WestJEM

Volume X, Number 2, May 2009 Open Access at www.westjem.org ISSN 1936-900X

Western Journal *of* Emergency Medicine

A Peer-Reviewed Professional Journal

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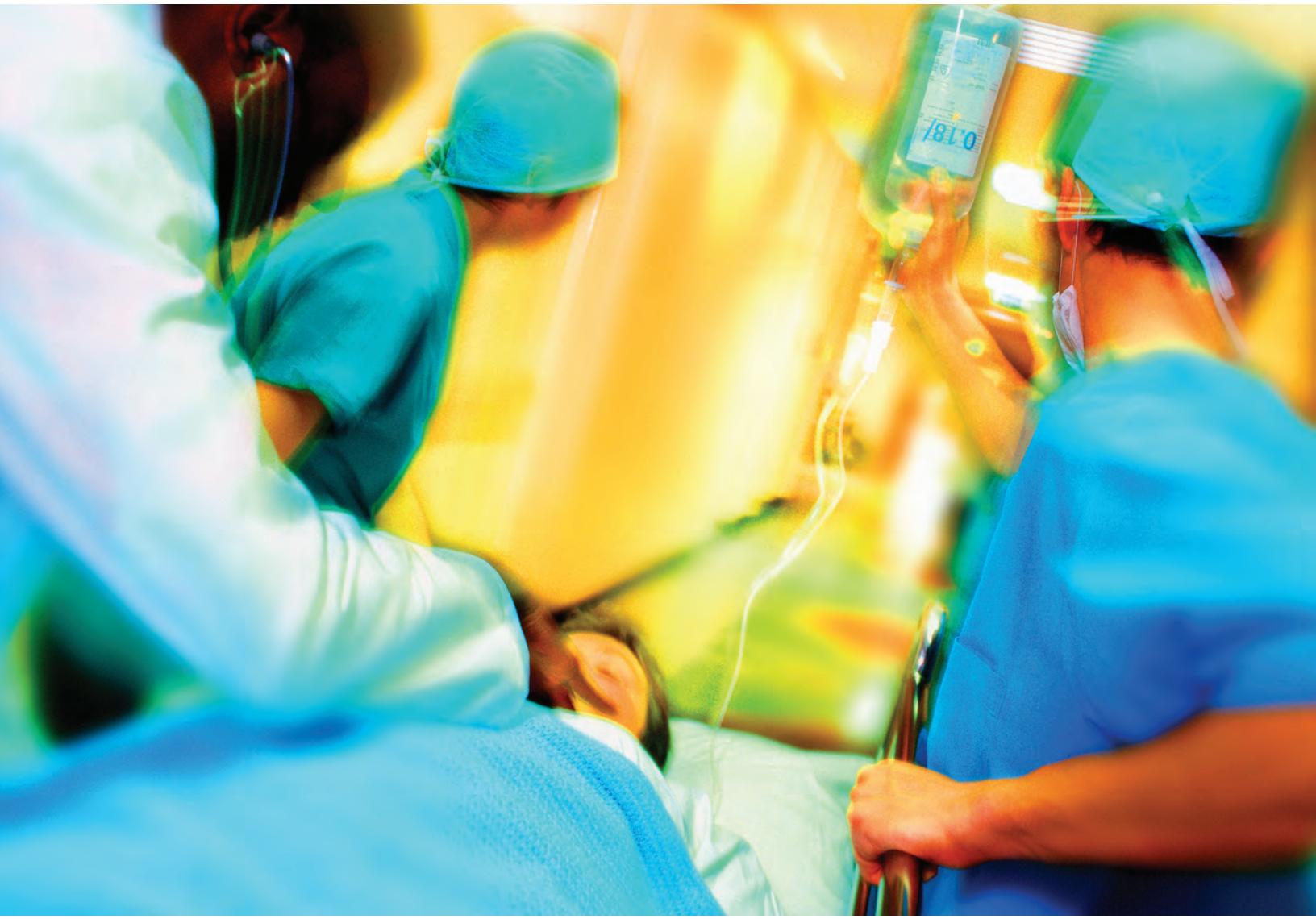

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Crash Injury Prediction and Vehicle Damage Reporting by Paramedics

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Supervising Section Editor: Bharath Chakravarthy, MD, MPH
Submission history: Submitted August 21, 2008; Revision Received December 08, 2008; Accepted December 12, 2008.
Reprints available through open access at www.westjem.org

Objective: The accuracy of pre-hospital crash scene details and crash victim assessment has important implications for initial trauma care assessment and management. Similarly, it is known to influence physician perception of crash victim injury severity. The goal of this feasibility study was to examine paramedic accuracy in predicting crash victim injury profile, disability outcome at hospital discharge, and reporting vehicle damage with other crash variables.

