAT equipment for respiratory and skin protection. First responders must be equipped with and trained to use this PPE prior to a major chlorine release. Because of the potential for large numbers of exposed patients who may require treatment and monitoring, a hospital can become overwhelmed. It is important that hospitals and municipalities have mutual-aid agreements that coordinate the transfer of medications, equipment and personnel to the areas they are most needed. Especially important is respiratory support equipment. During the previously mentioned event in South Carolina, 10% of the hospitalized patients required intubation and mechanical ventilation.[3] Additionally, incident command must help coordinate patient triage and transportation to appropriate medical facilities. Equitable distribution of patients based on each hospital's surge capacity can minimize the strain on individual hospitals.

Triage is an ongoing process, and must be repeated as patients move through the levels of decontamination. The initial level of decontamination is the "hot zone," which is typically the actual incident location. The "warm zone" is geographically distant from the incident and is frequently the entry point to decontamination. This area can restrict patient flow and may be an appropriate time to re-triage. As patients complete the decontamination process, they pass from the "warm zone" to the "cold zone." Upon reaching this area, patients may need to be re-triaged again, then directed to the appropriate level of care.[39]

A critical challenge to MASCAL incident command is maintaining clear and regular communication. People working or living in areas being evacuated must be notified of the need to leave, as well as safe evacuation routes that avoid exposure. The general population must be notified of signs and symptoms of chlorine exposure and then directed to triage and care areas for the "walking wounded." Hospitals nearest the incident scene must be prepared to receive most of the "walking wounded," as well as the most critical patients. There must also be a point of contact for friends and families seeking missing loved ones. The best mechanism for the spread of such information will vary, depending on the size and demographics of a given community.

SUMMARY

In addition to the occult HAZMAT threat, the intentional use of chlorine as an unconventional weapon is now occurring. Large chlorine stores in the U.S. are vulnerable

and lack adequate security. Operation Iraqi Freedom has demonstrated multiple events of successful use of weaponized chlorine transport vehicles, resulting in hundreds of casualties. Successful management of a chlorine MASCAL incident requires increased awareness and planning. As for all HAZMAT responses, proper equipment and training for first responders and a network of supporting medical facilities are needed to provide adequate care. Management of chlorine exposure involves decontamination and treatment of potential pulmonary injuries. Beta-agonists can be helpful for bronchospasm. Nebulized bicarbonate may decrease symptoms and prevent lung injury. Early corticosteroid use may play a role in treating lung inflammation and, possibly, preventing post-injury scarring. Severe cases may require endotracheal intubation and mechanical ventilation. While all these measures may prove useful in the treatment of patients after a chlorine exposure, further research is needed to delineate the optimal treatment regimen. Recognizing the evolving threat posed by chlorine, both in the form of an accidental release as well as an unconventional weapon, is an important first step to being prepared for this type of incident.

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Cocaine-Associated Seizures and Incidence of Status Epilepticus

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Objectives: Acute complications from cocaine abuse are commonly treated in the emergency department (ED); one of the most consequential is status epilepticus. The incidence of this complication is not clearly defined in the prior literature on cocaine-associated sequelae. We evaluated the incidence of status epilepticus in patients with seizures secondary to suspected cocaine use.

Methods: We performed a retrospective multi-center study of patients with seizures resulting from cocaine use. We identified study subjects at 15 hospitals by record review and conducted a computer-assisted records search to identify patients with seizures for each institution over a four-year period. We selected subjects from this group on the basis of cocaine use and determined the occurrence of status epilepticus among them. Data were collected on each subject using a standardized data collection form.

Results: We evaluated 43 patients in the ED for cocaine-associated seizures. Their age range was 17 to 54, with a mean age was 31 years; 53% were male. Of 43 patients, 42 experienced a single tonic-clonic seizure and one developed status epilepticus. All patients had either a history of cocaine use or positive urine drug screen for cocaine.

Conclusion: Despite reported cases of status epilepticus with cocaine-induced seizures, the incidence of this complication was unclear based on prior literature. This study shows that most cocaine-associated seizures are self-limited. [West J Emerg Med. 2010; 11(2):157-160.]

INTRODUCTION

Cocaine intoxication has several emergency department (ED) presentations. Of those chief complaints, seizures have been considered one of the most consequential with a high morbidity and mortality.[1] However, recent studies have shown that cocaine-associated seizures are commonly self-limited and may not require lengthy evaluation and work up in patients who have compete resolution of symptoms and a normal neurological examination.[2-6] The incidence of cocaine-associated seizures is unclear. One study showed that among ED patients who had used cocaine, seizures were the chief complaint in approximately 8% of cases.[5] Among pediatric patients with seizures, status epilepticus is one of the most serious complications with a short-term mortality of 8-20%.[7,8]

Although cocaine-associated status epilepticus has been reported in the literature, its incidence is unclear. The purpose of this study is to evaluate the incidence of status epilepticus in patients who present to the ED with cocaine-associated seizures.

METHODS

The study utilized a multi-center retrospective design. We identified patients with cocaine-associated seizures by retrospective record review over a four-year period at 15 hospitals, which included both urban and suburban teaching and non-teaching hospitals in New Jersey. In addition, the

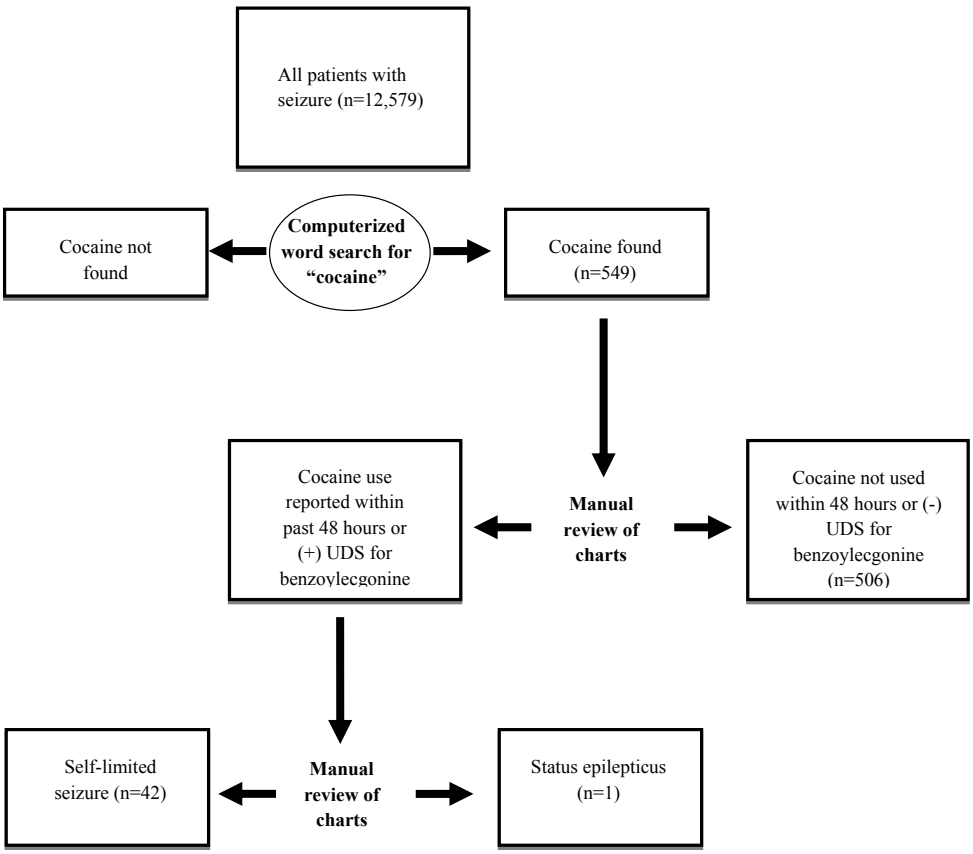

Figure. Urine drug screen identification of study subjects and computer-assisted record search.

EDs included in this study used electronic medical records. We identified patients by ICD-9 code search for seizure or status epilepticus. After these records were identified, we performed a computerized search to identify cases associated with cocaine use. Cocaine use was defined as positive cocaine urine metabolites or a recent history of use within the previous 48 hours. Status epilepticus was defined as a seizure lasting longer than five minutes, or more than two discrete seizures with no intermittent period of normal consciousness (Figure 1).

We collected data on each patient using a standardized closed-question data collection instrument. Information on patient demographics included age, gender, time from last illicit substance use, and urine toxicology results. Prior seizure history and past medical history was recorded. We also recorded results of head computed tomography (CT) scan, ethanol levels, electrolyte levels, and glucose. Drug co-ingestion was defined as an elevated alcohol level, a history of recent non-cocaine illicit drug use or positive drug testing of non-cocaine illicit drugs.

RESULTS

ED patient records from the 15 New Jersey hospitals totaled 1,590,629 over a four-year period between January 2002 and December 2006. All ED visits had digital medical records. Of these patient visits, we identified 12,579 seizure cases, and the word "cocaine" appeared in 549 patients' charts. Forty-three patients met the study inclusion criteria for cocaine-associated seizure. Of those with cocaine-associated seizures, 23 of 43 (53.5%) were male; 26 (60.5%) met criteria for co-ingestion; seven (16.3%) had prior history of a seizure disorder; and only one patient (2.3%) had status epilepticus. All study participants had generalized tonic-clonic seizures.

The sole patient with status epilepticus was a 41-year-old woman with a history of heavy ethanol and intranasal cocaine use over the previous day, who was found seizing by her mother. The seizures continued despite multiple doses of intravenous lorazepam and phenytoin, and she was paralyzed and intubated for approximately 24 hours. She was discharged without sequelae.

Of the other 42 cases, all had self-limited seizures that resolved while in the ED or prior to arrival. Three of these 42 patients had severe agitation after their self-limited episode of seizure activity. Two of these three were paralyzed and intubated but not actively seizing when rapid sequence intubation was performed. A CT scan of one showed a subarachnoid hemorrhage on CT scan, and one of the others was a body "stuffer" who ingested a large amount of cocaine

while being arrested by law enforcement officials.

All 43 patients had normal sodium, calcium, magnesium, and glucose levels in the ED. Paramedics noted prehospital hypoglycemia in one patient with a blood glucose of 41 mg/dL. They treated the patient with glucagon, and he had a normal glucose level in the ED with complete resolution of seizure activity although no dextrose administration was documented. This patient also tested positive for phencyclidine on a urine drug analysis.

Twenty-six patients had documentation of past co-ingestion with other drugs of abuse or ethanol by history or urine drug screen. Ethanol was the most common co-ingestant, with 12 of 26 cases having detectable ethanol levels. Additionally, there were nine cases of opioids, eight of marijuana and one case of phencyclidine co-ingestion.

In 10 of 43 cases we documented routes of cocaine use, including nasal insufflation, ingestion, inhalation, and intravenous injection. Intranasal insufflation was the most commonly documented. Most patients (27 of 43) were discharged from the ED, although length of stay is unknown. Nine of these admissions had some neurologic or psychosocial sequelae ranging from agitation, psychosis, and suicidal ideation to lethargy and post-ictal states.

DISCUSSION

Status epilepticus secondary to cocaine use has been described in the medical literature. These cases are rare, predominantly documented in case reports, and associated with massive cocaine ingestions.[9,10] Little information is available on the frequency of cocaine-associated seizures or status epilepticus. Further, the reported literature comes from EDs in urban settings.[2-6] Our study attempted to identify patients with cocaine-associated seizures and to assess the incidence of status epilepticus using a 15-ED network in New Jersey. Yearly census for these 15 hospitals ranged from 24,000 to 83,000 patients with a mean of about 50,000. This ED network included both suburban and urban settings, covers approximately 15% of all EDs in New Jersey and may represent a better population cross segment than previously reportedly studies.[2-6]

The catchment area totaled over 1.5 million ED patient visits during the four-year study period. Despite the large number of patient visits, our study identified only 43 cases of cocaine-associated seizures, which included one case of status epilepticus. This rate is lower than in previous studies which were predominantly performed in urban EDs. Our study included mostly suburban EDs.[2-6] Although the retrospective study design may have failed to identify all patients with cocaine-associated seizures, the frequency of this event is likely to be low and the occurrence of status epilepticus even more uncommon. It is not clear why the incidence of cocaine-associated seizures is rare; however, it may be related to how they are caused. Experimentally, status epilepticus can be induced by single massive exposures to cocaine. Several reported human cases corroborate this mechanism.[11] However, most cases of cocaine-associated seizures are likely due to the pharmacological phenomenon known as kindling, where repetitive administration of sub-convulsive doses of cocaine lead to seizure. This may be the reason for the low rate of cocaine-associated status epilepticus.[12-14]

The one patient we identified in our study was critically ill and difficult to manage medically, requiring multiple doses of benzodiazepines, paralysis and intubation. The role of ethanol co-ingestion is unclear but may have been a contributing factor. It is well known that cocaine and ethanol co-ingestion can lead to the formation of cocaethylene, a metabolite considered to be more cardio- and neurotoxic than those of cocaine alone. Similar to several previous reports, the majority of patients with cocaine-associated seizures cases did not involve status epilepticus.[2-6] In addition, the majority of cases were managed without hospital admission.

LIMITATIONS

Our study was retrospective, lacked electroencephalogram testing and had limited follow up. And while cocaine is one xenobiotic often implicated in seizures, it is unclear if other potential ingestions may have been implicated. We did not perform confirmatory testing of other potential xenobiotics. In addition, we were unable to accurately assess the temporal relationship of cocaine use to seizure onset. Although some authors stress that cocaine-associated seizures occur early after use, especially within 90 minutes when peak concentrations of cocaine occur, the literature documents many cases occurring hours after drug use. Further, many of the study subjects had seizures witnessed by pre-hospital personnel upon arrival at the scene, although it is unclear how many. Thus, the diagnosis of seizure was often made by pre-hospital historical information. Further, we were unable to assess the duration of these pre-hospital seizures.

CONCLUSION

Status epilepticus is a rare event in patients presenting to the ED with cocaine-associated seizures. Most patients with this ED presentation were evaluated, treated and discharged.

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Etomidate as an Induction Agent in Septic Patients: Red Flags or False Alarms?

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Despite its widespread use in North America and many other parts of the world, the safety of etomidate as an induction agent for rapid sequence intubation in septic patients is still debated. In this article, we evaluate the current literature on etomidate, review its clinical history, and discuss the controversy regarding its use, especially in sepsis. We address eight questions: (i) When did concern over the safety of etomidate first arise? (ii) What is the mechanism by which etomidate is thought to affect the adrenal axis? (iii) How has adrenal insufficiency in relation to etomidate use been defined or identified in the literature? (iv) What is the evidence that single dose etomidate is associated with subsequent adrenal-cortisol dysfunction? (v) What is the clinical significance of adrenal insufficiency or dysfunction associated with single dose etomidate, and where are the data that support or refute the contention that single-dose etomidate is associated with increased mortality or important post emergency department (ED) clinical outcomes? (vi) How should etomidate's effects in septic patients best be measured? (vii) What are alternative induction agents and what are the advantages and disadvantages of these agents relative to etomidate? (viii) What future work is needed to further clarify the characteristics of etomidate as it is currently used in patients with sepsis? We conclude that the observational nature of almost all available data suggesting adverse outcomes from etomidate does not support abandoning its use for rapid sequence induction. However, because we see a need to balance theoretical harms and benefits in the presence of data supporting the non-inferiority of alternative agents without similar theoretical risks associated with them, we suggest that the burden of proof to support continued widespread use may rest with the proponents of etomidate. We further suggest that practitioners become familiar with the use of more than one agent while awaiting further definitive data.
[West J Emerg Med. 2010; 11(2):161-172.]

When did concern over the safety of etomidate first arise?

Etomidate was first introduced into clinical practice in Europe in 1972 and was approved for use in the United States in 1983. In early June 1983, and later that same month, letters to the editor were published in *The Lancet* describing increased mortality in the setting of continuous sedation for trauma patients after the introduction of etomidate.[1,2]

In these reports Ledingham and Watt, in Glasgow, noticed that prior to etomidate introduction patient mortality ranged from 22-29%, whereas after etomidate introduction, mortality rose to 44%, despite no significant changes in the injury severity score (ISS) throughout the study period. Comparing patient outcomes from 1979 through 1980 (a total of 55 patients; mean age 55 years; ISS 24) with outcomes during 1981 through 1982 (a total of 88 patients; mean age 35 years; ISS 26), they found that despite the lower mean age of the latter group and a similar ISS, mortality increased from 25% when sedation agents were primarily morphine and benzodiazepines to 44% when sedation agents were primarily morphine and etomidate. Three quarters of the patients in each group were mechanically ventilated, and it was in these patients that the increased mortality appeared to occur. When patients in each group were stratified strictly by sedation agent, the results were even more striking. For all patients, mortality was 25% in patients not receiving etomidate and 69% in patients who received etomidate. When stratified by severity of illness using the ISS, the differences in mortality were as follows: ISS 10-20: 6% versus 50%; ISS 21-30: 36% versus 77%; and ISS greater than 30: 35% versus 100%. The

authors noted that suppression of adrenocortical function, which had recently been reported in rats[3] and critically ill patients,[4,5] might explain the apparent effect of etomidate. A footnote by the editor accompanying this report notes: "the company (Janssen) has agreed to cease promotion of the drug for sedation in intensive care."

In a follow-up letter in late June 1983, the same group reported that their initial findings led to the end of etomidate use at their institution.[1] Following this decision, they noted that 21 patients were treated with an alternative sedative agent, 15 of whom were regarded as critically ill, and none were found to have low cortisol levels. In a 1984 study, they reported that mortality fell to 25% in 12 patients treated after etomidate use was discontinued.[6]

Criticisms of these reports began almost immediately. In *The Lancet* of June 25, 1983, a letter responding to Ledingham and Watt's initial report notes "alarm that a technique so useful in critically ill patients can so easily be discredited by a letter so lacking in objective information," and suggests the effect of a number of additional confounding variables. Another letter suggests that the greater depth of anesthesia obtained with etomidate may explain the mortality. Additional reports by Fellows et al.[7] in late 1983 as well as by Chee et al.[8] and by Logan and McKee[9] in early 1984, all in the *British Medical Journal*, lent further support to the relation between etomidate and the suppression of adrenal steroidogenesis.

Several recent articles and letters to the editor in various journals question the safety of etomidate for even a single bolus dose in patients with illnesses such as sepsis or trauma that rely upon an adrenal stress response,[10-18] citing the risk of causing relative adrenocortical insufficiency after a single bolus. Jackson, in March 2005,[12] discusses a number of small randomized studies reporting significant but transient adrenocortical suppression after etomidate administration, and notes that these studies failed to prove that the resultant adrenal dysfunction was insignificant. In an editorial accompanying Jackson's article,[19] the effect of short-term suppression of adrenal synthesis on patient outcomes is described as being unclear, with the authors noting that etomidate is still a useful agent for the induction of unconsciousness, and when combined with muscle relaxation provides the best scenario for rapid, smooth, hemodynamically stable intubation.[19] Zed et al.[18] conclude that given the significant evidence that etomidate causes transient adrenal insufficiency of uncertain clinical effect, further research is necessary. Bloomfield and Noble[11] suggest that a moratorium on the use of etomidate in critically ill patients outside clinical trials may be prudent until its safety is established. In contrast, Crozier[20] suggests that "the fervor of the current discussion is excessive, particularly since it is based on rather shaky and perhaps misinterpreted data," and notes that although the case against etomidate might appear compelling, none of the studies were actually designed to test the effect of etomidate on mortality. Morris and McAllister[16] question whether etomidate's reputation for being safe in emergency anesthesia is justified and ask if it should continue to be used in any practice. Schultz-Stubner,[17] in a letter to the editor responding to Vincent and Berre,[21] cites recent evidence[13] for a single bolus of etomidate in intensive care patients being a major risk factor for the development of relative adrenal insufficiency for at least 24 hours. The author suggests that etomidate should be avoided and replaced by an amnestic dose of a benzodiazepine in combination with an opioid or ketamine to facilitate endotracheal intubation in patients with traumatic brain injury. Berre and Vincent counter with the fact that the decrease in steroidogenesis caused by intravenous administration of a single dose of etomidate has never been demonstrated to be deleterious and that the advantages of etomidate over other agents are numerous.

In summary: Etomidate was determined to be unsafe for long-term use in the ICU shortly after it was introduced in the U.S. in 1982. The question of whether a single bolus dose of etomidate for rapid sequence induction is safe remains a contentious and unresolved issue.

What is the mechanism by which etomidate is thought to affect the adrenal axis?

The mechanism of etomidate's effects on the adrenal axis is through a reversible and concentration-dependent blockade of 11β-hydroxylase and, to a lesser extent, 11β/18-hydroxylase (aldosterone synthase, CYP11B2) and the cholesterol side-chain cleavage enzyme known as cholesterol desmolase, or P450scc. Early characterization of the mechanism was reported in May 1984 by Wagner et al.,[22] who described the effect of etomidate infusion on cortisol, and the aldosterone responses to stimulation with adrenocorticotropic hormone (ACTH), in five patients. Wagner et al. also examined the direct effects of etomidate on enzymes in rat cells, noting a marked suppression of adrenal steroidogenesis followed by gradual recovery of glucocorticoid production during four days of observation after stopping etomidate infusion. They concluded by recommending that physicians consider treating selected patients with corticosteroids if etomidate is used for induction. Decreased cortisol and aldosterone levels due to this adrenal suppression have been documented to occur approximately 30 minutes after a single induction dose of etomidate, with the duration of the effect being as long as 24 hours to 48 hours.[13,15,23-26]

In summary: The mechanism of etomidate's affect on the adrenal axis is well characterized and uncontroversial.

How has adrenal insufficiency in relation to etomidate use been defined or identified in the literature?

No gold standard exists for the diagnosis of relative adrenal insufficiency. The methods currently used include measuring cortisol concentrations, cosyntropin stimulation testing, and determining various ratios of cortisol, 11-deoxycortisol, ACTH, and other hormone intermediates and derivatives.

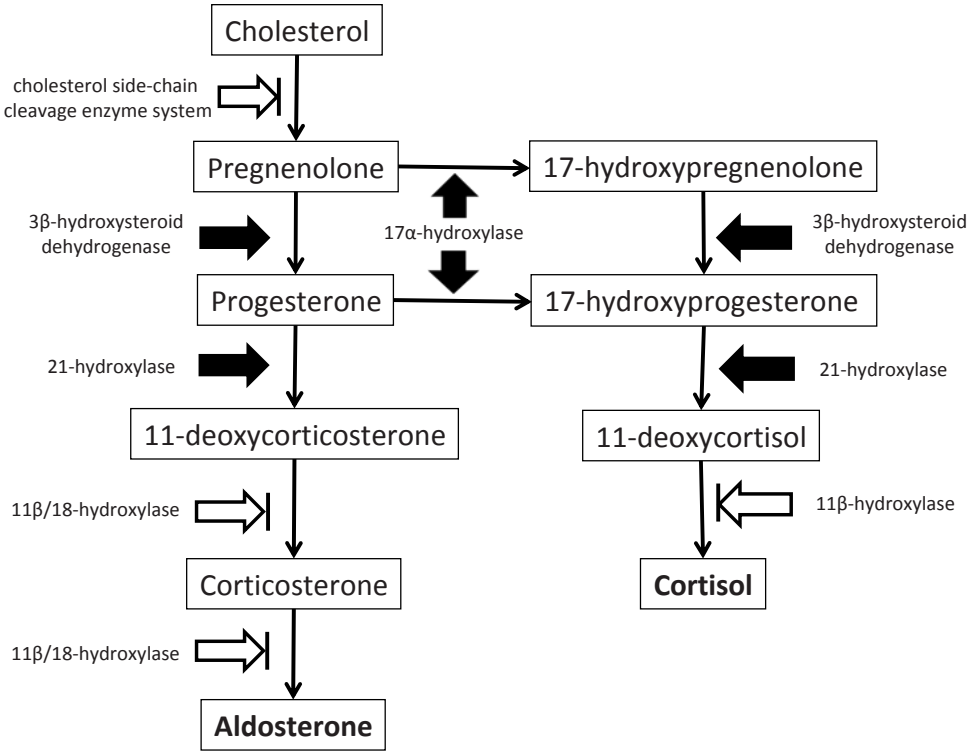

Figure 1. Adrenal aldosterone and cortisol biosynthetic pathways. Key steps have been labeled with the enzymes responsible for catalysis. Enzymes inhibited by etomidate have been demarcated by the blocked white arrowheads. Etomidate primarily inhibits 11β-hydroxylase, and exerts decreasing effects at 11β/18-hydroxylase & the cholesterol side-chain cleavage enzyme system, respectively.

The cosyntropin test involves measurement of baseline serum cortisol, then the parenteral administration of 250 mcg of synthetic ACTH, followed by serum cortisol measurements at 30 minutes and 60 minutes later. The normal response is considered an increase of greater than 9 mcg of cortisol per deciliter. In an excellent discussion of the assessment of adrenocortical function in the critically ill, Rai et al.[27] note that although adrenocortical function is essential for patient survival during critical illness, what constitutes adrenocortical insufficiency in critically ill patients is not clear. Absolute insufficiency, as defined by very low plasma cortisol concentrations, is uncommon in the ICU population (and moreover, it is difficult to determine what constitutes a normal reference range for the critically ill patient). The term "relative adrenocortical insufficiency" (abnormal increases in plasma cortisol concentrations following an ACTH stimulus) is controversial since definitions have been obtained through studies in unstressed volunteers. Critics note that the test is only a measurement of adrenal reserve, not adrenal function, and thus its use to determine adrenal insufficiency in the setting of sepsis is inappropriate. A normal response to the test does not rule out adrenal suppression, because the dose of ACTH used is far higher than normal physiological concentration and may override adrenal resistance to corticotropin, thus producing a false-negative test in patients with mild secondary adrenal insufficiency. An alternative "low-dose" cosyntropin test, using 1 mcg of corticotrophin, has been suggested. A recent consensus statement from the American College of Critical Care Medicine (ACCM) suggests that dysfunction of the hypothalamic-pituitary-adrenal axis in critical illness is best described by the term critical illness–related corticosteroid insufficiency (CIRCI), and that the terms absolute or relative adrenal insufficiency are best avoided in the context of critical illness.[28]

Regardless of the debate over how best to test for adrenal insufficiency, a clear and unambiguous relation between serum cortisol and mortality in critical illness has not been demonstrated. Plasma cortisol assays tend to vary considerably between different institutions, and circadian rhythms of cortisol levels result in significant fluctuations over a 24-hour period, such that the diagnosis of impaired cortisol secretion may be wrong if based on a single plasma cortisol measurement. Commercial assays only measure the total plasma cortisol, so physiologically significant increases in free cortisol can be missed. For the many reasons noted above, there continues to be uncertainty about the optimal method of detecting clinically significant adrenal insufficiency in acutely ill patients. This is one important factor that makes the relation between etomidate and adverse outcome difficult to address.

In summary: Although it is clear that etomidate inhibits adrenal hormone production, definitions to uniformly characterize levels of adrenal inhibition are still being developed.

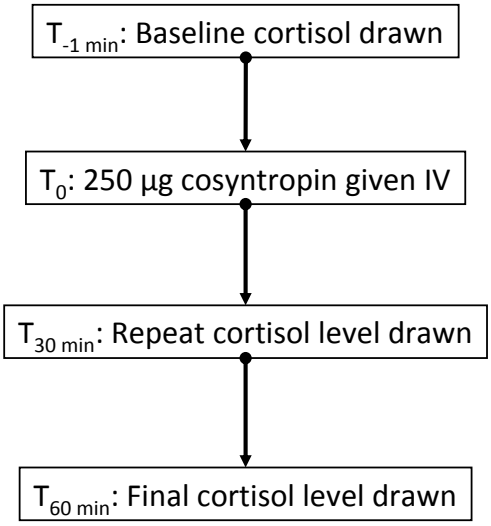

Figure 2. Standard-dose short cosyntropin stimulation test. Cortisol response is measured as the difference between the baseline cortisol level and the highest of the concentrations taken after cosyntropin administration. Relative adrenal insufficiency is typically defined by a response of <9 µg/dL.

What is the evidence that *single dose* etomidate is associated with subsequent adrenal-cortisol dysfunction?

Multiple studies have evaluated the effect of etomidate on adrenocortical function in patients undergoing elective operative procedures, with the results showing evidence of adrenocortical dysfunction after a single induction dose. In a small observational study of patients undergoing minor surgery, Duthie et al.[29] compared the use of etomidate to thiopentone by measuring the effect on synthesis of corticosteroid hormones and ACTH, and found higher levels of plasma 11-deoxycorticosterone (an intermediate molecule in steroid synthesis) at four hours and at 24 hours after administration in patients receiving etomidate. However, the clinical significance of the results remains uncertain in this small study performed in non-septic patients.

In 2001, Schenarts et al.[26] performed a prospective randomized controlled (but non-blinded) trial of a small number of consecutive patients presenting to the ED requiring intubation. These patients were randomized to receive a single bolus dose of either midazolam or etomidate during a standardized rapid sequence intubation with succinylcholine. The primary outcome variable was adrenocortical function at 4, 12, and 24 hours post induction, as measured by serum cortisol responses to cosyntropin testing. After exclusion of 13 patients, eight control patients and 10 patients were given etomidate; all controls had a normal response to cosyntropin at four hours, whereas only 30% of the etomidate patients had a normal response. Patients were excluded if steroids were used at any time during the first 24 hours of hospitalization. Although responses to the cosyntropin testing were blunted, baseline cortisol levels, although lower than in controls, tended to be within normal laboratory reference ranges. Normal responses returned at 12 to 24 hours post induction. Although no differences in clinical outcomes were reported, it is interesting to note that for the patients receiving etomidate, the number of hours intubated and the time in ICU were roughly twice the times recorded for the patients receiving midazolam. Also, the hospital length of stay (LOS) was an average two days longer for the etomidate group.

In a retrospective study of patients with septic shock, Mohammad et al.[15] examined the incidence of relative adrenal insufficiency after etomidate administration. After identifying 1,207 consecutive patients who had their serum cortisol concentrations measured, these authors were able to include in their study 152 adults with septic shock who underwent cosyntropin stimulation testing; 38 of these patients received etomidate, with an incidence of relative adrenal insufficiency of 76% compared to 51% in the controls ($p = 0.0077$). Relative adrenal insufficiency was defined as a rise in serum cortisol of less than 9 mcg per deciliter. Patients who did not authorize their medical records to be reviewed for research were excluded; however, this number is not readily available in the published paper. Overall hospital mortality rate was 57%, with etomidate patients having a mortality of 63% and controls having a non-significantly different mortality of 55% ($p = 0.45$).

In 2008, den Brinker et al.[23] reported a retrospective analysis of 60 pediatric patients who presented with meningococcal sepsis between 1997 and 2004. Of these patients, 23 had been intubated with etomidate, eight without etomidate, and 29 had not been intubated. Children receiving etomidate had significantly lower cortisol levels and retained decreased ratios of cortisol to 11-deoxycortisol up to 24 hours after admission. However, severity of illness was not specified in this population. Patients given etomidate also had higher mortality rates (although the clinical outcome is not emphasized in the manuscript, given the limitations in attributing causation through this retrospective study). The authors hypothesize that etomidate "might therefore increase risk of death."

Vinclair et al.[30] performed a prospective observational study of 40 ICU patients without sepsis who received etomidate for endotracheal intubation. The patients were assessed using serial cosyntropin tests and measurements of 11-deoxycortisol levels at 12, 24, 48, and 72 hours after etomidate administration. Adrenal inhibition was defined as a rise of less than 9 mcg per deciliter after ACTH stimulation and an accumulation of 11-deoxycortisol of greater than 8 nmol per liter from baseline. On the basis of this definition**,** etomidate-related adrenal insufficiency occurred in 80% of the patients at 12 hours, 46% at 24 hours, 9% at 48 hours, and 7% at 72 hours.

In summary: Data from these studies support the contention that a single bolus dose of etomidate results in adrenal-cortisol dysfunction as measured by laboratory analysis.

What is the clinical significance of adrenal insufficiency or

dysfunction associated with single-dose etomidate? Where are the data that support or refute the contention that single-dose etomidate is associated with increased mortality or important post-ED clinical outcomes?

The CORTICUS trial reported in 2008 by Sprung et al.[31] provided evidence of the clinical significance of adrenal insufficiency associated with single-dose etomidate. This study evaluated the effect of randomized steroid use on the outcomes of septic patients, but did not randomize the use of sedative agents. Of 499 patients randomized to receive either hydrocortisone or placebo, there was no statistically significant difference in mortality (39.2% versus 36.1% in the placebo group) at 28 days for patients who did not respond to corticotropin stimulation testing or for patients who did have a response to corticotropin (28.8% versus 28.7% in the placebo group). When all groups were combined, 86 of 251 patients in the hydrocortisone group versus 78 of 248 patients in the placebo group had died at 28 days (34.3% versus 31.5%). The authors noted more episodes of superinfection, including new sepsis and septic shock, in patients treated with steroids. A post-hoc analysis to evaluate the association between outcomes and the use of etomidate showed that mortality at 28 days increased among patients who received etomidate before randomization (mortality was 45.1% in the hydrocortisone group and 40.0% in the placebo group). Mortality in patients who did not receive etomidate was 31.5% in the hydrocortisone group and 29.6% in the placebo group. This difference was statistically significant, with $p = 0.03$. In view of the lack of randomization of these patients to receive etomidate or alternative agents, and the consequent limitation in causative attribution, the authors state that "an association between etomidate and the likelihood of adrenal hypo-responsiveness was also found in our study."

In 2002**,** Annane et al.[32] reported a reduction in mortality after low-dose corticosteroid administration in septic shock patients who failed cosyntropin testing. Almost two years into the study, these investigators amended the eligibility criteria to exclude patients who had received etomidate for endotracheal intubation. Of 72 patients who had received a single dose of etomidate to that point, 68 (94.4%) failed their cosyntropin test, compared to 71% of those who did not receive etomidate. A subgroup analysis of these 68 non-responders revealed significantly higher mortality rates in those who had been randomized to receive placebo versus corticosteroids (75.7% versus 54.8%, respectively; $p = .03$).

A prospective observational study by Malerba et al.[13] also indirectly suggests a statistically significant increase in mortality due to etomidate-associated relative adrenal insufficiency. In this study of 62 patients needing mechanical ventilation for greater than 24 hours, each patient's cosyntropin response was tested at 24 hours after endotracheal intubation. Multivariate analysis revealed that etomidate was associated with relative adrenal insufficiency (OR 12.21; 95% CI 2.99–49.74) and that the patients with relative adrenal insufficiency demonstrated more organ dysfunction and higher mortality (70.4% versus 31.4%, $p < 0.005$).

Lipiner-Friedman et al.[33] describe data collected from patients in 20 European ICUs. Data for 77% of the patients were extracted from databases of previously published studies, with data for the remaining patients coming from centers participating in (but prior to the actual start of) the CORTICUS study. After evaluation of 562 patients, 477 were retained (due to various exclusionary criteria). Of these patients, 237 received etomidate, resulting in an unadjusted odds ratio for death of 1.53 (95% CI 1.06-2.26), which becomes nonsignificant after adjustment for severity of illness in multivariate analysis.

Ray et al.[34] conducted a retrospective review of 159 septic shock patients and assessed the associations between outcome and induction agent, vasopressor use, inotrope use, and steroid use. Vasopressor use, inotrope use, or steroid administration and outcome were found not to be related to the induction agent chosen. The induction agent used and timing of administration did not influence subsequent steroid administration or dose of hydrocortisone. Of 87 patients who started steroid therapy, 58 (67%) died; of 60 patients who received no steroid, 36 (60%) died. Forty-three patients who received etomidate also received steroids; 32 of these patients (74%) died compared with 19 (58%) who died and did not receive steroids ($p = 0.121$). Hospital mortality was as follows: 69% (etomidate), 56% (propofol), 46% (thiopental), 67% (other), and 81% (none), with no statistically significant differences found. Vasopressor therapy was required less frequently and in smaller doses during endotracheal intubation when etomidate was used to induce anesthesia. The authors concluded that neither clinical outcome nor therapy was affected by the use of etomidate.

In late 2008, Hildreth et al.[25] described a prospective and randomized (but nonblinded) study of trauma patients requiring intubation. Patients were randomized to receive either etomidate (0.3 mg per kilogram) or fentanyl (100 mcg) and midazolam (5 mg). Although 61 patients met inclusion criteria, 31 were subsequently excluded from data analysis for various reasons. The average baseline serum cortisol for the etomidate group was 31 mcg per deciliter versus 27 mcg per deciliter for the controls; after medication administration, the serum cortisol average for the etomidate group was 18 versus 28 mcg per deciliter, with ACTH stimulation testing resulting in increases of 4.2 mcg per deciliter for the etomidate group versus 11.2 mcg per deciliter in controls. Hospital LOS for the etomidate group was 13.9 days versus 6.4 for the controls; ICU length of stay was 8.1 days versus three, and ventilator days were 6.3 days versus 1.5 (all comparisons were significant). Mortality between groups was not statistically significant, with 16 of 18 patients in the etomidate group surviving (11% mortality) and all patients in the control group surviving. The large number of excluded patients, combined with the small study size, unfortunately limits the generalizability of these findings.

A retrospective analysis of intubated septic patients found

a non-statistically significant increase in mortality in patients given etomidate.[35] Of the 46 patients receiving alternative agents or no agent, 18 died, yielding an unadjusted mortality of 39.1% (95% CI 25.5% to 54.6%), while of the 135 receiving etomidate, 63 died, for an unadjusted mortality of 46.7% (95% CI 38.1% to 55.4%).[35] A prospective observational study performed by the same investigators followed the outcomes of all patients meeting sepsis criteria intubated over a seven-month period.[36] A total of 106 patients with sepsis were intubated over the study period; 74 received etomidate and 32 received alternative agents or no induction agent. In-hospital mortality of patients given etomidate (38%, 95% CI 28% to 49%) was similar to those receiving alternatives (44%, 95% CI 28% to 61%). Surviving patients had a non-statistically significant increase in hospital median LOS after receiving etomidate (10 days) compared to those receiving alternatives (7.5 days), p = 0.08.[36] In these studies, however, the retrospective design and lack of randomization of patients limits the possibility of establishing causation.

In 2009, Warner et al.[37] performed a retrospective analysis of data previously collected as part of a clinical trial evaluating hypertonic saline (HS) resuscitation in hypotensive blunt trauma patients over the age of 18. The primary endpoint was development of acute respiratory distress syndrome (ARDS). Of the 209 patients initially enrolled in the HS trial, 107 underwent RSI; 13 died within the first 24 hours and could not be assessed for ARDS. There were no statistically significant differences in mortality between those that received etomidate and those that received benzodiazepines (15% versus 25%, p = 0.33). Of the 94 patients that underwent RSI and survived 24 hours, 35 received etomidate and 59 received benzodiazepines at the discretion of either the treating physician or EMS provider. In univariate analyses, the authors found a statistically significant increase in the development of ARDS and Multiple Organ Dysfunction Score (MODS) in patients given etomidate. In multivariable analysis controlling for HS, Acute Physiology and Chronic Health Evaluation (APACHE II) scores, etomidate, massive transfusion, and ISS, the authors found that use of etomidate, an APACHE II score >20, and massive transfusion remained significant predictors of the development of ARDS and MODS. Also, in the most severely injured patients with APACHE II scores of >20, patients that received etomidate had significant increases in hospital LOS, ventilator days, and ICU length of stay. Conclusions regarding etomidate use being causally related to the development of ARDS and MODS were limited because the analysis was post-hoc.