Methods: This prospective case series study was undertaken at a Southern California, Level I trauma center certified by the American College of Surgeons. Paramedics transporting crash injured motor vehicle occupants to our emergency department (ED)/trauma center were surveyed. We abstracted ED and in-patient records of injured vehicle occupants. Vehicle and crash scene data were obtained from a professional crash reconstruction, which included the assessment of deformation, crash forces, change in velocity, and the source of each injury.

Results: We used survey, injury, and crash reconstruction data from 22 collision cases in the final analysis. The median Injury Severity Score (ISS) was five (range 1-24). No enrolled patients died, and none were severely disabled at the time of discharge from the hospital. The paramedic crash injury severity predictions were sensitive for an Abbreviated Injury Scale (AIS) of 2-4. Paramedics often agreed with the crash reconstruction on restraint use, ejection, and other fatalities at the scene, and had lower levels of agreement for front airbag deployment, steering wheel damage, and window/windshield impact. Paramedics had 80% accuracy in predicting any disability at the time of hospital discharge.

Conclusion: Paramedic prediction of injury profile was sensitive, and prediction of disability outcome at discharge was accurate when compared to discharge diagnosis. Their reporting of vehicle specific crash variables was less accurate. Further study should be undertaken to assess the benefits of crash biomechanics education for paramedics and other pre-hospital care providers.
[*West*JEM. 2009;10:62-67.]

INTRODUCTION

Pre-hospital information gathered at the scene of a motor vehicle crash can yield important clues to life-threatening injuries. The crash mechanism (single vehicle, multivehicle), crash geometry (frontal, side-impact, rollover), vehicle speed, restraint use, and the extent of occupant space intrusion can all influence the likelihood of serious injury.[1] As out-of-hospital personnel incorporate their initial in-field victim assessment along with crash scene details, crash victim injury profiles emerge and are relayed to definitive trauma care providers.

The accuracy of crash scene details and crash victim assessment have important implications for initial in-hospital acute care assessment and management, as well as physician perception of crash injury severity.[2] To date, out-of-hospital personnel accuracy of crash injury profiles and crash victim outcome prediction has had limited evaluation.

Crash reconstruction combines technical knowledge of motor vehicle crash characteristics, thorough measurement of vehicle deformation, and mathematic analysis of crash dynamics to determine the sequence of crash events, the speeds and forces involved, and the specific sources of each injury. The forces acting on a vehicle are typically summarized by Delta V, the change in velocity as a result of the impact, which is well correlated with injury to occupants.[3] Because it uses all the available evidence from crash reports, inspection and measurement of the vehicle and medical records, it represents a true gold standard for crash variables.[4] The goals of this study are to determine the feasibility of crash injury research in a clinical setting and to examine paramedic accuracy in predicting crash victim injury profile, disability outcome, and reporting vehicle damage with other crash variables.

METHODS

Study Design

We used a convenience sample of paramedics caring for crash-injured victims. The data collected included questionnaires from paramedics, abstraction of emergency department (ED) and in-patient hospital records, as well as vehicle and crash scene data from professional crash investigation. The study protocol was reviewed and approved by the local institutional review board.

Study Setting and Population

The study was undertaken at a Level I trauma center certified by the American College of Surgeons. The ED/trauma center is located in Southern California and in 2002 had an ED census of 40,000 and 1,800 trauma activations.

Study Protocol

Paramedics transporting crash-injured motor vehicle occupants to our ED between the hours of 8am–12am daily from November 2001 to August 2002 were eligible for participation in the study. Immediately after transferring the patient to the trauma team, the paramedic who provided verbal report to the trauma team captain was approached by a trained research assistant, who introduced the study and obtained verbal consent for participation. The paramedic completed an anonymous questionnaire that recorded their assessment of the condition of the patient and the vehicle occupied by the patient. The paramedic was asked to identify restraint use, occupant location, occupant ejection, other fatalities, passenger compartment space intrusion near occupant, crash type, airbag deployment, steering wheel damage, and window/windshield impact. They were also asked to predict, when applicable, the severity of the patient's injuries by placing a mark on a 100 mm visual analog scale (VAS) anchored by the words "mild" and "severe," for each of eight body areas (head, neck, chest, back, abdomen, pelvis, upper extremities, and lower extremities). The VAS was used for simplicity in assessing the predicted level of injury without reference to a standard coding system. Finally, paramedics were asked to predict the crash victim's disability outcome at the time of discharge from the hospital from eight categories corresponding to disability scores: level 0 - living with no disability; levels 1-6 for increasing levels of disability, and level 9 for death.[5]