In 2009, Cuthbertson et al.[38] reported further details on a sub-group of patients in the CORTICUS trial.[31] Their goal was to evaluate the effects of etomidate on corticotropin response and 28-day mortality. Of the 499 patients analyzed, 96 received etomidate within 72 hours of inclusion in the study. Univariate analysis revealed that the number of non-responders to corticotropin was significantly higher in patients who received etomidate than in other patients (61.0%, versus 44.6%, p = 0.004), and mortality was increased in those who received etomidate (OR = 1.70, 95% CI: 1.07–2.68; p = 0.02). The authors also performed two logistic regression analyses. In the first model they adjusted for the treatment group (steroid/placebo), response to corticotropin (responder/non-responder), baseline cortisol value (as continuous variable), and simplified acute physiology score (SAPS II), and found etomidate to have a non-statistically significant effect on mortality (p = 0.06). The second model further added the sequential organ failure assessment (SOFA) score, and revealed a statistically significant increase in mortality in patients who received etomidate (OR 1.75, 95% CI 1.06 to 2.90). In patients receiving etomidate, administration of hydrocortisone did not have a significant effect on mortality. This study remains limited by the non-randomized administration of etomidate, and the limitations inherent in making adjustments for severity of illness.

Jabre et al.[39] recently performed a multicenter, controlled, single-blind trial of all non-pregnant patients over the age of 18 who required sedation for emergency rapid sequence intubation. Patients were randomized to receive either 0.3 mg/kg of etomidate or 2 mg/kg of ketamine. The primary outcome was the maximum SOFA score during the first three days in the ICU. In an effort to capture the most critically ill population, patients were excluded from analysis after randomization if they died prior to reaching the hospital or were discharged from the ICU within three days. Of the 655 patients randomized, 181 were excluded due to the aforementioned reasons, four due to missing data, and one because of withdrawn consent, which left 234 patients in the etomidate group and 235 in the ketamine group. The authors found no significant difference between the etomidate and ketamine groups in their maximum SOFA scores during the first three days in the ICU (10.3 versus 9.6, p = 0.056), and in secondary outcomes, no significant difference between the groups in their changes in SOFA scores, 28-day mortality, ventilator-free days, transfusion, fluid, or vasopressor requirements, Glasgow outcome score, or ICU-free days. Ease of intubation was also similar in the two groups, probably as a result of the muscle relaxant effect provided by succinylcholine, which was administered to all intubated patients. The only statistically significant difference between the groups was a decrease in adrenal responsiveness in patients given etomidate. Sub-group analysis of septic patients showed a non-statistically significant 7.2% increased risk of death in patients given etomidate (OR 1.4, 95% CI 0.5 to 3.5). However, the small total number of septic patients (41 receiving etomidate and 35 receiving ketamine) limits the power of this analysis.

In summary: The studies that support the contention that single-dose etomidate is associated with increased mortality or important adverse post-ED clinical outcomes are limited by their observational design. Thus, the strength of any association between etomidate and an adverse outcome can imply, but not prove, causation.

How should etomidate effects in septic patients best be measured?

The optimal method of determining relative adrenal insufficiency in critically ill patients continues to be a matter of debate. Various methods have been suggested, including a randomly drawn cortisol level of less than 15 mcg per deciliter, combined with an increment in cortisol level after a cosyntropin test of less than 9 mcg per deciliter; a cortisol increment after a cosyntropin test of less than 9 mcg per deciliter regardless of basal cortisol levels; and a random cortisol level of less than 25 mcg per deciliter in hypotensive patients or less than 20 mcg per deciliter in normotensive patients.

Rai et al.[27] recommend the use of plasma-free cortisol in the assessment of adrenal function in critical illness and further suggest that the low-dose corticotropin test is more sensitive than the conventional high-dose test. Cortisol is bound to an alpha-globulin called transcortin, or corticosteroid-binding globulin, as well as albumin, and also exists in a free form. The free hormone is the active form, and less than 5% exists as free cortisol in the plasma at normal levels of total plasma cortisol. During critical illness, levels of cortisol-binding globulin decrease, and free cortisol levels may increase secondary to the cleavage of cortisol-binding globulin by neutrophil elastase. However, because commercial assays only measure the total plasma cortisol, a physiologically significant increase in free cortisol can be missed. Serum total cortisol levels can be reduced in hypoproteinemic patients, while serum-free cortisol levels are elevated. Rai et al.[27] suggest that baseline free cortisol levels of 2 mcg per deciliter should be considered the threshold level that identifies patients at risk for adrenal insufficiency during critical illness, and that a corticotropin stimulated serum-free cortisol concentration of 3.1 mcg per deciliter or greater defines a normal response in critically ill patients.

According to a recently published ACCM consensus statement,[28] CIRCI is best diagnosed (after administration of 250 mcg of cosyntropin) by a delta cortisol of <9 mcg/dL or a random total cortisol of <10 mcg/dL. Measurement of free cortisol is not recommended for routine use, because although the free cortisol assay has some advantage over the total serum cortisol, this test is not readily available. Furthermore, the normal range of free cortisol in critically ill patients is currently unclear.[28] With regard to the use of supplemental steroids, the consensus is that clinical criteria, as opposed to ACTH stimulation testing, should be used to identify which patients with septic shock or ARDS should receive glucocorticoids.[28]

In summary: Although the clinical significance of adrenocortical suppression caused by etomidate remains uncertain, measurments of delta cortisol after administration of 250 mcg of cosyntropin, or measurement of a random cortisol level, appear reasonable to identify critical illness related corticosteroid insufficiency (CIRCI).

What are alternative induction agents? What are the advantages and disadvantages of these agents relative to etomidate?

Both ketamine and benzodiazepines, particularly midazolam, appear to be suitable alternatives to etomidate for most cases of rapid sequence intubation of septic patients. The recommended dose of midazolam for induction is between 0.1 and 0.3 mg/kg (although the package insert notes initial dose requirements of up to 0.35 mg/kg with resistant cases requiring up to 0.6 mg/kg). The recommended dosage for diazepam is 0.2-0.5 mg/kg, methohexital 1.0-3.0 mg/kg**,** and thiopental 3.0-5.0 mg/kg. As noted by Sagarin et al.,[40] in their review of the National Emergency Airway Registry database, under-dosing with midazolam is common, despite its minimal hypotensive effects, even at high doses used on patients with limited cardiac reserve.

The possibility has been raised that alternative agents, such as midazolam, may have increased hypotensive effects compared to etomidate.[41] However, the literature that suggests such adverse outcomes is itself limited by observational analyses that suggest associations but cannot prove causality.[42-47] Despite any adjustments made to account for severity of illness, the fact remains that unmeasured confounders in these studies are likely to have influenced outcome.

Ketamine has been suggested to have an excellent hemodynamic profile, making it a reasonable alternative to etomidate, at least in some patients.[41] Evidence supporting the safety of ketamine for rapid sequence intubation is now available in the form of a multicenter randomized controlled trial (discussed earlier), which concluded that ketamine is a safe and valuable alternative to etomidate.[39] Nevertheless, prior evidence suggesting adverse cardiovascular effects from ketamine may leave some physicians hesitant to adopt it as a substitute for etomidate in all patients, particularly in patients with known or suspected cardiovascular disease.[48,49,50,51] Additionally, ketamine has historically been avoided by clinicians following actual or potential brain injury due to its potential to elevate intracranial pressure, despite recent reviews questioning the significance of this effect on outcome.[52]

In summary: Both midazolam and ketamine appear to be suitable alternatives to etomidate. Given the limitations in available evidence, a strong recommendation for any particular agent at this time is not possible; however, with the need to balance theoretical harms and benefits in the presence of data supporting the non-inferiority of alternative agents which do not have similar theoretical risks associated with them, we suggest that further studies to support continued widespread use of etomidate in sepsis are warranted. As with any therapeutic decision, practitioners must choose between agents. There is sufficient reason to think that ketamine and midazolam are safe alternatives and that in the context of clear sepsis or septic shock, these agents should be considered. Practitioners would be well served by becoming familiar with the use of more than one agent while awaiting further definitive data.

What future work is needed to further clarify the characteristics of etomidate as it is currently used in patients with sepsis?

It is possible, or even likely, that the largest randomized study to date of etomidate was underpowered for detection of mortality differences in septic patients, and that further study is warranted.[39] Some doubt remains over the safety of using etomidate as an induction agent for rapid sequence intubation in septic patients.[10-12,14-20,23,35,53-57] If etomidate does in fact have a negative influence on patient outcome, this will only be proved by conducting randomized, controlled studies with sufficient power to detect what may be small but clinically important differences in outcomes. Such studies will undoubtedly require large, multicenter trials. A recent manuscript describes the creation of a prioritized Emergency Medical Services for Children research agenda specific for multicenter research, and concludes that the creation of the Pediatric Emergency Care Applied Research Network (PECARN) provides a means to answer important clinical controversies**,** mainly because it will facilitate the procedures necessary for conducting large-scale randomized, controlled trials and observational studies.[58] Likewise, the formation of the Resuscitation Outcomes Consortium now provides for a well-developed infrastructure for the conduct of multicenter trials, and offers great promise for the resuscitation community.[59]

Because the patient population requiring emergent intubation precludes their informed consent being obtained prior to treatment, studies of etomidate in these patients require exception from informed consent. Historically, this has been a challenging proposition, but recent recommendations for implementation of community consultation and public disclosure under the Food and Drug Administration's "Exception From Informed Consent Requirements For Emergency Research" now provides guidance that will probably increase the ability of investigators to obtain IRB approval to pursue research on etomidate.[60] A study in the United States (ClinicalTrials.gov Identifier NCT00441792) is in its final stages, and the results of this study may shed further light on the effects of etomidate.

CONCLUSION

The observational nature of almost all available data suggesting adverse outcomes from etomidate does not currently support abandoning its use for rapid sequence induction. On the other hand, given the limitations in the available evidence, strong support for any particular agent at this point cannot reasonably be made. The only published randomized, controlled trial evaluating etomidate (comparing it to ketamine) did not show a statistically significant difference in outcomes. However, the possibility exists that this trial was underpowered for the subgroup of patients with sepsis. Because etomidate decreases the cortisol response, and because cortisol production in some settings may be clinically important, practitioners should be familiar with the available evidence while awaiting newer studies that may clarify these issues. The authors do not currently have unanimous agreement on a single best agent but feel that the potential for adverse effects of etomidate in clearly septic patients without cardiovascular disease warrants consideration of ketamine or midazolam in these patients.

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Authors	Year	Design	Population
Duthie DJR, Fraser R, Nimmo WS	1985	Prospective, randomized, controlled trial	Patients undergoing minor surgery
Malerba G, Romano-Girard F, Cravoisy A, et al.	2005	Prospective observational	Mechanically ventilated ICU patients
Schenarts CL, Burton JH, Riker RR	2001	Prospective, randomized, controlled trial	Consecutive patients presenting to the ED requiring intubation
Mohammad Z, Afessa B, Finkielman JD.	2006	Retrospective study	Adults with septic shock given a CST
den Brinker M, Hokken-Koelega AC, Hazelzet JA, et al.	2008	Retrospective study	Pediatric meningococcal sepsis
Vinclair M, Broux C, Faure P, et al.	2008	Prospective, observational cohort study	Critically ill patients without sepsis who received a single dose of etomidate
Sprung CL, Annane D, Keh D, et al.	2008	Observational outcome from a randomized, double-blind, comparison of hydrocortisone versus placebo	Patients with septic shock
Annane D, Sebille V, Charpentier C, et al.	2002	Observational outcome from a randomized, double-blind, comparison of hydrocortisone + fludrocortisone versus placebo	Patients with septic shock
Malerba G, Romano-Girard F, Cravoisy A, et al.	2005	Prospective observational study	Consecutive, acutely ill patients needing mechanical ventilation for more than 24 h
Lipiner-Friedman D, Sprung CL, Laterre PF, et al.	2007	Retrospective cohort study	Patients with severe sepsis and septic shock who had undergone an ACTH stimulation test on the day of the onset of severe sepsis
Ray DC and McKeown DW	2007	Retrospective cohort study	Patients with septic shock
Hildreth AN, Mejia VA, Maxwell RA, et al.	2008	Prospective, randomized, controlled, non-blinded study	Adult trauma patients requiring intubation
Tekwani K, Watts H, Chan C, et al.	2008	Retrospective cohort study	Intubated patients with sepsis
Tekwani KL, Watts HF, Rzechula KH, et al.	2009	Non-randomized, prospective observational study	Intubated patients with sepsis
Jabre P, Combes X, Lapostolle F, et al.	2009	Randomized, controlled, single-blind trial	Patients 18 years or older who needed sedation for emergency intubation
Cuthbertson BH, Sprung CL, Annane D, et al.	2009	Substudy of CORTICUS randomized, double-blind, placebo-controlled trial	Patients with septic shock
Warner KJ, Cuschieri J, Jurkovich GJ, et al.	2009	Post-hoc analysis of clinical trial of prehospital hypertonic saline administration	Critically ill trauma patients requiring intubation

CST, corticotropin stimulation test; *ICU*, intensive care unit; *PICU,* pediatric intensive care unit; *SOFA,* sequential organ failure ass

Number of patients	Etomidate Dose	Outcome	Author's Findings
12	0.3 mg/kg	Plasma steroid levels	Increased 11-deoxycorticosterone in patients receiving etomidate
62	0.2–0.4 mg/kg	Cortisol level after CST after 24 hrs of ventilation	Lower cortisol levels in patients given etomidate (OR 12.2)
31 (13 excluded)	0.3 mg/kg	Cortisol level after CST at 4, 12, and 24 hours post-induction	Decreased cortisol response at 4 hrs after etomidate
152	Not specified	Serum cortisol after CST	Lower cortisol levels in patients given etomidate
60	Median 0.29 mg/kg (range 0.20–0.67mg/kg)	Adrenal hormone concentrations after PICU admission and after 12h and 24h	Children who received etomidate had significantly lower cortisol levels
40	Median 0.33 mg/kg (range 0.22 to 0.80 mg/kg)	Cortisol at baseline and 60 min after CST at 12, 24, 48, and 72 h after etomidate administration	Decreased cortisol response at 12 hrs after etomidate, improving by 48 hrs
499 (with subgroup of 96 receiving etomidate)	Not specified (etomidate not randomized)	Mortality at 28 days in patients not responding to corticotropin test	Increased rate of death among patients given etomidate (non-randomized)
300 (with subgroup of 72 patients receiving etomidate)	Not specified (etomidate not randomized)	Mortality at 28 days	Increased rate of death among patients given etomidate (non-randomized)
62	0.2–0.4 mg/kg	Response to short corticotropin test	Increased relative adrenocortical deficiency seen in patients given etomidate
477 (237 receiving non-randomized etomidate)	Not specified (etomidate not randomized)	In-hospital mortality	Increased mortality (unadjusted) in patients receiving etomidate
159	Median of 12 mg (range of 5 mg to 20 mg)	In-hospital mortality	No statistically significant differences found
30	0.3 mg/kg	Adrenal function, length of stay on ventilator, ICU, and hospital, and in-hospital mortality	Increased adrenal insufficiency, length of stay on ventilator, in ICU, and in hospital in patients receiving etomidate
181	Not specified (physician-chosen, single dose)	In-hospital mortality	No statistically significant differences found
106	Not specified (physician-chosen, single dose)	In-hospital mortality and length of stay	No statistically significant differences found
655	0.3 mg/kg	SOFA score	No statistically significant differences found
499 (with subgroup of 96 receiving etomidate)	Not specified (etomidate not randomized)	Corticotropin response, 28-day mortality	Increased non-responders to corticotropin and higher 28-day mortality in one multi-variate model in patients who were given etomidate
94	Not specified (etomidate not randomized)	Development of posttraumatic ARDS	Higher rates of late onset ARDS in patients given etomidate

sessment; *ARDS,* acute respiratory distress syndrome

A Pilot Study of the Performance Characteristics of the D-dimer in Presumed Sepsis

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Objectives: To determine if a sensitive D-dimer assay can exclude progression to organ dysfunction, death, and intensive care unit (ICU) admission in patients presenting to the emergency department (ED) with suspected infection, and if increasing levels of D-dimer are predictive of those end points.

Methods: The study took place at two academic EDs, both located in tertiary care hospitals. This was a prospective convenience sample of adult patients presenting with an infective process and at least two of four criteria for the Systemic Inflammatory Response Syndrome. We measured D-dimer levels in the participants and abstracted their records for the end points. Sensitivity and specificity were calculated and receiver operating characteristic analysis was performed to determine if a higher cutoff would have a greater specificity for our end points.

Results: We enrolled 134 patients. Twelve were excluded from analysis (10 for lack of a D-dimer, one for recent surgery, and one for complete loss to follow up). Using the cutoff of 0.4 established by our laboratories as positive, the D-dimer had a sensitivity of 94% (CI95; 76-99) for organ dysfunction in the ED, 93% (72-99) for organ dysfunction at 48 hours, 93% (81-98) for ICU admission, and 100% (63-100) for 30-day mortality. However, at this cutoff, specificity was not statistically significant. Significantly raising the cutoff for a positive resulted in a decrease in sensitivity but improved specificity.

Conclusion: This study was limited by its nonconsecutive patient recruitment and sample size. A normal D-dimer may exclude progression to organ dysfunction, ICU admission, and death and, at higher cutoff levels, could help risk stratify patients presenting to the ED with signs of sepsis.
[West J Emerg Med. 2010;11(2):173-179.]

INTRODUCTION

Background

Patients presenting to the emergency department (ED) in septic shock have been shown to benefit from early goal-directed therapy aimed at improving perfusion[1] and early antibiotic therapy.[2] Our tools are currently limited in predicting which ED patients with an infection, but without overt sepsis or organ dysfunction, will progress to severe sepsis, shock, or death. The Systemic Inflammatory Response Syndrome (SIRS) criteria, while part of the definition of sepsis, are not adequately sensitive or specific to be used alone to predict the clinical course of a patient.[3] A predictive biomarker could be helpful to clinicians to risk-stratify infected patients to an appropriate level of care.

Importance

As a candidate biomarker of sepsis, fibrin D-dimer stands apart in its availability in the ED. It has demonstrated sensitivity for sepsis in ICU patients.[4,5] Additionally, it has been correlated with other potential markers of sepsis and is a potential predictor of mortality and organ system failure.[6-9] Shilon et al.[10] demonstrated an association between levels

Table 1. Systemic Inflammatory Response Syndrome Criteria

Temperature	<36 degrees C or >38 degrees C
Heart Rate	>90 beats per minute
Respiratory Rate	>20 breaths/min or $PaCO_2$ <32 mm Hg
White Blood Cell Count	>12,000 cells/mm^3, <4,000 cells/mm^3, or >10% bands

Table 2. Sepsis Definitions

Sepsis	2 or more symptoms of inflammation and presumed/confirmed infection
Severe Sepsis	Sepsis + Organ Dysfunction
Septic Shock	Sepsis + hypotension not reversed by fluid resuscitation.

of D-dimer and severity of disease in hospitalized patients with community-acquired pneumonia. These studies have focused primarily on patients requiring ICU-level care and have not examined a broader patient population, therefore limiting application of the data to ED patients. However, not all studies have shown the D-dimer to be useful early in the course of sepsis. Iba et al.[11] in 2007 failed to show a difference in D-dimer levels on Day 0, but a difference appeared on Day 2. In an ED pilot study, D-dimer had a sensitivity of only ~61-67% for patients who ultimately were found to have positive blood cultures.[12] This study used a semi-quantitative D-dimer assay and only looked at blood culture results without looking at clinical outcomes. If the early correlation of D-dimer levels with illness severity described in ICU patients could be reproduced in the ED population, the D-dimer could be used to better risk stratify patients with infections into appropriate levels of care.

Goals of This Investigation

We sought to determine if the D-dimer is an appropriate test in the initial evaluation for sepsis. Our primary hypotheses are that the D-dimer is adequately sensitive to exclude organ dysfunction, ICU requirement, and mortality in patients presenting with clinical presentations consistent with sepsis, and that higher levels of D-dimer are predictive of organ dysfunction, ICU requirement, and death. We considered a sensitivity ≥ 90% clinically important and desired to demonstrate 95% confidence intervals of 10% or less. A test with these characteristics would potentially help determine which patients (who typically would be admitted to a ward level of care) would benefit from more intensive monitoring or aggressive therapy.

METHODS

Study Design

We performed a prospective, observational study using a combination of prospective laboratory analysis and chart auditing to investigate the correlation between a positive D-dimer and the end points of hospital admission, initial ICU admission, organ dysfunction, and 30-day mortality. Our sample size was calculated to be 116 patients, based on the estimate of a relative risk of 5.5 for mortality in patients with an elevated D-dimer compared to those with normal D-dimers,[7] and 50% of the patients having positive D-dimers.

Setting

All patients in the study visited the EDs at two tertiary-care military medical centers from August 2007 through March 2008. The institutional review board approved and monitored the study at both institutions.

Selection of Participants

All adult patients presenting to the ED regardless of mode of arrival with a suspected infection (radiographic, laboratory, or clinical findings indicating a need for antibiotics), as determined by the treating team's attending physician and/or third year resident and at least two out of four SIRS criteria (Table 1), were eligible for enrollment. The presence of two or more of the four SIRS criteria was established as a criterion to focus the study on a higher acuity level of infection consistent with the diagnostic criteria for sepsis (Table 2). Patients with a history of thromboembolic disease, recent surgery, or those in basic military training (due to issues with follow up and ethical issues centered on ability to consent) were excluded. Pregnant women and patients with cancer were not excluded from the study. Patients were identified, consented, and enrolled as a convenience sample by senior resident and attending physicians in the ED at the time of presentation. Next of kin or powers of attorney were allowed to provide consent in incapacitated patients.

Data Collection

Patients who agreed to participate in the study had blood samples sent separately from their clinical lab work for measurement of their D-dimer levels. All laboratory work including the D-dimer assay was performed by the institutions' regular lab facilities. The treating teams did not have access to the D-dimer results unless they had ordered a separate D-dimer study as part of their clinical evaluation. To evaluate end organ dysfunction we ordered a complete metabolic panel, complete blood count, PTT, PT, and serum lactate as part of the study. The results from these studies were available to the ED and admitting teams. Data from the ED encounter (SIRS criteria, suspected infection, and disposition) were entered on a standard data sheet by the enrolling physician. ICU admission was determined by the admitting service in conjunction with the emergency physicians. Generally, patients requiring vasopressor support, ventilator support, or close monitoring as determined by the admitting service were

Table 3

Demographics		
Average Age	59	Range (19-93) std dev= 21
Gender	45% Male	55% Female
Presenting Infection	**Number**	**Percentage**
Pulmonary	69	57%
Urinary	14	11%
Intra-abdominal	21	17%
Neurologic	3	2%
Oropharyngeal	5	4%
Skin/Soft tissue	10	8%
Severity of Illness		
Mean # of SIRS Criteria	2.5	Range (2-4)
Mean lactate	1.7	Range (0.6-5.8) std dev= 1.0
MSOF in ED	16	13%
Admissions	99	81%
Average length of stay (days)	5.3	Range (1-30) std dev= 5.4
ICU admissions	29	24%
Average ICU stay (days)	4.7	Range (1-24) std dev= 5.5
MSOF at 48 hours	14	11%
MSOF within 30 Days	25	20%
In-hospital deaths	5	4%
30-days mortality	6	5%

SIRS, systemic inflammatory response syndrome; *MOSF*, multisystem organ failure; *ICU*, intensive care unit

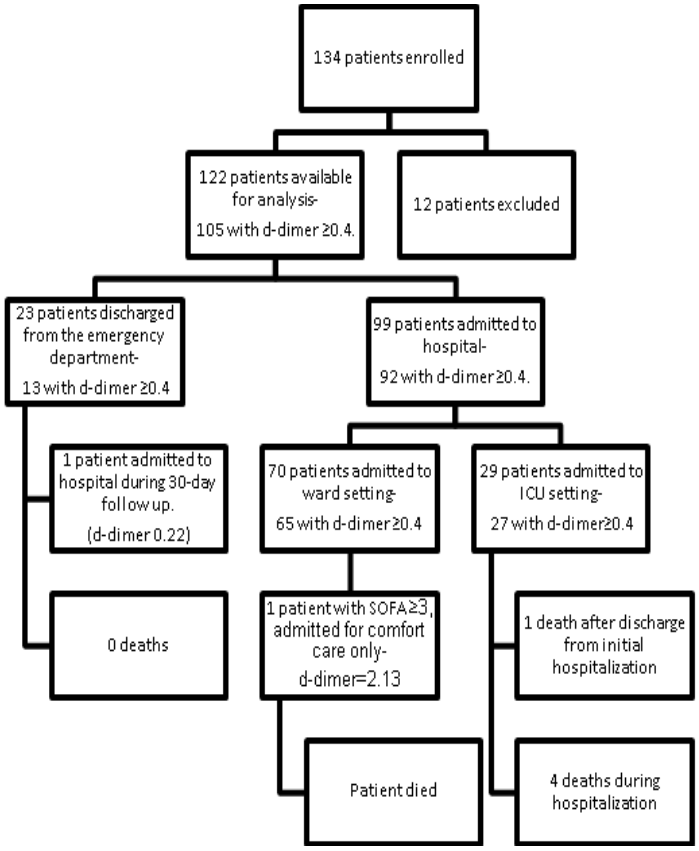

Figure 1. Outcomes for all enrolled patients.

admitted to the ICU teams. The primary investigator then used the same sheet to abstract the patients' ED and inpatient charts through the next 30 days for evidence of the primary end points. Laboratory results, including lactate, coagulation panels, chemistry panels, and blood counts, were abstracted as well. Patients were called at the end of the 30-day follow-up period to confirm that no other hospitalizations occurred outside the primary medical system. After all other variables were abstracted the D-dimer result was added to the datasheet. The primary investigator was not blinded to the study objectives during the abstraction phase.

Methods of Measurements

We used the Liatest D-dimer assay (Diagnostica Stago, Parsippany, New Jersey), a quantitative, microlatex agglutination test with a reference cut-off of 0.4 mg/dL as positive. The assay is run on venous blood collected in calcium citrate tubes. This assay is the same assay used in the evaluation of thromboembolic disease at both of our institutions. We utilized the Sepsis-related Organ Failure Assessment (SOFA) to determine the presence of organ dysfunction. The SOFA score uses measurements of cardiovascular, neurologic, coagulation, hepatic, renal, and respiratory function to create a composite score. We maintained the convention of a SOFA score of three or greater as positive for significant organ dysfunction.[13] When explicit data needed to calculate a complete SOFA score were missing from the record the patient was assigned the least dysfunctional value for that system and were included in the data analysis. Mortality was determined using a combination of the inpatient and ED records and telephone follow up. After the 30-day follow up was completed, the primary investigator transferred the de-identified data into a password protected Microsoft Access (Microsoft, 2007) database.

Primary Data Analysis

We used SPSS 16.0 (SPSS, 2007) to compute descriptive statistics of the participants and to determine the sensitivity, specificity, odds ratio, positive likelihood ratio and negative likelihoods associated with a cut point of 0.4 mg/dL. We then constructed receiver operating characteristic (ROC) curves for each of the study end points, and a D-dimer cut point at ~95% specificity was evaluated for its sensitivity, odds ratio, and positive and negative likelihood ratios. Selected randomly, 10% of the records (14) were abstracted by a second reviewer blinded to D-dimer results, and inter-rater variability was evaluated using the kappa statistic.

In a 1996 article Gilbert and Lowenstein described

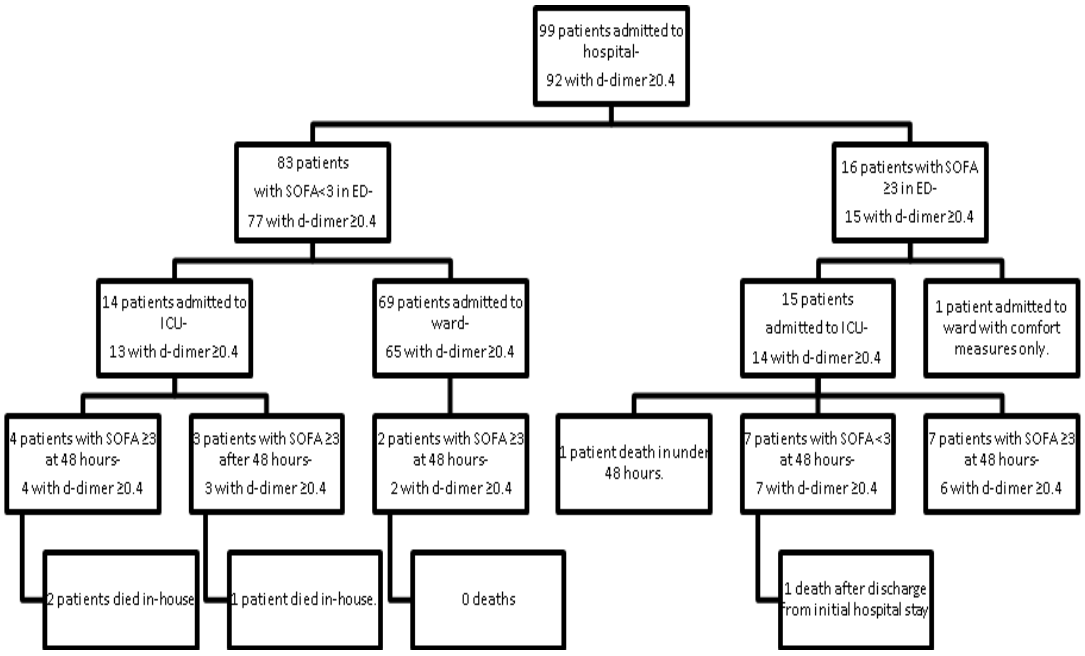

Figure 2. Outcomes for all admitted patients.

eight criteria of a quality retrospective review study. Those criteria are trained abstractors, explicit case-selection criteria, definition of variables, abstraction forms, meetings among abstractors and study coordinators, monitoring of abstractor performance, blinding of abstractors to study goals, and testing of interrater agreement.[1,4] We used a single abstractor, who was not blinded to the study objectives, but remained blinded to D-dimer results until after the other data points were abstracted. Selection criteria and variable definition were explicitly defined *a priori*. Abstractor performance was monitored through the blinded re-abstraction of a random 10% of the charts by a blinded second abstractor and then calculating interrater reliability with a kappa statistic. Other than the lack of complete blinding of the primary abstractor, Gilbert and Lowenstein's criteria were met.

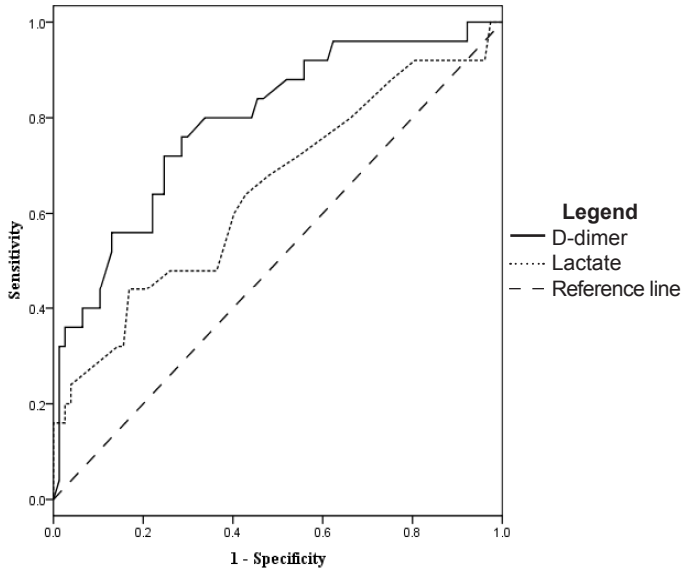

Figure 3. Receiver operator characteristic curve for intensive care unit admission. D-dimer area under the curve 0.79 (95% CI 0.69-0.89) Lactate area under the curve 0.65 (95% CI 0.52-0.78).

RESULTS

We enrolled 134 patients in the study from August 2007 to March 2008. Twelve patients were excluded from data analysis, 10 for lack of a D-dimer (due to hemolysis or loss of the sample), one for a recent surgery, and one for complete loss to follow up. Demographic data is presented in Table 3. There were no discrepancies between the abstractors in the recording of the primary variables of interest, (admission, ICU admission, organ dysfunction in the ED, organ dysfunction at 48 hours, organ dysfunction during the 30-day follow up, in-hospital death, and 30-day mortality), giving a kappa of 1.0 (95% CI; 0.5-1.0).

Figures 1 and 2 show the outcomes of patients entered in to the study. Thirty-day mortality was 5%, 24% were admitted to the ICU, and 20% had SOFA scores greater than three at any point in the 30-day follow-up period.

Retrospectively using quality improvement data collected separately from our study, we estimate that 60 patients were admitted to the ICU with sepsis through both of our EDs during the study period and we were only able to enroll 29. If the same proportion of ambulatory and ward patients was missed, then we were only able to enroll an estimated 50% of the eligible patients.

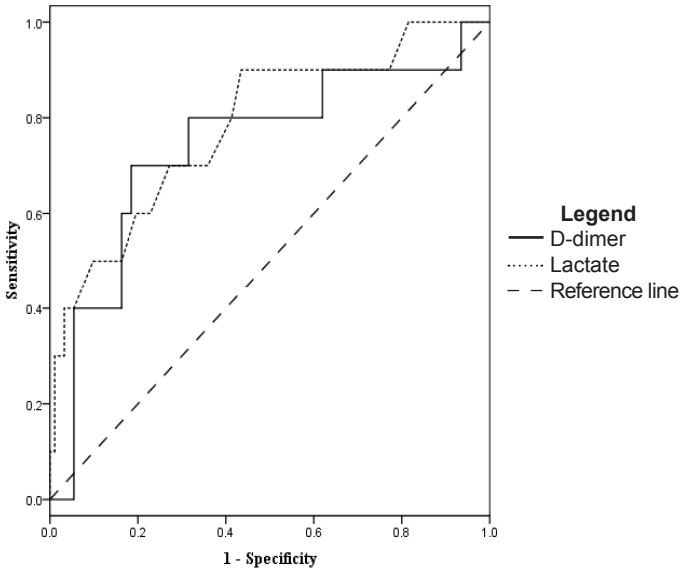

Figure 4. Receiver operator characteristic curve for Organ Dysfunction at 48 hours. D-dimer area under the curve 0.74 (95% CI 0.56-0.92). Lactate area under the curve 0.78 (95% CI 0.63-0.94).

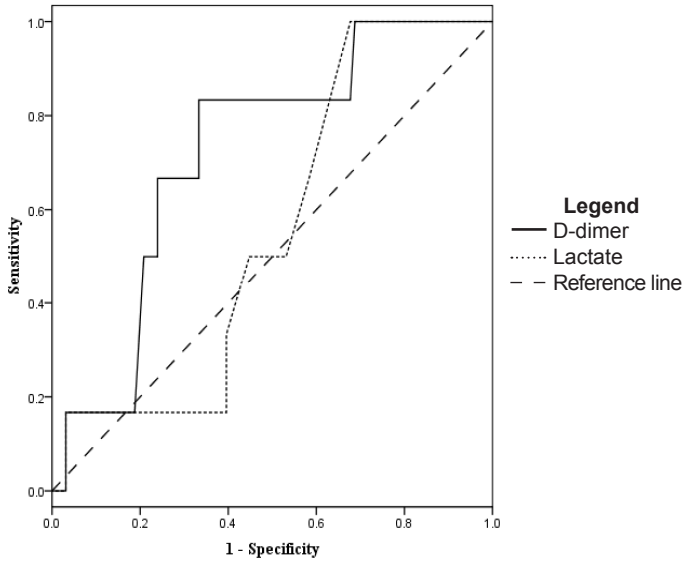

Figure 5. Receiver operator characteristic curve for 30-days mortality. D-dimer area under the curve 0.72 (95% CI 0.55-0.89). Lactate area under the curve 0.65 (95% CI 0.37-0.74).

The D-dimer was associated most closely with the need for ICU level care. At a level of 0.4 mg/dL the sensitivity was 93% (95% CI 81-98) and specificity was 16% (95% CI 12-18). However, other measures of association did not reach statistical significance. Odds ratio was 2.6 (95% CI 0.62-11), positive likelihood ratio 1.1 (95% CI 0.93-1.2), and negative likelihood ratio was 0.43 (95% CI 0.11-1.5). After ROC analysis (Figure 3) we found that 95% specificity was achieved with a D-dimer level of 4.0 mg/dL. At this cut off sensitivity was 35% (95% CI 23-43), the odds ratio was 9.3 (95% CI 2.9-29), the positive likelihood ratio was 6.4 (95% CI 2.5-17), and the negative likelihood ratio was 0.69 (95%CI 0.58-0.85).

Using the D-dimer to evaluate which patients would have a SOFA score greater than three at 48 hours from admission gave a sensitivity of 93% (95% CI 72-99) and a specificity of 15% (95% CI 12-16). Other measures of association did not reach statistical significance, with an odds ratio of 2.3 (95% CI 0.35-14), positive likelihood ratio of 1.1 (95% CI 0.82-1.2), and a negative likelihood ratio of 0.48 (95% CI 0.08-2.3) at D-dimer cut off of 0.4 mg/dL. ROC analysis (Figure 4) gave a D-dimer level of 7.0 mg/dL as 94% specific, with a sensitivity of 29% (95% CI 13-47), odds ratio 6.8 (95% CI 1.7-27), positive likelihood ratio of 5.1 (95% CI 1.7-15), and negative likelihood ratio of 0.76 (95% CI 0.55-0.95)

For 30-day mortality, a D-dimer level of 0.4 mg/dL or greater gave a sensitivity of 100% (95% CI 63-100), failing to achieve our desired degree of precision. The remaining tests were not significant with a specificity of 15% (95% CI 13-15), an odds ratio of ∞ (95% CI 0.25-∞), a negative likelihood ratio of 0 (95% CI 0-2.9), and a positive likelihood ratio of 1.2 (CI 95% 0.73-1.2). Using the ROC curve (Figure 5), a 95% specificity for 30-day mortality occurred at a D-dimer level of 9.0 mg/dL, and had a sensitivity of 17% (CI 95% 3-52), an odds ratio of 3.1 (95% CI 0.44-24), a positive likelihood ratio of 2.8 (95% CI 0.46-12), and a negative likelihood ratio of 0.89 (CI 95% 0.51-1).

Lactate levels were available in 102 of the 122 patients. We generated ROC curves using the data from these 102 patients for the end points of ICU admission, organ dysfunction at 48 hours, and 30- day mortality. These curves are shown in Figures 3-5 for comparison with the curves for the D-dimer data.

DISCUSSION

Our results suggest that the D-dimer could be used as a screening test in the ED to exclude significant organ dysfunction, intensive care requirement, and possibly mortality in patients with suspected infection and SIRS. While the values for the sensitivity of the test were above our 90% threshold, the confidence intervals remained too wide to definitively state that the test is adequate to use by itself in determining the disposition of patients from the ED. At the typical cut off for normal (0.4 mg/dL) the odds ratio, positive likelihood ratio, negative likelihood ratio and specificity failed to reach significance.

In this study the D-dimer performed better as a positive predictor at cut points 10-20 times greater than normally used for thromboembolic disease. Specifically in the setting of organ dysfunction, the test might provide useful clinical positive predictive power. These odds ratios at the higher cutoffs were in a range that could allow the test to be used

alone or in a panel of tests to increase or decrease the pretest probability. However, the value of the useful cut point was different for different end points, and requires prospective validation in a larger study to be of use clinically.