When the crash victim was deemed clinically stable by members of the trauma team, he was approached by a study team member, apprised of his role in the study, and consented by the study team for chart review and separately for vehicle crash investigation. At the conclusion of the patient's course of hospital treatment, his charts were reviewed and relevant data were abstracted from ED/trauma care records, radiological reports, surgical reports, and discharge summary. A trauma surgeon reviewed all cases, ranked all injuries on an Abbreviated Injury Scale (AIS) from 1 (minor injuries) to 6 (unsurvivable), computed Injury Severity Scores (ISS), and assigned disability scores based on the patient's status at discharge using the same scale by the paramedic.[6,7]

Following initial patient consent and without knowledge of paramedic prediction, the senior crash investigator performed a complete vehicle and crash scene investigation. This industry-standard evaluation consisted of detailed vehicle measurement and photography, as well as physical reconstruction of the crash. Data were gathered on all crash variables previously evaluated by paramedic on the anonymous questionnaire. The investigator assessed restraint use by examining seat belts for scoring due to movement of the belt through metal components during crash loading. Ejection was assessed from the crash report and from injuries consistent with impacts with objects in the environment. Other fatalities at the scene were assessed from the police crash report. Intrusion was measured by the deformation of the interior surfaces of the passenger compartment near the occupant and defined as positive if 3cm or more. The investigator assessed airbag deployment by inspecting the airbag. Steering wheel damage and window/windshield impact were assessed by inspecting these parts of the vehicle for damage and traces of blood or tissue at impact points. After completion of crashed vehicle investigation, we matched each diagnosed injury to specific damage in the vehicle and evidence of bodily contact.

Data Analysis

Data from paramedic questionnaires were divided

Figure 1. Frontal damage with measurement of vehicle deformation

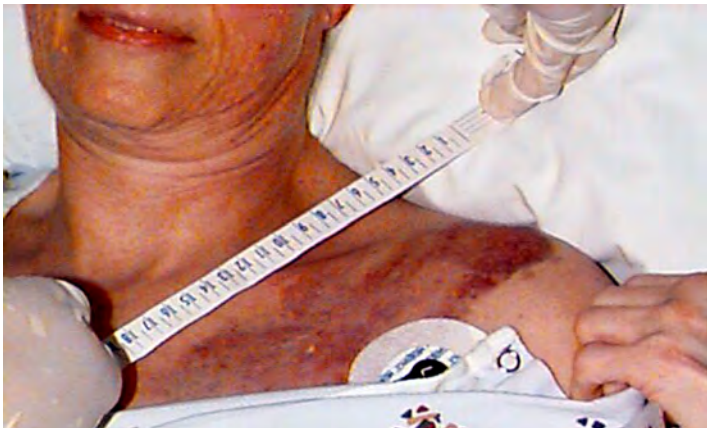

Figure 2. Seatbelt-related contusion and abrasion

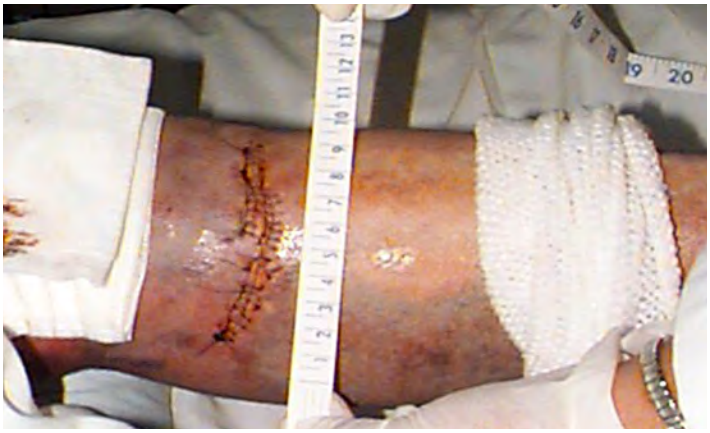

Figure 3. Left lower extremity laceration due to contact with car alarm LED

Figure 4. Car alarm LED

into three sections: crash variables, VAS and AIS injury assessments, and disability outcome predictions. Paramedic-reported crash variables were compared with the corresponding variables from the formal crash investigation report, which was considered the gold standard.