Notably, the D-dimer was elevated in the nine patients who had not yet developed organ dysfunction, but who went on to do so later in their hospital course (Figure 2). Patients who demonstrate severe sepsis or shock early in their hospital course generally have more severe organ dysfunction, but they may have a decreased mortality rate and decreased length of stay in the ICU when compared to patients who develop sepsis later in their hospital course.[15] Utilizing the D-dimer in the early testing of patients with suspected sepsis may help to identify these patients earlier in their illness.

LIMITATIONS

The primary limitation of our study is its sample size and convenience patient sampling. We estimate that only 50% of patients eligible to be enrolled during the study period were enrolled, and this reflects in the wide confidence intervals for the test characteristics computed. Particularly, this lack of power limits our ability to comment on the ability of the D-dimer to exclude or predict mortality.

Additionally, not all data points were available for all patients. This may have lead to an underestimation of the patients' SOFA scores and a resulting underestimation of the number of patients suffering from organ dysfunction. This underestimation of the degree of organ dysfunction likely would skew our results away from confirming our hypotheses given the number of patients with elevated D-dimers.

We kept our study population relatively broad with no exclusion criteria for patients with renal disease, cancer, pregnancy, or advanced age to better mirror an actual ED population. These populations can have higher D-dimer levels than a young healthy population and represent a possible confounding variable in our results.

Our lack of universal screening for thromboembolic disease creates a potential confounder. One patient in this study was found to have a pulmonary embolism during a subsequent hospitalization. She was diagnosed with pneumonia and sepsis syndrome during her initial evaluation and her blinded D-dimer was 1.85 at that time. One week later, she returned to the ED and was diagnosed with a pulmonary embolism by CT angiography. Given the large percentage of D-dimers in our study, positive D-dimers are not likely to be useful in distinguishing pneumonia from pulmonary embolism. Ordering angiograms solely on the basis of a D-dimer in our population would lead to overutilization of ionizing radiation.

CONCLUSION

Our preliminary study demonstrated that the fibrin D-dimer is a potentially sensitive diagnostic test for use in the exclusion of organ dysfunction, need for intensive care unit admission and 30-day mortality with ROC curves similar to serum lactate, but has poor specificity at usual D-dimer thromboembolism cutoffs. As a confirmatory test for the presence of organ dysfunction the assay performed well enough at higher cut points (10-20 times normal) to potentially be used as a component of a model or scoring system, but not well enough to use as a stand-alone test. These higher cutoffs must be tested *a priori* in a larger patient sample to validate their potential use.

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Incidence, Radiographical Features, and Proposed Mechanism for Pneumocephalus from Intravenous Injection of Air

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Background: Pneumocephalus typically implies a traumatic breach in the meningeal layer or an intracranial gas-producing infection. Unexplained pneumocephalus on a head computed tomography (CT) in an emergency setting often compels emergency physicians to undertake aggressive evaluation and consultation.

Methods: In this paper, we report three cases of pneumocephalus that appear to result from retrograde injection of air through an intravenous (IV) catheter. We also performed a retrospective study to determine the incidence of presumed IV-induced pneumocephalus and etiologies of pneumocephalus in our emergency department (ED) population.

Results: The incidence of idiopathic and presumed IV-induced pneumocephalus was 0.034% among all head CTs ordered in the ED and 4.88% among cases of pneumocephalus seen in the ED. These cases are characterized clinically by the absence of signs and symptoms of pathologic pneumocephalus and radiographically by the distribution of air densities along the cranial venous system on head CTs.

Conclusion: Idiopathic and presumed IV-induced pneumocephalus could be considered in the workup of ED patients with unexplained intracranial air on head CT if there are no findings of pathological causes for the pneumocephalus on history and physical examination and if the head CTs show a characteristic distribution of air limited to the cranial venous system. Knowledge of this clinical entity in the evaluation of ED patients with unexplained pneumocephalus can lead to more efficient emergency care and less patient anxiety. [West J Emerg Med. 2010; 11(2):180-185.]

INTRODUCTION

Pneumocephalus on computed tomography (CT) of the head indicates the presence of air or gas within the cranial vault and implies a breach in the craniodural barrier or an intracranial gas-producing infection. Pathological conditions that can give rise to pneumocephalus include head injury, tumor, barotrauma, and infection, among others. Although rarely encountered, tension pneumocephalus is a clinical emergency in which pneumocephalus produces a mass effect on the brain. In the emergency setting, the identification of pneumocephalus on head CT thus usually compels emergency physicians to pursue aggressive evaluation and specialty consultation. These measures are costly and can add to patient discomfort and anxiety.

Pneumocephalus has been recognized with increasing frequency in medical and emergency medicine literature.[1] Our search of the MeSH database in English, using the major heading "pneumocephalus," yielded 652 articles.

Of these, 301 (46.2 %) were published in the last 10 years. Although pneumocephalus is most commonly seen after a neurosurgical procedure and trauma, many case reports have implicated a diverse range of etiologies. We have recently noted occasional cases of pneumocephalus in the emergency department (ED) that lack an obvious medical cause. We report here three cases of pneumocephalus that appear to result from retrograde injection of air through an intravenous (IV) catheter. The lack of signs and symptoms of pathologic causes of pneumocephalus in these cases, combined with distinct radiographic features, can be useful to emergency physicians. We also performed a retrospective study to determine the incidence of idiopathic and presumed IV-induced pneumocephalus and the etiologies of undifferentiated pneumocephalus in our ED population.

METHODS

This is a case series of idiopathic pneumocephalus and retrospective study from May 2005 to May 2007 at an inner-city university ED in the Midwest. The ED, which sees 48,000 patients per year, is a Level 1 trauma center and a major tertiary referral center for neurosurgical services. All neuroradiology studies at this institution are read by one of the two neuroradiologists (MFO and FH), who manually collected the cases of pneumocephalus for this study. At the end of the study period, we performed a computer query using the free-text method. The query searched for all head CTs ordered from the ED between May 2005 and May 2007, using the search terms pneumocephalus, pneumocephali, (intracranial) air, (intracranial) gas, (intracranial) aerocele, (intracranial) pneumocyst, and (intracranial) pneumocele. We performed a free-text search method, examining dictated radiology reports for the above search terms during the study period. Once electronically identified, these reports were manually reviewed and verified against the cases identified by the neuroradiologists. Medical records of pneumocephalus cases were subsequently reviewed, clinical data abstracted, and etiology categorized by a research associate and one of the authors (TPT); patients were not contacted directly. The protocol was approved by the local IRB.

RESULTS

There were 8,747 CTs performed during the 24-month study period. Of these, 68 (0.78%) showed pneumocephalus. Table 1 tabulates the etiologic categories for these 68 cases. We identified three cases of idiopathic pneumocephalus, due presumably to injection of air through IV catheter, for an incidence of 0.034%.

Case 1

A 55-year-old female presented to the ED with the chief complaint of a frontal headache. A peripheral IV line was placed during the initial management. The initial head CT without contrast in the ED showed pneumocephalus in or surrounding the cavernous sinuses, as well as a small amount of epidural air at the level of the foramen magnum (Figure 1). The patient was admitted to the hospital for observation and neurosurgical consultation, and her hospital course was uneventful. The consensus by the admitting service, neurosurgery, and neuroradiology was that the pneumocephalus was iatrogenic, presumably from IV injection of air. The patient was discharged home the next day. A repeat head CT six days later showed complete resolution of the pneumocephalus. Follow up at four months as an outpatient showed no symptoms related to her pneumocephalus.

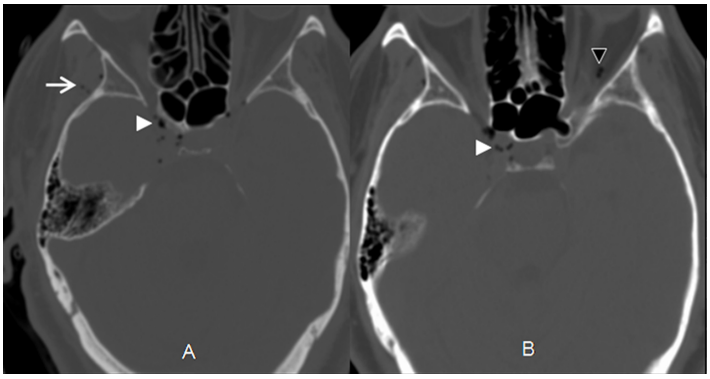

Figure 1. (Case 1). Axial cranial computed tomography through the sella region of a 55-year-old female who presented to the emergency department with the chief complaint of frontal headache. Air in the right cavernous sinus (white arrow heads, A and B), right superficial temporal veins (arrow, A), and left intraorbital veins (black arrow head, B).

Case 2

An 87-year old-female presented to the ED with the chief complaint of altered mental status. The family stated that the patient was agitated more than usual, with no history of a recent fall, head trauma, fever, or surgery. A peripheral IV line was placed during the initial management. The initial head CT without contrast in the ED showed gas in the right cavernous sinus and superior ophthalmic vein (Figure 2). The patient was admitted for observation and medical management. The consensus by the admitting service and neuroradiology was that the pneumocephalus was iatrogenic, presumably from IV injection of air. The patient was discharged to an assisted living facility two days later. A follow-up CT scan two months later showed complete resolution of the pneumocephalus.

Case 3

A 56-year-old male presented to the ED with the chief complaint of a fall after experiencing a loss of control of his body. The patient did not suffer any head trauma as a result of the fall. A peripheral IV line was placed during the initial management. The initial head CT without contrast in the ED showed small punctate areas of air within the cavernous sinus (Figure 3). The patient was admitted to the hospital for

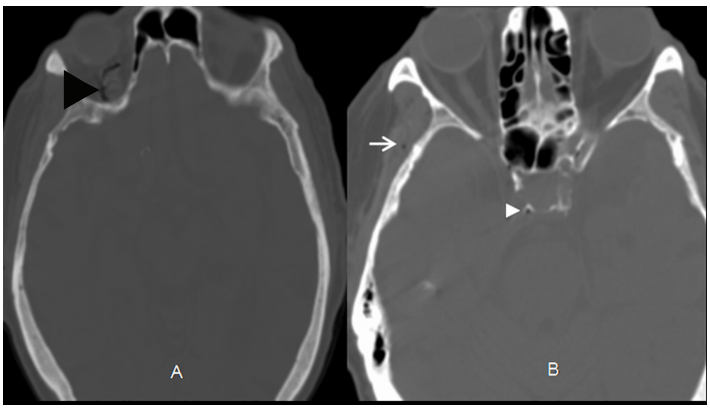

Figure 2. (Case 2). Axial cranial computed tomography through multiple levels in an 87-year-old female who presented to the emergency department with the chief complaint of altered mental status. Air is seen in the in the right cavernous sinus (white arrow heads, B), right superior orbital veins (black arrow head, A) and right superficial temporal veins (arrow, B).

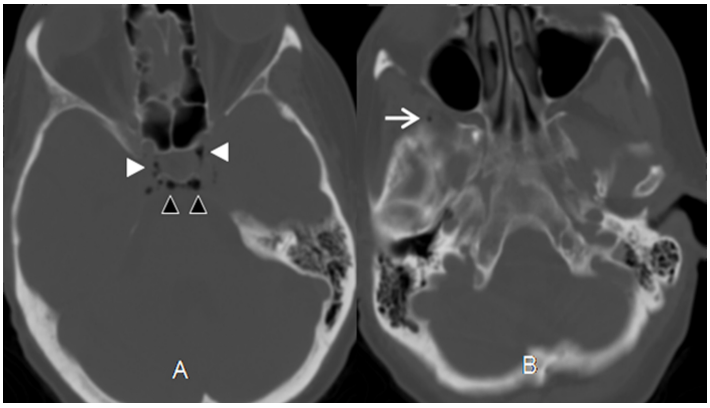

Figure 3. (Case 3). Axial cranial computed tomography through the sella region of an 56-year-old male who presented to the emergency department with the chief complaint of fall after feeling a loss of control of his body. Air is seen in bilateral cavernous sinus (white arrowheads, A), behind the dorsum sella (black arrowheads, A), and right superficial temporal veins (arrow, B).

further workup. The consensus by the admitting service and neuroradiology was that the pneumocephalus was iatrogenic, presumably from IV injection of air. He was discharged home the next day. Follow-up 10 weeks later showed no lasting sequelae from the pneumocephalus.

In all three cases we found no evidence in the nursing documentation that pointed to an identification of witnessed IV infusion of air, malfunction of the IV contrast injection equipment, or one particular individual who might have been responsible for the three cases presented.

DISCUSSION

In this study idiopathic pneumocephalus, presumably from retrograde IV injection of air, is a relatively uncommon event, occurring in approximately one out of 3,000 CT head scans ordered from the ED. As discussed in subsequent sections, the diagnosis of presumed IV-induced pneumocephalus could be considered in the evaluation of unexplained pneumocephalus if 1) the history and physical examination are inconsistent with infection in the head and neck area, craniofacial trauma, barotrauma, or recent cranial surgery; 2) patients do not have the classic symptoms of tension pneumocephalus; and 3) the pattern of air observed on head CT follows the cranial venous anatomical distribution.

Pneumocephalus was first described by Lecat in 1741.[2] Thomas revisited the concept in an 1866 autopsy report of a patient who sustained head trauma, and Chiari in 1884 in another autopsy report of a patient with chronic ethmoid sinusitis.[3] Chiari's report was remarkable not only because he was the first to demonstrate the presence of intracranial air during life, but also because he was the first to advance a mechanism for the intracranial air. The force of sneezing, which blew air through a fistula between the ethmoid sinus into the frontal cavity, resulted in the fatal pneumocephalus in this patient. The term *pneumocephalus*, however, was not officially introduced into the medical vernacular until Wolff's paper in 1914.[3]

Pneumocephalus, which literally means "air inside the head," implies a compromise in the craniodural barrier or the presence of gas-forming infection inside the cranial vault. This breach in the craniodural barrier is most commonly associated with traumatic fractures of the sinuses, skull base, cranial vault or mastoid air cells. While as much as 2 ml of air is required for pneumocephalus to be visible on x-rays, with the advent of CT, as little as 0.5 ml can be detected.[4] Depending on the route of entry, air can be seen in the intraventricular, brain parenchymal, subarachnoid or subdural space. Intracranial air that produces a mass effect is known as tension pneumocephalus. This clinical emergency is caused by a ball-valve mechanism that allows air (or anesthetic gas) to enter but not to exit the cranium.[3] Pneumocephalus on a head CT usually compels emergency physicians (EP) to pursue a thorough search for its cause.

Numerous case reports on pneumocephalus in the literature in recent years demonstrate a wide range of etiologies. In Markham's series of 295 cases of pneumocephalus, 73.9% were caused by trauma, 12.9% neoplasm, 8.8% infection, 3.7% post-operative, and 0.6% idiopathic.[5] In our review of 68 cases of pneumocephalus seen in the ED, 55 (80.88%) were caused by trauma, one (1.47%) neoplasm, zero (0%) infection, nine (13.24%) post-operative, and three (4.88%) idiopathic, presumed to be from IV injection of air (Table 1). The differences between Markham's and this case series are largely due to selection bias and detection method. This study was a case series of a heterogeneous ED patient population whose pneumocephalus was detected by CT vs. Markham's series of 284 cases, whose

Table 1. Emergency department etiologies of pneumocephalus in this retrospective study

Study	Number (percent [95%CI])
Total head CTs ordered in the ED during the study period	8,747
Total cases of pneumocephalus	68 (0.78% [0.60-0.98%])
Post-operative	9 (13.2% [6.2-23.6%])
Trauma	55 (80.9% [69.5-89.4%])
Tumor	1 (1.5% [0.04-7.9%])
Presumed IV injection of air	3 (4.4% [0.9-12.4%])
Incidence of pneumocephalus presumed from IV injection of air among all CTs ordered in ED	0.034% [0.007-0.100%]

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

Table 2. General causes of pneumocephalus

Trauma	Basilar skull fracture, other types of open head and facial fracture
Neoplasm	Sinus osteoma (frontal, ethmoid), various types of intracranial neoplasm (e.g., meningioma, astrocytoma, posterior fossa epidermoid tumor)
Infection	Chronic otitis media and mastoiditis, chronic sinusitis, intracranial infection by gas-producing microbes
Post-neurosurgical procedure	Craniotomy, post-intrathecal and spine procedure, chest procedure (e.g., subarachnoid pleural fistula), otolaryngologic procedure (e.g., transphenoidal operation, rhinoplasty, ethmoidectomy, polypectomy), ophthalmologic procedure (e.g., macular hole repair)
Others	Lumbar puncture, hypercellular mastoid, nasotracheal intubation, bag-mask ventilation, continuous positive pressure ventilation, spinal anesthesia, nitrous oxide anesthesia, abdominal procedure in patients with ventriculo-peritoneal shunts, nasogastric tube placement, congenital defect, hyperbaric oxygen therapy, spontaneous, pneumosinus dilatans, barotrauma [air travel, diving, Valsalva maneuvers], bronchopleural-subarachnoid fistula, intravenous injection of air

pneumocephalus was detected by x-rays. Incorporating recent case reports, we have updated and categorized the general etiologies for pneumocephalus (Table 2).

Patients with clinically significant pneumocephalus may present with nausea, vomiting, fever, headache, confusion, agitation, syncope, lethargy, speech changes, aphasia, vision changes (scotoma, double vision, hemianopsia), seizure, paresis/hemiparesis, ataxia, and rhinorrhea.[2,6] The evaluation of such patients should focus on signs of infection, level of consciousness, pupillary responses, eye movements, and motor responses.[7] A sudden decrease in the patient's level of consciousness or a lack of a pupillary response would strongly suggest increased intracranial pressure and the need for urgent neurosurgical evaluation. CT of the head is the mainstay of imaging in the workup of such patients.

On a head CT without contrast, pneumocephalus is best seen on a soft tissue window. Air having a Hounsfield unit of approximately -1,000 can be distinguished from fat (-50), water (0-10), and gray/white matter (20-30). The presence of tension pneumocephalus may show the findings of "Mount Fuji" (Figure 4) or "Bubbling Brain."[8,9]

Our review of the case reports in the literature indicates that in the majority of cases, pneumocephalus is treated expectantly.[10-14] Since absorption of air occurs in 85% of the cases in the first week, once the source of air is identified or controlled, most patients without significant signs or symptoms of increased intracranial pressure can be observed clinically. Suspicion of tension pneumocephalus warrants urgent medical treatment and neurosurgical consultation as neuronal damage may occur secondary to reduced cerebral perfusion. Nevertheless, expectant therapy may still be appropriate in moderately severe tension pneumocephalus. Hyman reported successful expectant management during the acute phase for a patient who presented in coma from spontaneous tension pneumocephalus.[15] Conservative medical management of pneumocephalus includes bed rest, analgesia, head elevation, and avoidance of coughing, sneezing, nose blowing, or the Valsalva maneuver. Additional therapeutic recommendations include laxative use to decrease intra-abdominal pressure during bowel movements and supplemental oxygen therapy to hasten the absorption of pneumocephalus (vs. air).[16] Although clinicians have prescribed hyperbaric oxygen therapy (HBO) for treating pneumocephalus, there is currently no literature on HBO efficacy. Hyperosmolar therapy with mannitol can be used as

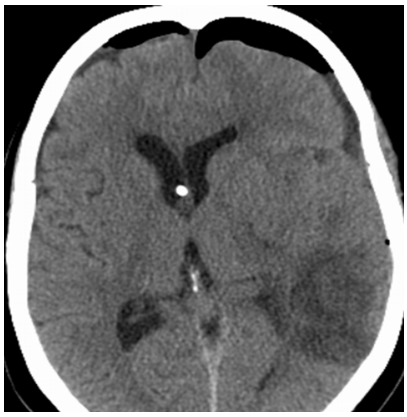

Figure 4. "Mount Fuji" sign. Axial cranial computed tomography through the level of frontal horns shows a large subdural bilateral pneumocephalus post-operatively. Note the compression of the frontal lobes and widening of the interhemispheric space between the frontal lobes, simulating the appearance of Mount Fuji.

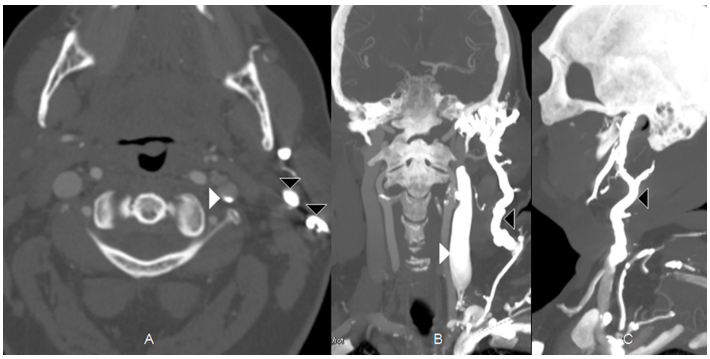

Figure 5. Axial (A), coronal (B) and sagittal (C) computed tomography reformatted views of soft tissue of the neck, showing contrast flow cephalad into the left internal (white arrowheads) and external jugular veins (black arrowheads) during a left upper extremity contrast injection for a head and neck computed tomography angiogram (white arrowheads: internal jugular, black arrowheads: external jugular).

a temporizing medical therapy prior to surgical treatment.[17,18] Pneumocephalus and CSF leaks secondary to traumatic dural tears are self limited and do not require prophylactic antibiotics unless there are signs of infection.[19-21] Definitive surgical treatment is indicated for significant intracranial hypertension, persistent craniodural leaks, or persistent pneumocephalus lasting longer than one week. In these cases, prophylactic antibiotics are usually recommended, with or without signs of infection, while patients await neurosurgical repair.[22]

Having considered the standard causes for pneumocephalus, the consensus among the neurosurgical and neuroradiological consultants was that these three cases of idiopathic pneumocephalus occurred as a result of the injection of air into the IV. While infusion from a peripheral IV site in the upper extremities normally travels through the axillary, subclavian, and brachiocephalic veins to empty into the superior vena cava (SVC), the infusion can also flow cephalad through the internal/external jugular veins to the cranial venous system under certain clinical situations (Valsalva maneuvers as in coughing, stenotic brachiocephalic vein, partially obstructed SVC, or low flow state as in heart failure). We have documented CT images of retrograde flow of contrast dye from a peripheral IV site into the internal and external jugular venous system (Figure 5). Since air is lighter than blood, which in turn is lighter than contrast, under similar clinical situations, air bubbles can flow retrograde up through the jugular veins with less difficulty than contrast dye, especially in patients who are in a reclining position (due to the buoyancy force). Once in the jugular veins, air continues its ascension in those patients who are in reclining position to accumulate in the highest areas of the head: the orbital veins, cavernous sinuses, frontal venous system, petrosal sinuses, and the superficial temporal veins. This is what we observed in Figures 1-3.

Clinically**,** this model explains the clinical response to the expectant management for these three patients. All three had peripheral IVs. None of the three had the typical etiologies for pneumocephalus, such as post-craniofacial procedure, trauma, neoplasm, or infection. Detailed examinations of these three cases revealed no history of congenital septal defects, congenital craniodural defects, or barotrauma. All were treated for idiopathic pneumocephalus, presumably from IV injection of air and improved rapidly, with follow up showing no clinical sequelae of pneumocephalus. Based on these considerations, we propose that the possibility of IV-induced pneumocephalus be considered in the evaluation of unexplained pneumocephalus in the ED, if there is an absence of clinical features associated with trauma, infection, tumor, barotrauma, or tension pneumocephalus and in combination with the presence of characteristic air distribution on head CT (Table 3). Our data and hypothesis for the retrograde reflux of air are consistent with those proposed by Thompson and Liu.[23, 24]

In this series, the incidence of idiopathic pneumocephalus, presumably from IV injection of air, is approximately 0.034% of the head CTs performed in the ED (with an IV placement). While pneumocephalus usually signifies a serious pathological condition in the emergency setting, recognizing the possibility of pneumocephalus secondary to IV injection of air can help narrow the differential, facilitate care, avoid unnecessary diagnostic tests, interventions, prolonged hospital stays, anxiety, and discomfort for this subset of patients.

LIMITATIONS

The study is limited by its small size and single-site location in the Midwest. The incidence data for pneumocephalus in other EDs may be different, depending on the patterns of local clinical practice. We have offered no definitive proof for the retrograde flow of air through the IV catheter, only surrogate data with contrast dye. An animal model can help verify this retrograde flow hypothesis.

CONCLUSION

IV-induced pneumocephalus in this study is rather uncommon, occurring in one in 3,000 head CTs ordered from

Table 3. Distinguishing characteristics of IV-induced pneumocephalus

Clinical characteristics	History and physical examination findings are not consistent with trauma, infection, barotrauma, or tension pneumocephalus (headache, confusion, lethargy, nausea, and vomiting, visual-field deficits, seizures, behavioral changes)
Radiographic findings	The pattern of air observed on the head CT is limited to the cranial venous anatomical distribution.

IV, intravenous; *CT*, computed tomography.

the ED, but accounts for one of 20 cases of pneumocephalus in this retrospective study. IV injection of air should be considered in the evaluation of unexplained pneumocephalus in the ED by noting the absence of pathological findings on history and physical examination and identifying the characteristic radiographic air pattern on head CTs. Awareness of the clinical entity of IV-induced pneumocephalus can help improve the care for patients presenting with unexplained pneumocephalus in the ED.

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Catatonia Associated with Initiating Paliperidone Treatment

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We present a case of catatonia, which occurred shortly after starting a new antipsychotic, paliperidone, an active metabolite of risperidone. Catatonia may be caused by a variety of conditions, including metabolic, neurologic, psychiatric and toxic processes. Interestingly, risperidone, which has been thought to cause several cases of catatonia, has also been recommended as a potential treatment. We discuss potential mechanisms for causes of drug-induced catatonia as well as potential treatment options. [West J Emerg Med. 2010; 11(2):186-188.]

INTRODUCTION

Catatonia can be caused by a variety of metabolic, neurologic, psychiatric, and toxic conditions. Risperidone, an atypical antipsychotic, has been reported to induce catatonia in several patients,[1,2] although paradoxically, antipsychotics, including risperidone, have been used successfully to treat catatonia.[3,4] Paliperidone, a major active metabolite of risperidone, was approved by the United States Food and Drug Administration (FDA) in December, 2006, for the treatment of schizophrenia. We report what we believe is the first case of catatonia temporally related to paliperidone, after a single dose.

CASE REPORT

An 84-year-old female with history of major depression and anxiety was evaluated by her psychiatrist for worsening anxiety and given a single dose of 3 mg of paliperidone. Eight hours later she became increasingly agitated and, according to her daughter, "looked like she was going to crawl out of her skin." She then told her daughter "make it go away, make it go away," and subsequently stopped speaking and responding to any physical or verbal stimuli, although she appeared awake and alert. She had no prior documented episodes of catatonia. Her daughter brought her into the local emergency department (ED).

In the ED, she had a temperature of 37.3°C, pulse 80 beats per minute, blood pressure 161/72 mm Hg, respiratory rate 20 breaths per minute and oxygen saturation of 98% on room air. Her medications were citalopram, trazodone, levothyroxine, and paliperidone. She lived with her daughter, who related no recent trauma. The patient previously took risperidone, but it had been discontinued after several months because of mild akathisia, with both restlessness and tremor.

Physical exam showed an alert, well appearing elderly female in no acute distress. Her pupils were equal round and reactive to light; she would not comply with extraocular muscle testing. She did open her mouth on request and stuck out her tongue midline; there was no erythema, and mucous membranes were moist. Cardiopulmonary exam was unremarkable; abdominal palpation did not cause any change in her facial expression and was soft without masses. While she complied with several requests for the cranial nerve exam she would not move her fingers or toes when asked, but was noted to turn her head in all directions and roll from side to side, moving all extremities equally. Her brachioradialis and achilles reflexes were equal and Babinski reflexes were downgoing. She exhibited stupor and mutism with fixed postures.

Finger-stick glucose was 114 mg/dL. Intravenous diphenhydramine, 25 mg and benztropine, 0.5 mg were given for dystonia without any change. Noncontrast head computed tomography (CT) was performed due to concern for stroke and was unremarkable. Laboratory tests showed white blood cell count of 7.4 K/mm^3 with 60% neutrophils, her hematocrit was 37.6%, and platelets were 203 K/mm^3. Electrolytes and renal function showed sodium 135 mmol/L, potassium 3.5 mmol/L, chloride 101 mmol/L, bicarbonate 20 mmol/L, calcium 9.8 mg/dL, blood urea nitrogen 12 mg/dL, and creatinine 1.0 mg/dL.

Due to the lack of inpatient psychiatric beds, she was observed in the ED for 12 hours. Psychiatric consultation had no specific recommendations. Sixteen hours after the dose

of paliperidone, without other therapy, she began to talk and interact. More detailed neurological exam showed no focal deficits. Her mood and affect were appropriate. She did not recall the events of the previous evening but remembered her daughter talking, although she was unable to respond.

DISCUSSION

Catatonia is a neuropsychiatric syndrome characterized by a combination of mental, motor, vegetative, and behavioral signs and symptoms.[5] It has been described as a syndrome with prominent motor signs, with positivistic or excitatory symptoms, including mitgehen, in which there are excited movements with light stimulation, even with instructions to the contrary. Other signs include stupor, immobility, mutism, and negativism, including gegenhalten (increasing resistance to passive movement of the limbs), waxy flexibility, posturing, stereotypic movements, echolalia, and echopraxia.[6] Mutism and stupor are generally regarded as principal signs of catatonia, although neither are certainly pathognomonic.

The Diagnostic and Statistical Manual of Mental Disorders, DSM – IV, defines catatonia as the presence of at least two of the following: motoric immobility, excessive motor activity, extreme negativism/mutism, posturing/ stereotyped movements/prominent mannerisms or grimacing, and echolalia or echopraxia.[6]

Our patient exhibited several of these features, including immobility, with posturing at times, and extreme negativism, including mutism. While her presenting differential was broad, lack of fever, headache, and a normal white count were inconsistent with infection. A lumbar puncture was not obtained, but complete reversal of symptoms without other therapy would also argue against meningitis or encephalitis. Non-convulsive status epilepticus or partial complex seizures should also be considered, although there was no history of a previous seizure disorder. An electroencephalogram (EEG) should be obtained if clinical suspicion warrants.

Catatonia has been associated with schizophrenia, major depressive disorder, as well as other medical conditions, including alcoholism, bi-frontal tumors, encephalitis, transient ischemic attack, chronic obstructive pulmonary disease, rheumatic heart disease, Alzheimer's and vascular dementia, central diabetes insipidus, closed head injury, end stage renal disease, and renal tubular acidosis.[8] Neuroleptic malignant syndrome, as well as severe extrapyramidal reactions, may also present initially with catatonic features, and has been considered by some to be a subset of catatonia.[9]

While no studies have specifically evaluated the prevalence of drug-induced catatonia, studies regarding general causes of catatonia suggest that 17-19% of all cases diagnosed as medical catatonia are actually drug-induced catatonia.[5] Another study found that antipsychotic-induced catatonia accounted for 24% of all catatonic patients referred to the ED of a general hospital.[8]

Drug-induced catatonia has mostly been reported with psychotropic drugs, including fluphenazine, haloperidol, risperidone, and clozapine, non-psychotropic drugs such as steroids, disulfiram, ciprofloxacin, several benzodiazepines, as well as drugs of abuse, including phencyclidine, cannabis, mescaline, LSD, cocaine and ecstasy.[5] While psychiatric disorders may simply cause catatonia, it does appear that medications themselves can either cause or unmask an underlying predisposition to catatonia.

The mechanism by which medications cause catatonia is not known. Mechanisms have been proposed based on animal models: 1) dopamine hypoactivity at the D_2 receptor, 2) GABA hypoactivity at the $GABA_A$ receptor and hyperactivity at the $GABA_B$ receptor, 3) serotonin hyperactivity at 5-HT_{1A} receptor and hypoactivity at 5-HT_{2A} receptor, and 4) glutamate hypoactivity at the NMDA receptor.[5]

Paliperidone is the active major metabolite of risperidone. It was approved by the FDA in December 2006 and released to consumers in the United States in January 2007. Its therapeutic activity is believed to be a result of both central dopamine type 2 and serotonin type 2 receptor antagonism. It is also an antagonist at α_1 and α_2 adrenergic receptors and H_1 histaminergic receptors. Plasma concentrations are estimated to peak approximately 24 hours after dosing with a terminal half-life of approximately 23 hours. Bioavailability is 28% with apparent volume of distribution of 487 L. Plasma protein binding of paliperidone is 74%. Unlike risperidone, paliperidone is not extensively metabolized by the cytochrome P450 enzymes and is not expected to cause clinically relevant pharmacokinetic drug interactions.[10,11]

ED evaluation of patients who present with catatonic symptoms requires a comprehensive evaluation and a wide differential and should not be initially attributed to the underlying psychiatric disorder. Treatable common causes of catatonia should be ruled out. Further diagnostic and laboratory studies may include complete blood count, comprehensive metabolic panel, thyroid stimulating hormone, urinalysis, cerebral spinal fluid evaluation, CT, magnetic resonance imaging, EEG, and other studies as clinical history and physical findings dictate.

In most cases of drug-induced catatonia, stopping the implicated drug and supportive care is usually sufficient. Benzodiazepines and electroconvulsive therapy have also been recommended as potential treatments.[5,12] Typical antipsychotics such as haloperidol should be avoided, although a trial of atypical antipsychotics (e.g. risperidone, olanzapine) has been suggested for patients who do not respond to other measures.[3,4,13,14] Caution should be taken in considering using paliperidone in patients who have already had previous adverse reaction to risperidone. Anticonvulsants, valproate,[1] and carbamazepine[2] have also been reported to be effective but may take longer to work than benzodiazepines.

The Naranjo scale of adverse drug reactions[15] is a validated score that assesses the probability of a causal relationship between a drug and a clinical event and is

reported based on several criteria as definite, probable, possible, and doubtful. Although this medication-catatonia relationship was scored as "possible" on the Naranjo scale, there had been no other change in medications or initiation of other medications, which may have been responsible for her condition. Also of note is no previous history of catatonic-like symptoms presented prior to initiation or after discontinuation of the paliperidone.

SUMMARY

A number of medications have been associated with catatonia, including antipsychotics. Providers should consider multiple etiologies when evaluating a patient who presents with catatonia-like symptoms. Paliperidone, similar to risperidone, may be a cause of drug-induced catatonia.

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Effect of Hospital Staff Surge Capacity on Preparedness for a Conventional Mass Casualty Event

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Objectives: To assess current medical staffing levels within the Hospital Referral System in the City of Cape Town Metropolitan Municipality, South Africa, and analyze the surge capacity needs to prepare for the potential of a conventional mass casualty incident during a planned mass gathering.

Methods: Query of all available medical databases of both state employees and private medical personnel within the greater Cape Town area to determine current staffing levels and distribution of personnel across public and private domains. Analysis of the adequacy of available staff to manage a mass casualty incident.

Results: There are 594 advanced pre-hospital personnel in Cape Town (17/100,000 population) and 142 basic pre-hospital personnel (4.6/100,000). The total number of hospital and clinic-based medical practitioners is 3097 (88.6/100,000), consisting of 1914 general physicians; 54.7/100,000 and 1183 specialist physicians; 33.8/100,000. Vacancy rates for all medical practitioners range from 23.5% to 25.5%. This includes: nursing post vacancies (26%), basic emergency care practitioners (39.3%), advanced emergency care personnel (66.8%), pharmacy assistants (42.6%), and pharmacists (33.1%).

Conclusion: There are sufficient numbers and types of personnel to provide the expected ordinary healthcare needs at mass gathering sites in Cape Town; however, qualified staff are likely insufficient to manage a concurrent mass casualty event. Considering that adequate correctly skilled and trained staff form the backbone of disaster surge capacity, it appears that Cape Town is currently under resourced to manage a mass casualty event. With the increasing size and frequency of mass gathering events worldwide, adequate disaster surge capacity is an issue of global relevance.
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INTRODUCTION

Crowds are becoming larger, allowing for a greater impact after major and minor events alike. In addition, healthcare systems suffer from daily crowding and lack capacity for even small increases in volume and types of patients.[1,2]

Cape Town is a host city for nine soccer matches as part of the FIFA World Cup™ 2010, a sporting event founded in 1930. It is second only to the Olympic Games in numbers of participants and visitors, including 32 international football teams.[3]

Historically Cape Town has hosted large one-time events such as the 1995 Rugby World Cup, the 1996 African Cup of Nations and the 2003 Cricket World Cup. In excess of 450,000 football-specific overseas visitors are expected in South Africa for the World Cup, in addition to the regular 300,000 tourists.[4] An excess of 150,000 visitors are projected to be in Cape Town alone. The Western Cape region is thus uniquely poised to test its disaster preparedness and the special challenges that large, culturally diverse, multi-lingual international crowds demand.

Standard medical needs for crowds at mass gatherings are well understood and can be met with available resources when properly coordinated. Depending on the type, location, duration and time of day of the event, as well as weather characteristics[5], the highest predicted patient presentation rates (PPR) are projected to be 2.6 to 3.3 patients/1,000 participants.[1,7,8] Studies indicate that the transport to hospital rate (TTHR) ranges from 0.01 to 0.55/1,000 patients.[1]

The potential for a planned mass gathering escalating to a mass casualty incident (MCI), raises the following question:

Table 1. Absolute numbers of private and state healthcare practitioners working in the Cape Town Metropolitan Area, Western Cape, South Africa

Specialty	Fulltime Private	Fulltime State	Totals
Ambulance Emergency Assistant	64	161	225
Emergency Care Practitioner	67	437	504
Paramedic	27	63	90
Medical Intern		310	310
Generalists	992	922	1914
Specialists	565	618	1183
Basic Nurse aid (1 year training)	1	3243	3244
Basic Nurses (2 year training)	9	1633	1642
Nursing Sister	922	3990	4912
Radiographer	56	335	391
Pharmacist	507	253	760
Pharmacist Assistant	54	227	281
Physiotherapist	395	114	509
Occupational Therapist	222	127	349
Psychological Support Staff *	775	184	959
Pathologist - Forensic	3	6	9
Messenger	n/a	82	82
Porters	n/a	307	307
Security Officers (day)	n/a	466	466
Security Officers (night)	n/a	278	278

*The category "Psychological Support Staff" includes all social workers, registered counselors, psychologists and psychiatrists.

Does Cape Town have adequate resources to meet ordinary patient care needs the increased requirements linked to mass gatherings expected in June 2010 for the Football World Cup, but also for a large casualty-producing incident should it occur?

Study Objectives

Most disaster planning is performed at institutional or organizational levels with little collaboration between organizations, especially public and private providers. Specific objectives of this study are to assess the combined current medical staffing levels within the Hospital Referral System in the City of Cape Town Metropolitan Municipality, South Africa, within both private and state healthcare sectors, as a basis for determining whether current resources are adequate to manage a conventional mass casualty incident.

METHODOLOGY

Study Design

Using Pivot tables in Microsoft® Excel, investigators queried all available medical databases of state employees and private medical personnel within the greater Cape Town area to determine current staffing levels and distribution of personnel across public and private domains. The Human Resource, Personnel and Salary (***PERSAL) system*** is used by the Provincial Government of the Western Cape to register and pay employees.[9] It allows for data retrieval on salaried state-employed staff by institution and category, as well as salary level. Part-time and seasonal employees were excluded, while Department of Health contract and permanent workers were included. Qualifications are only recorded for about 10% of all employees.