Paramedic responses of "unknown" for variables known upon crash investigation were counted as incorrect. With the exception of airbag deployment, a response of "not applicable" was interpreted as "no." Sensitivity and specificity were calculated for all yes/no variables and for the disability scale. We calculated exact 95% confidence intervals using the binomial distribution (Stata 9.2, StataCorp, College Station, TX). We quantified injury severity predictions by measuring the distance in mm to each mark from the left side of the 100 mm horizontal line. No mark was interpreted as zero mm.

Crash case example

A 59-year-old female with a history of Addison's Disease and hypothyroidism was the driver of a small four-door sedan that collided with a large sedan traveling in the opposite direction. The crash occurred as the driver of the small sedan was attempting to make a left turn. At impact, the Delta V for the small sedan was estimated to be 31.7 km/h and 31.1 km/h for the large sedan.

Figure 1 shows the amount of crush deformation of the small sedan with crash investigation equipment. These measurements were used to calculate the crash forces at the time of impact and the Delta V. Seatbelt use by the small sedan driver was evident by the neck and chest wall contusion (seat belt sign) noted in Figure 2. The driver of the small sedan suffered a large full-thickness laceration of the left lower extremity (Figure 3) found to be due to impact with the after-market alarm LED shown in Figure 4. The role of this object as a significant source of injury was determined only through the comparison of crash reconstruction with clinical findings. Formal reconstruction of the crash demonstrated that on impact the driver translated forward and slightly underneath the seatbelt (submarine), allowing for pelvic contact with

the instrument panel resulting in sacral ala and pubic rami fractures (Figure 5). Once again, the true mechanism and source of these significant fractures could only be determined through an understanding of the crash kinematics offered by crash reconstruction.

RESULTS

We collected information from paramedics regarding 129 eligible crash victims. Fifty-six crash injured victims declined or were unable to provide consent; 22 cases were excluded because the vehicle had been sold for salvage before the crash investigator could gain access to it. Twenty-nine cases had incomplete investigation. Data from the remaining 22 cases were used in the analysis.

The median ISS was five (range 1-24). At the time of discharge from the hospital, none of enrolled patients died and none were severely disabled; 14 had no disability, six had a minor disability (disability score=1), and two had insufficient data on disability at discharge to assign a score. With the exception of one collision with a wall and one collision with a tree, all other cases involved collisions between two or more vehicles.

The frequency of agreement for seven yes/no crash variables are presented in Table 1. Paramedics most often agreed with the crash reconstruction on restraint use, ejection, and other fatalities at the scene, and had somewhat lower levels of agreement for front airbag deployment, steering wheel damage, and window/windshield impact. Paramedics reported space intrusion near the occupant for 19 of 22 cases, but the crash reconstruction identified occupant space intrusion in only half the cases. In addition, paramedics agreed with crash reconstruction on the specific seating location for 20 of 22 cases (91%, 95% CI 71-99%) and on the collision type for nine of 22 cases (41%, 95% CI 21-64%).

Paramedic injury severity predictions

Twenty injured crash victims had paramedic injury severity predictions for each of eight body regions. (For two cases, the paramedics described the injuries verbally and did not use the VAS.) Although the severity predictions were moderately related to the AIS scores (r=0.52), 18 of 20 of the predictions for AIS score of 2-4 (moderate to severe injuries) were 25 to 100 mm (Table 2). The two injuries of AIS 2-4 that had VAS predictions less than 25mm, were an abdominal injury (splenic laceration) and a pelvic injury (sacral and pubic rami fractures).

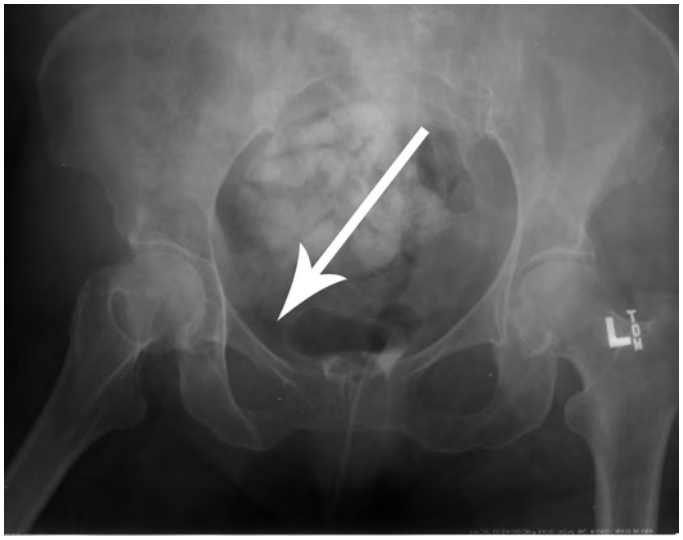

Figure 5. Pelvic x-ray with right sacral ala and pubic rami fracture

Outcome – Disability Results

Paramedics had 80% accuracy in predicting any disability at the time of hospital discharge as shown in Table 3. Paramedics overestimated disability in three cases and underestimated disability in three other cases.

DISCUSSION

We were able to obtain crash reconstruction data on approximately one of six crashes of eligible injured motor

Table 1. Agreement of paramedic response with reconstruction assessment, sensitivity, and specificity, for seven crash variables.

Crash variable	Reconstruction Assessment		Sensitivity	Specificity
	Yes	No	(95% CI)	(95% CI)
Restraint use	16/19	3/3	84% (60-97)	100% (29-100)
Ejection	0/0	21/22	undefined	95% (77-100)
Other fatality at scene*	0/1	20/20	0% (0-98)	100% (83-100)
Intrusion near occupant	10/11	2/11	91% (59-100)	18% (2-52)
Front airbag deployment	6/9	11/13	67% (30-93)	85% (55-98)
Steering wheel damage	2/2	12/20	100% (16-100)	60% (36-81)
Window/windshield impact	8/16	5/6	50% (25-75)	83% (36-100)

*Reconstruction could not determine correct value for one case.

Table 2. Paramedic injury severity predictions by AIS score, eight predictions on 20 crash victims using a 100 mm scale.

Paramedic Injury severity prediction	AIS 0	AIS 1	AIS 2-4	Total
0-24 mm	104 (86%)	12 (55%)	2 (12%)	118
25-100 mm	17(14%)	10 (45%)	15 (88%)	42
Total	121	22	17	160

Table 3. Paramedic prediction of disability score by disability status at discharge.

Disability Score	Status at Discharge		Missing	Total
Paramedic prediction	**0**	**1**		
0	13	3	0	16
1	0	1	1	2
2	1	2	0	3
3	0	0	1	1
Total	14	8	2	22
Exact Accuracy 0 vs. 1-3	70%	(46-88%)		
Accuracy	80%	(56-94%)		
Sensitivity	50%	(12-88%)		
Specificity	93%	(66-100%)		

vehicle occupants. The largest number of case exclusions was because injured crash victims, including the most severely injured subjects, did not or could not consent to data collection. Problems in obtaining consent were the most important barrier to the feasibility of performing crash injury research in this study.

This study compared paramedic predictions of injury profile and disability outcome to diagnosis at discharge. It also compared paramedic report of crash variables, based on their observations at the crash scene, to professional crash reconstruction, the highest quality of crash data. The crash reconstruction data represent a true gold standard for valid assessment of the accuracy of paramedic observations.

Crash variables are important indicators of severity and may suggest body regions for more intensive diagnostic evaluations. Paramedics accurately reported restraint use, ejection, and other fatalities at the scene, but had lower levels of agreement for airbag deployment, steering wheel damage, and window/windshield impact. They reported intrusion for most of the cases in which the reconstruction indicated none, suggesting that they define intrusion differently from the crash investigators. Compared to a previous study comparing ambulance reports to crash reconstruction,[8] we found a higher level of agreement for restraint use and airbag deployment.

Paramedics had sensitive predictions of the AIS 2-4 and had 80% accuracy in predicting any disability at discharge. Previous studies[9-12] reported mixed results for the usefulness of paramedic predictions. Accurate paramedic perceptions of injury severity may lead to more appropriate triage and transport of crash victims to trauma centers. It is axiomatic that quality improvement requires information feedback. Studies such as this may be useful to guide efforts to improve the crash and injury information that paramedics provide to definitive trauma care providers.

LIMITATIONS

This study is limited by the small sample size and the difficulties we experienced in obtaining consent and complete data on all the cases identified. In the process of attempting to enroll subjects, several prospective participants expressed concerns about legal ramifications or civil liability linked to having their crashed vehicle formally investigated and therefore declined study participation. Although some subjects could have given consent to collect data after they were stabilized, waiting several hours to days to try to obtain consent often precluded timely access to their crashed vehicles. Furthermore, we did not assess the level of training and experience of the paramedics. Nevertheless, we observed some trends that may suggest areas for further evaluation and improvement of in-field crash victim and vehicle integrity assessment.