The database was extracted from the PERSAL system on October 15, 2008. Analysis revealed 48 categories of staff, with similar functions grouped under the same heading. Pharmacists of all types were grouped in one category, while pharmacy assistants were categorized separately due to need for supervision.

Two additional sources were examined to determine the ancillary services within the state and medical personnel in private services. The Risk Management Division of the Provincial Government of the Western Cape was used to determine the number of outsourced security personnel available in healthcare facilities during both day and night shifts. We used the ***MEDpages*** database to obtain data on private practitioners, combined with locum agencies in Cape Town. This study was approved by the local institutional review committee.

RESULTS

Personnel in Cape Town available for first response and patient transport during a disaster are 17/100,000 population emergency care practitioners and 4.6/100,000 pre-hospital providers (Table 1). The overall number of medical personnel currently available is 88.6/100,000 population. This number excludes interns, as they are regarded as still being in training, and aggregates all other medical practitioners except psychiatrists. Of the total, general practitioners represent 54.7/100,000 population, incorporating all medical practitioners who are not registered as specialists in a surgical discipline or who are able to provide healthcare during a disaster. By definition, this group includes physicians with varying expertise, capable of providing non-surgical assistance ranging from triage and basic healthcare/first aid to more advanced medical stabilization and interventions.

The number of registered specialists is 33.8/100,000 population. This number includes registrars (senior residents), and aggregates all medical and surgical specialists, excluding psychiatrists, dermatologists and dentists, as well as those specialists "boarding" on non-specialist posts who hold an equivalent registration.

Vacancy rates for healthcare providers are available only for the public sector. For all medical practitioners, irrespective of qualifications, these lie between 23.5% and 25.5%, equaling that of all nursing posts at 26% (Table 2).

Table 2. Percent of posts filled in the public service in the Western Cape, South Africa

	Filled	Total	%
Emergency Care Practitioners	1069	1760	60.7%
Paramedics	132	397	33.2%
Medical Generalist	1062	1388	76.5%
Medical Specialist	738	991	74.5%
Nursing	6973	9465	73.7%
Nursing Assistants	3933	4856	81.0%
Pharmacist	329	492	66.9%
Pharmacy Assistants	245	427	57.4%
Physiotherapists	131	167	78.4%
Occupational Therapists	135	189	71.4%

All "specialist" registered nurses who have additional qualifications in intensive care, surgery and psychiatry, were grouped together. The number in total is 140/100,000 population for nurses. The relative number of staff and enrolled nurses is lower at 54.7/100,000 population and that of assistant nurses is 92.8/100,000 population.*

The psychological support staff category includes social workers, registered counselors, psychologists and psychiatrists who provide immediate support including reuniting families. There are 775 private and 184 state employees (total 959), or 27.4/100,000 population.

Eighty-one percent of security services are outsourced. There are currently no "disaster clauses" in the contracts with security services or catering companies. No data are available these essential support personnel for private facilities.

Limited numbers of ventilated and non-ventilated ("high care") beds exist in Cape Town (Table 3), which provides insight into the staffing needed per level of care.

LIMITATIONS

Data extraction is a challenge in South Africa; there are no audits to verify the internal validity and completeness of the PERSAL dataset. A complete list of named individuals was available only for state institutions. In contrast, it was impossible to determine whether private healthcare workers were double counted, as the same detail was not available for this group. Furthermore, many of the data are not available in an easily usable format, or underlying competitiveness (private sector) or privacy and security concerns (public and private sector) limit access to data.

Table 3. Available and staffed intensive care beds

	Private		State		
	Adult	Pediatrics	Adult	Pediatrics	Neonatal
Non-ventilatory capable	90				
Ventilatory capable	186	58	128	35	99

The data that are available are limited in scope, with only certain types of personnel necessary for a comprehensive disaster response. For example, staff performing essential services, such as cleaning, catering and laundry services, are not recorded in a database since these services have been largely outsourced.

DISCUSSION

"*At the heart of each and every health system, the workforce is central in advancing health.*"[10] The issues facing the system in South Africa are common to many parts of the world. Healthcare systems are strained on a daily basis and disaster planning is relegated below more urgent needs. In addition, the misconception that surge capacity can be equated with "bed capacity" remains pervasive. In many cases, the normal patient volume will still present to clinics and hospitals despite a major disaster. A review of the case mix presenting to emergency departments (ED) in Cape Town showed that the majority of patients self-presented[11] and would therefore not readily be diverted elsewhere during a disaster.

Background — Population

The latest census (February 2007), of Cape Town showed a population of 3.497 million[12], with an annual national growth rate of 0.8%.[13] Compared to 2001, the Western Cape showed a 16.7% increase, vs. a national average of 8.26% increase for the same time period.[14] Of the population of the Western Cape, 66.3% live within the City of Cape Town Metropolitan Municipality.[15] This results in a disproportionate burden on service delivery, including infrastructure, social services and in particular healthcare delivery.

Background – The South African Health System

The South African health system is dichotomous, with a private healthcare system that is among the best in the world[16] and a state system that is facing infrastructure, personnel and supply chain challenges that result in poorer health outcomes. More than 80% of the population relies on state medical care; private hospitals have capacity for less than 14% of the population.[17]

*What is termed "nursing sister" in South Africa refers to the only category of nursing staff that has gone to college and obtained a four-year degree. All the other categories of nursing staff undergo variable amounts of training, ranging from a home-based carer who only receives a three month basic nursing care training course, to nursing assistant (one year), to staff and enrolled nurses (two years of training but via different routes - one via full-time training, one via on-the-job training with off-site teaching sessions and minor differences in scope of practice. This means that the numbers of "non-sisters" seem high but the competency and training levels are quite variable.

During the first ever analysis of the world's health systems in 2000, the WHO ranked South Africa 175th of 190 member countries.[18] According to the latest available annual UN Human Development Report, South Africa ranks 121st internationally in resources, access and commitment to health services.[19] This is due to low life expectancies from pulmonary tuberculosis, HIV, and a high per-capita expenditure on health with lower than expected outcomes. The Years of Life lost in the Western Cape for HIV/AIDS and tuberculosis combined represent 22% of overall mortality, as the first and third leading causes respectively.[20]

This disproportionate spending also drives approximately 73% of general practitioners and 75% of specialists to work in the private sector, while only 41% of the nursing staff do.[21] As most of these physicians are in solo or small group practice, they are generally not connected with disaster planning.

In addition, these practitioners often work in more than one institution or have more than one practice. As is common in disaster planning where the same personnel tend to have multiple obligations, an institution might overestimate the number of medical staff available to it, should a mass casualty incident involve more than one healthcare institution or area.[22]

Surge Capacity

Every health system faces variable demand on its resources. In addition to a long-term increase in patient volume, there may be short-term increases in demand for emergency healthcare services, or "surge."[1] When the primary healthcare and outpatient systems are not functioning effectively, the EDs become the destination for patients who have no other access to primary healthcare.[2]

A number of actions can be taken to manage a catastrophic surge. These include discharging stable ED and inpatients, cancelling elective surgeries, opening alternate care areas, and calling in standby or off-duty staff. For such a system to work effectively, a clear plan must define who has authority to initiate such a cascade. In addition, the trigger points that activate these costly measures should be specified. The activation of a local or regional disaster plan may have residual health service delivery implications for days or longer. These measures, however, have not been rigorously investigated or consistently implemented in all patient populations. Hospital beds and staff are already routinely saturated to care for the sickest patients. Therefore, there are no additional staff to mobilize.

During catastrophic surges, authorities often rely on the assistance of the national armed forces, whether as part of the search and rescue phases, or by providing logistical support or medical care. The UEFA EURO 2008™ football cup illustrated the pre-emptive use of the armed forces to provide security and medical staff.[23] While legislative authority exists, this option is not feasible in South Africa, [24] despite having two large military medical facilities (2-MIL and IMM), in part due to personnel shortages.[25,26] South Africa also lacks a federally organized civil protection organization that could provide the framework for such a response.

Despite no scientifically-proven norms, a number of countries have attempted to define which parameters would allow for adequate disaster surge: the U.S. government, originally through the Health Resources and Services Administration (HRSA) and subsequently via the Department of Homeland Security, has planning scenarios for 500 beds/million population for patients with symptoms of acute infectious diseases, while 50 beds/million is thought to be adequate for non-infectious diseases and injuries.[27]

The U.S. National Disaster Medical System projections range from 100 – 600 patients/million population for traumatic disasters. The Israeli military defines adequate surge capacity during peacetime for an unspecified threat as being able to augment patient care capacity, including staffed beds in existing hospitals, by 20%.[28] It is unclear whether these extrapolations can be applied to the system in South Africa.

Healthcare worker absentee rates can severely disable disaster response. One survey predicted absentee rates of 14% in the case of a mass casualty incident, which increased to 40 - 50% in an infectious disease outbreak.[29,30] Fear and concern for family (almost half of the respondents) and fear and concern for self (almost one-third of respondents) were the most frequently cited reasons for being unwilling to report to work in one large U.S. study,[30] factors echoed in a Canadian study.[31] These are, however, theoretical rates, as these studies do not account for actual behavior during a disaster. Pre-event education and provision of care sites for families and pets may substantially improve response rates.

South Africa already has a pronounced lack of medical practitioners [32] (77 physicians per 100,000, as compared to 256 in the U.S. and 328 in Sweden).[33] This has now been institutionalized by making the District Health System nurse-led. However, there is lack of sufficient numbers of trained nurses. The more affluent provinces of Gauteng and Western Cape are at a slight advantage with the latter having 147 doctors/100,000. The majority of these (60%) work in the private sector. This implies that only 31 doctors/100,000 permanently work in the public sector in this province (i.e., excluding seasonal doctors).[34]

Only seven state hospitals (limited 24-hour operating room capacity) and nine community health centers (no operating room capacity) have EDs equipped and staffed to manage trauma patients. These centers are usually staffed by the most inexperienced personnel (community service medical officers) and there is no immediate access to senior clinicians.[32,34,35] This is due to a flattening of the pyramid of expertise, whereby a large number of junior personnel function at primary and regional levels and faculty are concentrated at academic centers. In addition, many posts are vacant, some having been frozen or abolished.

Calling in off-duty personnel has limited benefit, as the entire workforce will be subsequently exhausted in the first 24 hours. In a non-chemical, biological, radiological or nuclear (CBRN) sudden-onset, defined-scene event, the initial event is static, and would usually not result in further casualties after 24 hours. However, in a dynamic or evolving event, it would impact the delivery of "normal" medical care if all available staff were used without respite.[13]

As compared to previously published figures suggesting that the Western Cape has the highest level of medical personnel resources, with 147 doctors/100,000 [34], the findings of this study of a combined public/private medical practitioner number of 83.7/100,000 seems low. However, the published figure from 2004 is based on simple analysis of the *Health Professions Council of South Africa* (HPCA) database, which includes every paid member on the register who lists a residential address in the Western Cape.

Many doctors working overseas maintain their HPCSA registration using addresses of their relatives, while not actually working in the province, or even in the country. In addition, in 2008, a further 12,000 members, including physicians, dentists, occupational therapists, psychologists, optometrists, and emergency care practitioners were removed from the register[36], often because they no longer practice in South Africa. Thus, the data collected in this study represent a more accurate assessment of the true numbers of staff available for immediate disaster surge capacity than the previously published HPCSA registration numbers.

Between 1990 and 2000, 39% of all academic hospital professional staff were lost to the private sector and/or the health sector of other countries and the posts frozen.[37] Compared to the last officially published figures by the Provincial Government of the Western Cape, the total number of medical personnel in 2006/2007 is listed as 2108, much higher than the current 1850 (which includes 310 medical interns). This represents a decrease of 12.2% over one year.[38]

Another important consideration is that between 14% and 50% of primary healthcare workers (exclusive of support personnel) may not report for duty during a disaster, as determined in two large-scale surveys conducted in 2004 in the wake of the SARS epidemic.[29,30] Also, most call-out cascades are not regularly updated. There is only a single large-scale multi-agency drill within the city required every two years and that focuses on an MCI response at Cape Town International Airport, as directed by International Civil Aviation Organization regulations.[39]

Nursing staff, also a critical resource in any healthcare system, is in short supply. With 5,623 nurses working within the state service, responsible for covering a four-shift system, this leaves about 1,406 nurses per shift to support a total of 1,246 level 1, 1,485 level 2 and 1,460 level 3 beds, including 128 intensive care unit beds (see below). Nursing staff remain the group with the highest shortage, a scenario that is expected to worsen over the next decade.[40,41] Inter-hospital cooperation is hindered in part by fears that scarce nursing resources might be "poached."

Despite a re-examination of the systems underlying disaster preparation worldwide following the U.S. World Trade Center attacks and hurricanes Katrina and Rita, many of the recommendations have not been integrated into practice. A snapshot review presented to the U.S. House of Representatives in May 2008, referring to an event such as the bombings in Madrid, Spain, on March 11, 2004,[42] showed that none of the seven U.S. cities surveyed had sufficient capacity to manage the number of casualties that had sought care at a single hospital ED in Madrid in the first few hours following the terrorist bombings.[43]

Disaster modelers have proposed that up to 20% of a hospital's capacity can be augmented in the event of a disaster, by actions such as discharging patients awaiting elective surgery and low-risk medical and surgical patients in both in- and outpatient settings and calling in off-duty staff.[44] The U.S. congressional review stated that this assumption would not be viable in U.S. healthcare facilities[43] that already suffer from severe crowding on a daily basis.

Similarities and dissimilarities exist in South Africa. There is a large indigent population as a result of a "quadruple burden of disease," especially in the form of tuberculosis and HIV/AIDS, leaving many patients with Karnofsky indices of less than 50%.[45] When this is considered collectively with an already overburdened emergency transport system, it leads to discharged patients occupying acute in-patient beds while awaiting pick-up. These patients often need ongoing basic nursing care while awaiting skilled nursing facility or home-based nursing care.

The *Gregorio Marañón University General Hospital* in Madrid, an 1,800-bed facility, was only able to augment its bed capacity by 9% as a response to the influx of casualties following the 2004 bombings.[42] A team that could initiate rapid discharges of stable patients, for example using the New York Rapid Discharge Tool, would facilitate a more efficient process.[46] Such a team, able to coordinate a city-wide platform, is lacking in Cape Town. Additionally, real-time bed and personnel status data would not be available to itA U.S. Centers for Disease Control and Prevention analysis found that severely injured patients treated at hospitals with Level 1 trauma centers have a 25% lower risk of death than patients treated at a lower level or non-trauma center.[47] While these data were not collected in the setting of a disaster, they may suggest that a Level 1 trauma unit would be the preferred destination for wounded in the event of a mass casualty incident involving trauma. There are only two adult Level 1 trauma units and one pediatric Level 1 unit in Cape Town.

Fewer data exist for other capacity indicators like unoccupied intensive care unit (ICU) beds. Due to nursing shortages,[48] it is unclear what percentage of the 128 ICU

beds in the state are truly functional. To augment capacity, nurse:patient ratios may be shifted from 1:1 to 1:2.

Recommendations

A range of further audits is required to fully assess disaster readiness in the Cape Town Metropole. These should include:

- Real-time assessment of facilities, in view of ICU, high-care, burn and medical patient care capacity.
- Audit of available technical expertise in all fields (medical and paramedical) in state and private, culminating in the establishment of a medical reserve database.
- Individual hospitals require a situational awareness regarding the entire system. Rather than relying on an ad-hoc system of diversion reports or incident warnings, the Disaster Management Centre, in conjunction with the Emergency Medical Services, needs to seek out and establish a link with all registered healthcare institutions to determine actual and available staff. This should be legislated, implemented and kept current.
- The City of Cape Town Disaster Risk Management Centre needs to develop a system whereby private, as well as state, personnel can be mobilized as a single healthcare platform when certain criteria are met. This could be a graded mobilization, depending on the size of the response. Multiple public-private partnerships between private institutions, outsourced service providers, as well as pharmaceutical and medical supplies companies, must be in place before the disaster
- Pre-event credentialing of state and private healthcare providers (e.g., doctors, nurses, pharmacists, physiotherapists, social workers, psychologists) must be in place and renewed and reviewed semi-annually or quarterly. This could be easily accomplished if the updating and registration of qualifications and skills would form part of a continuous medical education system and be included both in the databases of the Health Professions Council, as well as the public and private personnel databases.
- Long-term medical staff training, recruitment and retention strategies need to be revised, so that the state system becomes the preferred employer. Apart from attracting South African-trained medical practitioners, nurses and pharmacists to return to the country, it should also include a streamlined process for registering adequately trained foreign qualified practitioners. Concurrently, local systems need to be able to train more staff; this would involve retaining adequate specialist posts at all levels of care to attract junior healthcare providers for supervised training, as well as allowing for sufficient skilled personnel with dedicated time in teaching institutions for increased student numbers.
- Outsourced services such as laundry, security, catering and cleaning need to have disaster clauses in their Service Level Agreements that clearly define them as essential services and outline their roles in a declared disaster, including responsibilities for costs.

CONCLUSION

Prevention and mitigation are cost-effective for disaster management. A hazard-vulnerability-analysis predicts that an MCI is a real possibility during a planned mass gathering such as the FIFA World Cup™ 2010. Pre-event systems that include practitioner identification, credentialing, agreements with individual practices, as well as large hospital groups, must be actively addressed in conjunction with strategies for improving long-term healthcare worker training, recruitment and retention.

Staff are sufficient to manage the expected ordinary healthcare needs at mass gathering sites in Cape Town, and medical resources have been planned based on a modified response matrix (*South African Medical Resource Model*)[49] modeled largely on the medical responses historically required at other large sporting events, in the United Kingdom and South Africa. However, deliberate planning for staffing to meet the needs of a mass casualty event has been lacking. The results of this database analysis suggest that Cape Town is currently understaffed for a mass casualty incident.

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Box 1

Surge Definitions		
Surge Capacity[1]	***S**taff*	(trained personnel),
	***S**tuff*	(equipment and supplies),
	***S**tructure*	(existing physical healthcare facilities or alternate care sites for patients coupled with incident management structure or organizational arrangement)
	***S**ystems**	(organizational arrangement to coordinate incident management components, and to guide with appropriate policies and procedures)
	****The 3S Surge System Model consists of "Staff, Stuff, & Structure"***	
Patient Care Capacity[2]		full spectrum of staff, stuff and structure, the components of surge capacity described above
Daily Surge[3]		Term that has been challenged, but sometimes used to describe fluctuations in patient care demands in a non-disaster situation; can be modeled and is generally predictable

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Ileocecal Intussusception in the Adult Population: Case Series of Two Patients

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Background: Intussusception is a condition found primarily in the pediatric population. In the adult population, however, intussusception is usually due to a pathological process, with a higher risk of bowel obstruction, vascular compromise, inflammatory changes, ischemia, and necrosis. Radiographic and sonographic evidence can aid in the diagnosis. Surgical intervention involving resection of affected bowel is the standard of care in adult cases of intussusception.

Case Reports: We present the case of a 21-year-old female who presented to the Emergency Department with diffuse cramping abdominal pain and distention. Workup revealed ileocecal intussusception, with a prior appendectomy scar serving as the lead point discovered during exploratory laparotomy. We also present the case of a 66-year-old male, who presented with one week of intermittent lower abdominal pain associated with several episodes of nausea and vomiting. Workup revealed ileocolic intussusception secondary to adenocarcinoma of the right colon, confirmed upon exploratory laparotomy with subsequent right hemicolectomy.

Conclusion: In the adult population, intussusception is usually caused by a lead point, with subsequent telescoping of one part of the bowel into an adjacent segment. While intussusception can occur in any part of the bowel, it usually occurs between a freely moving segment and either a retroperitoneal or an adhesion-fixed segment. The etiology may be associated with pathological processes such as carcinoma or iatrogenic causes, such as scars or adhesions from prior surgeries. The cases presented here demonstrate important etiologies of abdominal pain in adult patients. Along with gynecological etiologies of lower quadrant abdominal pain in female patients, it is important for the emergency physician to expand the differential diagnosis to include other causes, such as intussusceptions, especially given the symptoms that could be associated with bowel obstruction. [West J Emerg Med. 2010;197-200.]