CONCLUSION

Paramedic prediction of crash-victim injury profile was sensitive, and their prediction of disability outcome at hospital discharge was 80% accurate. Their reporting of certain vehicle-specific crash variables (airbag deployment, steering wheel damage, wind shield impact, and occupant space intrusion) was less accurate. While our study was limited by a small number of crash cases, we believe further study should be undertaken to further evaluate the benefits of enhancing education in crash biomechanics for paramedics and other pre-hospital care providers.

Acknowledgements

The authors would like to thank James Perry of Dynamic Science, Inc. and the University of California, Irvine, Department of Emergency Medicine's Emergency Medicine Research Associates Program for their dedicated help in this study.

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Conflicts of Interest: By the *West*JEM article submission agreement, all authors are required to disclose all affiliations, funding sources, and financial or management relationships that could be perceived as potential sources of bias. This study was conducted through a subcontract from Dynamic Science Inc.

REFERENCES

1. Jones IS, Champion HR. Trauma triage: vehicle damage as a prediction of injury severity. *J Trauma*. 1989; 29:646-653.
2. Dickinson ET, O'Connor RE, Krett RD. The impact of prehospital instant photography of motor vehicle crashes on receiving physician perception. *Prehosp Emerg Care*. 1997; 1:76-79.
3. Evans, L. Driver injury and fatality risk in two-car crashes versus mass ratio inferred using Newtonian mechanics. *Accid Anal Prev*. 1994; 26:609-616.
4. Van Kirk DJ. *Vehicular accident investigation and reconstruction*. Boca Raton, FL: CRC Press LLC; 2001.
5. States JD, Viano DC. Injury impairment and disability scales to assess the permanent consequences of trauma. *Accid Anal Prev*. 1990; 22:151-160.
6. Baker SP, O'Neill B, Haddon W Jr., Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma*. 1974; 14:187-196.
7. Association for the Advancement of Automotive Medicine. *The Abbreviated Injury Scale (AIS), 1990 Revision.* Des Plaines, Illinois: HarperCollins Publishers; 1990.
8. Grant RJ, Gregor MA, Beck PW, Maio RF. A comparison of data sources for motor vehicle crash characteristic accuracy. *Acad Emerg Med*. 2000; 7:892-897.
9. Fries GR, McCalla G, Levitt MA, Cordova R. A prospective comparison of paramedic judgment and the trauma triage rule in the prehospital setting. *Ann Emerg Med*. 1994; 24:885-889.
10. Mulholland SA, Gabbe BJ, Cameron P. Is paramedic judgment useful in prehospital trauma triage? *Injury*. 2005; 36:1298-1305.
11. Mulholland SA, Cameron PA, Gabbe BJ, et al. Prehospital prediction of the severity of blunt anatomic injury. *J Trauma*. 2008; 64:754-760.
12. Crystal R, Bleetman A, Steyn R. Ambulance crew assessment of trauma severity and alerting practice for trauma patients brought to a general hospital. *Resuscitation*. 2004; 60:279-282.

Unexpected Arrest-Related Deaths in America: 12 Months of Open Source Surveillance

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Supervising Section Editor: Harrison Alter, MD, MS
Submission history: Submitted December 11, 2007; Revision Received August 07, 2008; Accepted November 28, 2008.
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Introduction: Sudden, unexpected arrest-related death (ARD) has been associated with drug abuse, extreme delirium or certain police practices. There is insufficient surveillance and causation data available. We report 12 months of surveillance data using a novel data collection methodology.

Methods: We used an open-source, prospective method to collect 12 consecutive months of data, including demographics, behavior, illicit substance use, control methods used, and time of collapse after law enforcement contact. Descriptive analysis and chi-square testing were applied.

Results: There were 162 ARD events reported that met inclusion criteria. The majority were male with mean age 36 years, and involved bizarre, agitated behavior and reports of drug abuse just prior to death. Law enforcement control techniques included none (14%); empty-hand techniques (69%); intermediate weapons such as TASER® device, impact weapon or chemical irritant spray (52%); and deadly force (12%). Time from contact to subject collapse included instantaneous (13%), within the first hour (53%) and 1-48 hours (35%). Significant collapse time associations occurred with the use of certain intermediate weapons.

Conclusion: This surveillance report can be a foundation for discussing ARD. These data support the premise that ARDs primarily occur in persons with a certain demographic and behavior profile that includes middle-aged males exhibiting agitated, bizarre behavior generally following illicit drug abuse. Collapse time associations were demonstrated with the use of TASER devices and impact weapons. We recommend further study in this area to validate our data collection method and findings. [*West*JEM. 2009;10:68-73.]

INTRODUCTION

Death while in police custody is controversial. Specifically, a sudden and unexpected arrest-related death (ARD) occurring shortly after law-enforcement contact provokes speculation about the cause of death, such as by underlying health factors, law enforcement brutality, dangerous use of force practices, and illicit drug interaction. When an ARD occurs, polarizing reactions occur by law enforcement, the lay public, and the medical community. These groups may postulate competing explanations for the ARD. Most often, the truth remains elusive.

A large component of this problem is the lack of an accurate, uniform database to track this phenomenon. The only database currently available is the Bureau of Justice Statistic Report on Arrest Related Deaths.[1] This is comprised of deaths reported by law enforcement agencies, medical examiners, and related agencies such as correctional authorities. The data are derived from a questionnaire completed by the individual reporting the event and include all deaths that occur during custody, including homicide, suicide and accidental death. This report is an incomplete measure

Figure 1. Map of ARD locations during the 12-month surveillance period. Note that many of the mapped points are overlapping, so some map points represent more than one event.

of ARDs primarily due to lack of reporting compliance and the inclusion of all types of death that occurred in custody. Our project primarily examines deaths other than homicide or suicide, namely sudden, unexpected death during custodial arrest from no readily apparent cause.

Although literature on the topic of ARDs exists,[2,3] reliable prevalence data do not. Unlike trauma registries or acute myocardial infarction databases, which are maintained as part of national healthcare statistics in the U.S. and available as public information, no collection of current, reliable ARD information is available. In an attempt to improve ARD data, we used a unique method to collect ARD data over 12 months.

METHODS

We used a prospective, web-based, open-source research method. A web-based media search service (www.webclipping.com) was used to scan national media sources daily for intended search terms. This service reports scanning coverage of 20,000 online news sources, 63,000 Usenet news groups, 90 live-streaming newswires and 1.5 billion web pages each day. The following search terms were used and tried individually and in combinations: "excited delirium; metabolic acidosis; delirium; prehospital death; paramedic death; ambulance death; police; sheriff; custody; dies; death" (factorial calculation n!=39,916,800). The gathered data were electronically forwarded daily and filtered for this project. The authors evaluated each data entry to ensure that duplicate findings were only counted as a single event. Disagreement in the data was reviewed by the lead author for conflicting or confirmatory information. Duplicate events were only counted once, and if it could not be determined as a duplicate event it was not counted. An estimated 800 reports were filtered by the investigator to arrive at the final ARD count. This filtering process occurred after the reports had been filtered by the data search service based on keywords. Qualifying cases were then entered into a spreadsheet for further analysis (Excel, Microsoft Corporation, Redmond, WA).

Data points included: location, age, gender, duration of time between first officer contact and collapse (defined as the moment the subject was noted to become unresponsive), type(s) of force used (different types were counted individually), subject behavior prior to collapse and whether or not an illicit stimulant (e.g., cocaine or methamphetamine) was used just prior to the event (defined as reported use by any data source within 12 hours prior to death). Racial data was not reliably reported and was, therefore, not collected. An event was classified as an ARD only if time of the subject's death occurred within 48 hours of first officer contact and was unexpected. We used an arbitrary cut-off time of 48 hours to exclude deaths occurring in correctional facilities not related to the arrest control process. Homicide, suicide, and deaths due to incidents clearly leading to the death were excluded

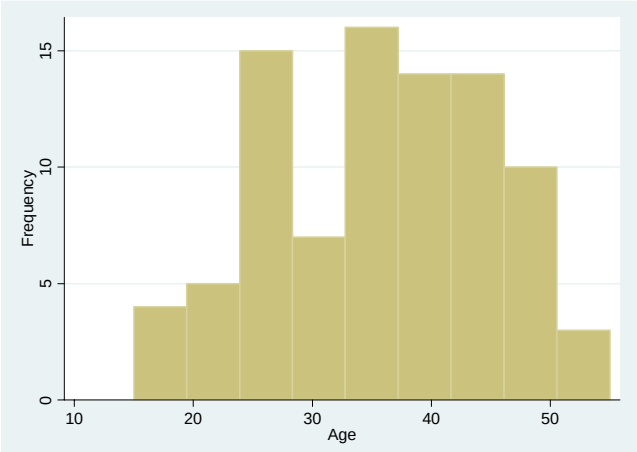

Figure 2. ARD Frequency by Age (years)

(e.g., a subject attacking an officer with a knife, which resulted in the officer fatally injuring the subject with his firearm).