INTRODUCTION

Intussusception is a rare cause of abdominal pain in the adult population, accounting for five percent of intussusception cases in all ages and 1-5% of intestinal obstruction.[1] The clinical presentation in adults is often nonspecific, including abdominal pain and distention, nausea, vomiting, gastrointestinal bleeding and change in bowel movements.[1-4] We present two cases of adult intussusception and then discuss diagnostic modalities, etiologies and treatment strategies.

Case 1

A 21-year-old female presented to the emergency department (ED) with a seven-hour history of distension and

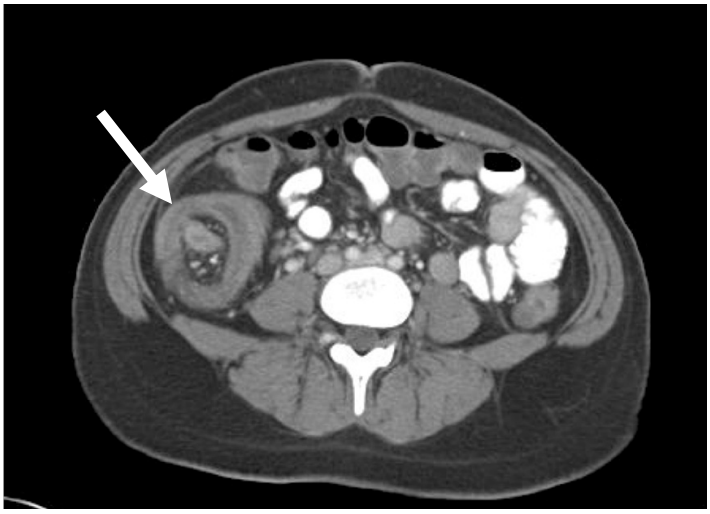

Figure 1. Computed Tomography abdomen and pelvis with oral contrast demonstrating target-shaped lesion in the right lower quadrant indicative of ileocecal intussusception.

worsening diffuse cramping abdominal pain, greatest in the right lower quadrant. The pain was rated as a seven out of ten, with no aggravating or alleviating factors. It was associated with diarrhea and flatus. Her last meal was the night prior to presentation to ED. In the ED, the patient had six bowel movements. She denied any history of similar episodes of pain, as well as fever, chills, nausea, vomiting, weight gain or loss.

The patient's medical history was significant for systemic lupus erythematous, patent foramen ovale, arteriovenous malformation of the lung status post coiling embolization, antiphospholipid syndrome and splenic and hepatic infarcts resulting in portal vein thrombosis requiring anticoagulation. The patient's past surgical history was significant for an appendectomy. The patient was a gravida 1, para 1, status post natural spontaneous vaginal delivery, without any complications, approximately three months prior to her presentation. She denied history of sexually transmitted diseases or multiple sexual partners. Medications included Plaquenil, Coumadin, Prednisone, Ferrous Sulfate, Azathioprine, and Zoloft. She denied any tobacco, alcohol or illicit drug use.

On examination, her vital signs were included: temperature of 36.6 degrees Celsius, heart rate of 58 beats per minute, blood pressure of 96/58 mm Hg, respiratory rate of 16 breaths per minute, and oxygen saturation of 97% on room air. She appeared moderately ill, in apparent discomfort but no acute distress. Abdominal examination revealed diffuse tenderness on palpation, particularly in the right lower quadrant, tenderness to percussion, and high-pitched bowel sounds. A pelvic speculum exam revealed a normal cervix with no erythema or discharge. Bimanual exam revealed normal-sized uterus, with no adnexal masses and no tenderness to palpation. Her physical exam was otherwise benign.

The patient's workup included a white blood cell count of 6.2 thous/mcL (reference range: 4.0-10.5) and elevated liver enzymes with aspartate aminotransferase (AST) of 66 IU/L (reference range: 8-40) and alanine aminotransferase (ALT) of 115 IU/L (reference range: 0-60). Normal total bilirubin was 0.4mg/dL (reference range: 0-1.4) and normal alkaline phosphatase was 50 IU/L (reference range: 26-110). Prothrombin time (PT) and international normalized ratio (INR) were elevated at 15.2 (reference range: 9.6-11.8) and 1.31 (reference range: 0.89-1.11), respectively. Partial thromboplastin time (PTT) was normal at 28.6 (reference range: 24.2-32.6). Urine analysis was negative for urinary tract infection. Urine pregnancy test was negative. Abdominal and pelvic duplex ultrasounds were unremarkable. Computed tomography (CT) scan of abdomen and pelvis showed a target lesion in right lower quadrant with obstruction of contrast and pericolonic fat stranding indicative of intussusception at the ileocecal junction (Figure 1).

An acute care surgery consultation resulted in an exploratory laparotomy and ileocecectomy with primary repair. In the operating room, the intussuscepted portion appeared to be at the site of previous appendectomy scar, thickened cecum intussuscepted within itself. Patient tolerated the procedure well with minimal blood loss and no complications. The specimen showed a well-healed scar, measuring 0.7 cm in length and 0.1 cm in diameter. Specimen pathology revealed pseudomembranous colitis involving the cecum and inflammatory debris in the terminal ileum, eight reactive lymph nodes, without evidence of well-formed granulomas, vasculitis, polyps or malignancy. Post-operative course was unremarkable with normalization of liver enzymes, advancement of diet and return of normal bowel function. The patient was discharged three days after the operation.

Case 2

A 66-year-old male presented to the ED with a four-day history of intermittent lower abdominal pain associated with several episodes of nausea, vomiting, and diarrhea. He described the pain as dull and heavy, worse with lying on his back and better when he laid on his side, without prior episodes of similar pain. Review of symptoms was negative for fever, chills, weight loss, black or bloody stools, change in bowel caliber, urinary symptoms, recent travel, camping or unusual foods. He had no recent sick contacts. His past medical history included degenerative joint disease and a past surgical history of an appendectomy. He had no family history and a social history of cigarette smoking only.

Initial vital signs were within normal limits: temperature 98 degrees Celsius, blood pressure of 122/82 mm Hg, heart rate of 98 beats per minute, respiratory rate of 18 breaths per minute, and oxygen saturation of 97% on room air. Initial exam revealed a patient in mild distress and an exam significant only for moderate suprapubic tenderness without rebound or guarding. There were no masses or hepato-

splenomegaly appreciated. In addition, bowel sounds were normal. Initial lab tests including a complete blood count, chemistry panel, urinalysis and coagulation profile were significant only for a WBC count of 19,000 cells/L (70% neutrophils, 18% lymphocytes, 9% monocytes, 3% basophils) and a hematocrit of 39%. CT scan of the abdomen and pelvis revealed evidence of ileocolic intussusception with edematous and possibly ischemic bowel (Figure 2). A right hemicolectomy was subsequently performed with primary ileo-mid-transverse colostomy. Examination of the patient's resected tissue revealed Duke's C adenocarcinoma of the right colon. The Duke's classification of colon cancer places patients into one of four categories based on spread of cancer. This patient's classification indicates that he had cancer spread out of the confines of his bowel wall and into adjacent lymph nodes without spread of beyond the confines of the lymph nodes. His post-operative recovery was otherwise uneventful.

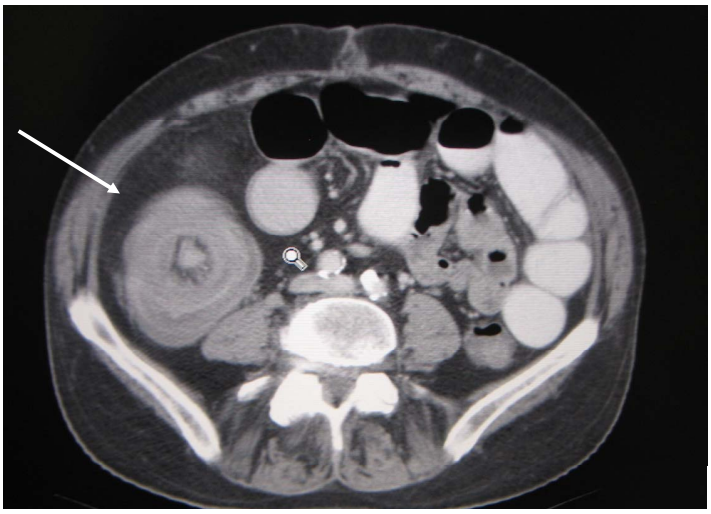

Figure 2. Ileocolic Intussusception from an adenocarcinoma causing bowel edema.

DISCUSSION

Intussusception, defined as telescoping of a proximal part of small bowel along with its mesentery into an adjacent segment, leading to impaired peristalsis, obstruction, and possible vascular compromise, occurs mostly in the pediatric population. The classic triad of intermittent abdominal pain, bloody diarrhea, and a palpable tender mass has been described primarily in children.[1] However, in adults, nausea, vomiting, gastrointestinal bleeding, changes in bowel habits and abdominal distension are the more common, nonspecific symptoms and signs of intussusception.[2-6]

In the adult population, intussusception is a rare condition, accounting for only 5% of all cases across all ages and 1-5% of small bowel obstruction.[2] Primary or idiopathic intussusception accounts for about 8-20% of cases.[2,4,7] Secondary intussusception, which is more commonly present in the adult population, is associated with a pathological condition involving a lead point. This causes one section of the bowel along with its mesentery to prolapse into adjacent bowel, leading to possible intestinal obstruction, vascular compromise, inflammatory changes, ischemia and even necrosis.[3,8,9] Lead points could be intraluminal lesions, such as inflammatory lesions, Meckel's diverticulum, polyps, or extraluminal lesions, such as adhesions, lipomas, lymphomas, and metastases. Malignancies are associated with 30% of small bowel intussusception, and 66% of large bowel intussusception.[10] Intussusceptions are classified according to their locations: enteroenteric, colocolic, ileocolic, and ileocecal.[3,11-13]

As seen in both cases, the presenting symptoms and physical exam findings were not specific for intussusception. Abdominal pain and distention along with changes in bowel movements are symptoms associated with a long list of differential diagnoses, including gynecological causes in female patients. However, with a negative pelvic exam and transvaginal ultrasound, attention is then directed to non-gynecological causes. Radiologic evidence helps in narrowing down and focusing attention to a subset of possible etiologies, as demonstrated with CT of the abdomen and pelvis in case one, demonstrating ileocecal intussusception around a previous appendectomy scar.

Plain abdominal radiographs is typically the first diagnostic screening tool, demonstrating an bowel obstruction or perforation. However, radiographs are neither sensitive nor specific for intussusception.[10,14-16] Ultrasonography is a useful clinical tool for the diagnosis of intussusception in both children and adults with high sensitivity and specificity: 98–100%, and 88%, respectively.[17] Ultrasonography reveals a "target" or "doughnut" sign on the transverse view and the "pseudo-kidney" sign or "hay-fork" sign in the longitudinal view.[18-21] CT is the most commonly used diagnostic modality with diagnostic accuracy of 58-100%.[2,7,22-27] CT shows "target" or "sausage"-shaped lesions, as well as defines the location, the nature and the relationship of the lesion to surrounding tissues.[11,22]

Surgical resection of involved bowel segments serves as the treatment of choice in the adult population,[4] since the lead point could be a malignancy, which could not only metastasize but also compromise blood flow, leading to necrosis of the involved bowel.

CONCLUSION

In the adult population, presenting complaints and physical exam are not sensitive or specific in making the diagnosis and identifying the lead point.[28,29] Radiographic evidence is needed in the diagnosis of intussusception. Once suspected, surgical intervention is necessary to prevent further obstruction, vascular compromise, ischemia and necrosis of bowel. These cases are presented to increase awareness regarding intussusception in the adult population, where

carcinoma and surgical scars can serve as lead points. Non-gynecological causes of right lower quadrant abdominal pain in female patients should also be considered, especially with a negative pelvic exam and transvaginal ultrasound.

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Analysis of Urobilinogen and Urine Bilirubin for Intra-Abdominal Injury in Blunt Trauma Patients

Gorchynski J, Dean K, Anderson CL. Analysis of Urobilinogen and Urine Bilirubin for Intra-Abdominal Injury in Blunt Trauma Patients. *WestJEM*. 2009; 10:85-88.

To the Editor:

We wish to comment on the article by Gorchynski et al,[1] "Analysis of Urobilinogen and Urine Bilirubin for Intra-Abdominal Injury in Blunt Trauma Patients," which concludes that initial urinalysis in the emergency department (ED) for adult blunt abdominal trauma patients should not be used as a screening tool for the evaluation of intra-abdominal injury.

In our ED trauma center with annual census of 33,837 patients, 50% of our cases are related to adult blunt trauma. We consider urinalysis an essential part of the work-up of patients with blunt trauma to the abdominopelvic cavity to detect possible renal or bladder injury. However, further work-ups are requested only in microscopic hematuria cases in pediatric patients or in patients who were hemodynamically unstable, who had pelvic fracture, flank trauma or gross hematuria.

We base our protocol on the fact that if urinalysis is checked in all patients with blunt trauma, microscopic hematuria may be present in many cases; however, microscopic hematuria by itself is not a predictor of genitourinary tract injuries.

The aim of this letter is to emphasize that in hemodynamically stable, conscious adult patients with blunt trauma to the abdominopelvic cavity, checking urinalysis is not an essential routine work-up in management. This strategy has two advantages: first, since our management is not based on urinalysis, we can manage patients more rapidly, and second, in busy trauma centers, especially in developing countries where accidents are the first etiology of surgical ED admissions, it can decrease costs superimposed on the healthcare system.

Shahram Paydar, MD
Roohollah Salahi, MD
Shahram Bolandparvaz, MD
Hamid Reza Abbasi, MD
Shiraz University of Medical Sciences, Trauma Research Center, Shiraz, Iran

In reply:

Thank you for your letter in response to the article "Analysis of Urobilinogen and Urine Bilirubin for Intra-Abdominal Injury in Blunt Trauma Patients" in which you state that your institution does not routinely use the urinalysis for assessment of intra-abdominal injury in adult blunt trauma patients. You may find that selective ordering and assessment of the urinalysis in the adult blunt trauma patient with a pelvic fracture or flank trauma at your institution may also prove not to be a useful adjunct tool for the determination of intra-abdominal organ injury. This would be due to the large number of related organ injuries associated with pelvic fractures and the routine computed tomography (CT) imaging in patients with flank trauma.

I support your statement that routine urinalysis is not an essential work-up in the hemodynamically stable and conscious adult blunt trauma patient for intra-abdominal injury. However, for adult blunt trauma patients who are hemodynamically stable but unconscious (or low GCS score), a urinalysis for the evaluation for an acute intra-abdominal injury may also not be necessary since those patients routinely undergo CT imaging for occult intra-abdominal-thoraco-cranial injury.

Agreed, that in busy trauma centers, especially in developing countries, the utility of routine urinalysis in the emergency department is not a useful adjunct tool for the assessment of intra-abdominal injuries in adult blunt trauma patients nor is it cost effective.

Julie Gorchynski, MD, MSc
Department of Emergency Medicine, JPS Health Network, Fort Worth, TX

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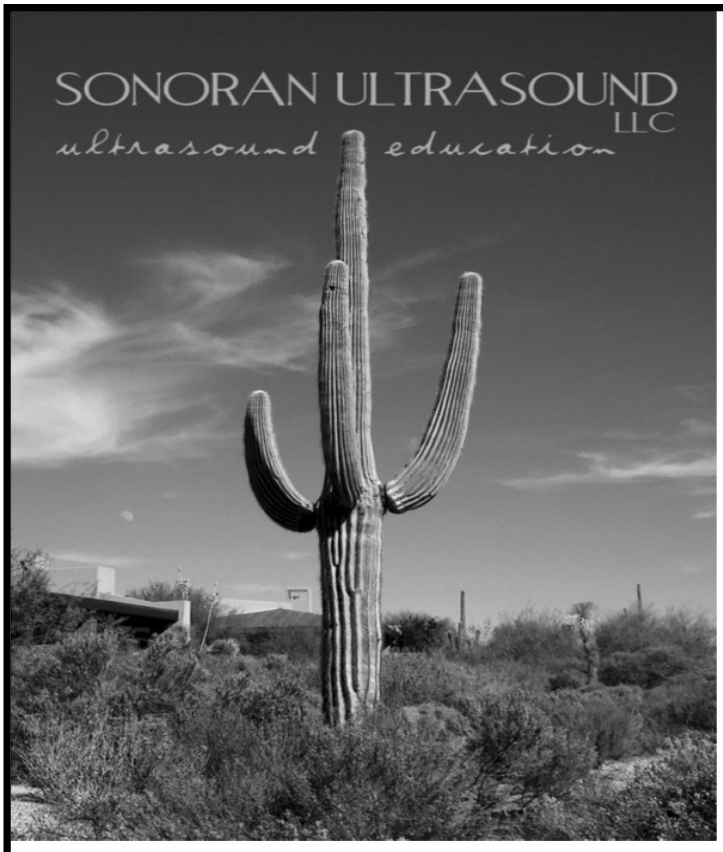

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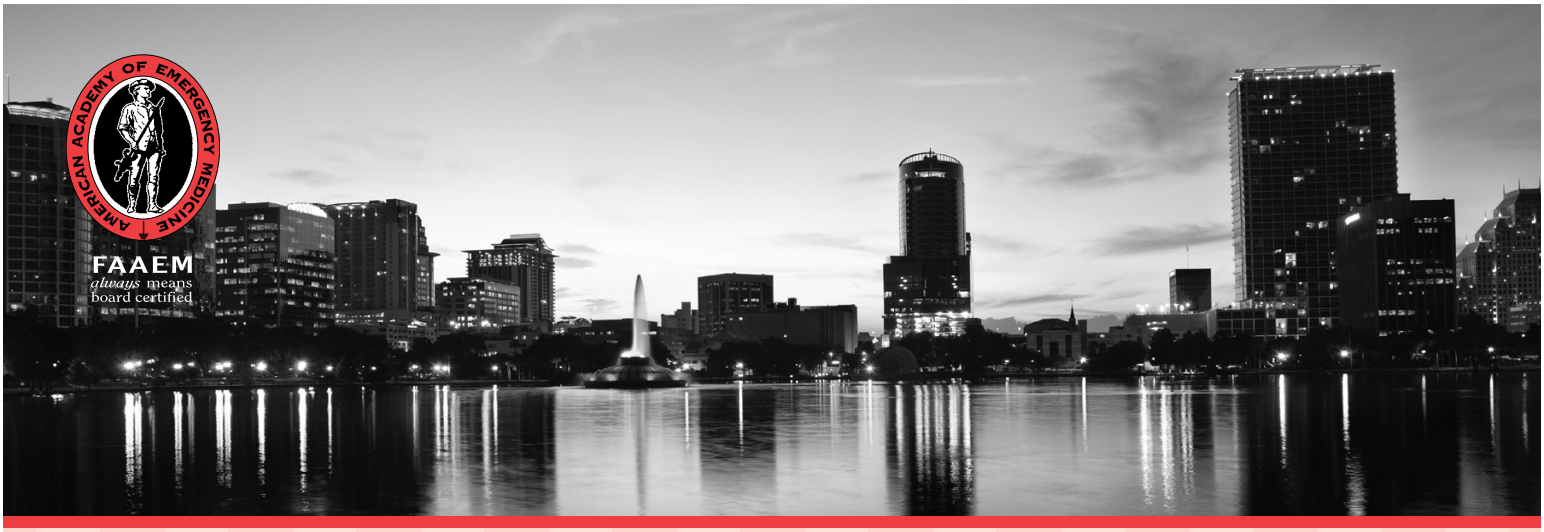

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