Unusual behavior that was included was defined as that which would be considered out of the ordinary to a layperson given the situation. Examples included: degrees of public nudity, incoherent speech, running in traffic, breaking of glass, attacking oncoming cars or other inanimate objects, attacking people in a non-purposeful manner, and extreme paranoia. Exposure to an illicit substance was defined as intentional use/abuse, or oral or rectal concealment from law enforcement. Ethyl alcohol ingestion or intoxication was not included, as this behavior was not readily reported in the data search service.

After initial inclusion of the event based on search service data, an attempt was made to obtain both the law enforcement arrest record and any autopsy records under the Freedom of Information Act. This information was sought to gain further information on the circumstances surrounding the death, the behavior of the deceased prior to death, and whether or not an illicit stimulant substance was involved. In many of the cases, these records were not provided because of pending litigation or investigation. In cases where we could not determine these factors, they were not included in the final tally of the data.

Descriptive statistics and chi-square testing were used to evaluate subject collapse times when intermediate weapons were used (intermediate weapons are those devices that generally can induce subject compliance due to pain or incapacitation and are a level above empty-hand control techniques but less than deadly force. Examples of intermediate weapons include devices such as aerosolized chemical irritants, impact batons, and projectile beanbags).

The definitions of the types of force used were as follow. **None:** No physical force was used at all, but law enforcement personnel were present and had legally informed the subject that they were in custody at the time of collapse. **Empty-hand control techniques** included a range of manually applied pain compliance techniques, wrist and arm locks, punches, kicks and strikes, as well as grappling or wrestling. This did not include the officer simply touching the person or providing manual guidance not involving pain for compliance. **Intermediate weapons:** chemical irritants (e.g. "tear gas" or pepper spray), impact weapons (e.g. fired baton or beanbag projectiles, flashlights, batons), and any conducted electrical weapon (CEW) such as a TASER® device (TASER International, Inc., Scottsdale, AZ). **Deadly force:** the discharge of any firearm or the use of any object in a manner intended to cause death.

Table 1. Time of death after intermediate weapon encounters

	CEW	Impact	Chemical Irritant
Instant	0	1	1
1 - 60 minutes	40	13	11
> 60 minutes	10	0	8
Total	50	14	20

Because the intent of this project was to present a comprehensive database inclusive of unexplained ARD events, we sought to correlate our data with two recognized organizations attempting to track ARD events. Both Amnesty International (AI) and the American Civil Liberties Union (ACLU) have posted statistics related to ARD events.[4,5] We were unable to determine the methodology used by these organizations to determine the number and cause of ARD events.

This project was registered as exempt by the Hennepin County Medical Center institutional review.

RESULTS

Over a 12-month period (May, 2004-April, 2005), 162 ARD events were reported in the United States that met inclusion criteria (Figure 1). An autopsy report or an arrest report was obtained in approximately 50% of cases. There were six females (3.7%) and 156 males (96.3%) with a mean age of 35.7 years (SD±9.8, range 15-75) (Figure 2). Of these, 102 (62.9%) exhibited unusual behavior and 101 (62.3%) had exposure to an illicit substance just prior to their encounter with law enforcement.

We encountered four categories of force used by law enforcement during encounters with ARD subjects prior to their collapse. These were: none, used in 22 (13.6%) subjects, empty-hand control techniques in 111 (68.5%), intermediate weapons in 84 (51.8%), and deadly force in 19 (11.7%).

In the intermediate weapon category, we collected data on the individual weapon used. Chemical irritants were used 20 times (12.3% of all ARDs and 23.8% of all intermediate weapons), impact weapons 14 times (8.6%, 16.7%), and CEWs 50 times (30.1%, 59.5%). Chi-square analysis of this

data revealed two significant associations (Table 1). First, when an impact weapon was used, it was highly associated with death occurring within the first 60 minutes of the encounter (13/14, p=0.019). Second, whenever a CEW was deployed, death did not occur instantaneously (0/50, p=0.001). Handcuff application was the only force factor recorded which had a 100% association (162/162) with ARD events. (Handcuffs are an expected end point after a significant use of force by law enforcement officers. They are used to control the hands of a potentially dangerous suspect and to place the suspect at a mechanical disadvantage for further resistance or escape). All other chi square analyses of collapse times and weapons used were not statistically significant.

Other factors frequently associated with an unexplained ARD event are male gender, age less than 44 years, history of illegal substance use, and exhibiting bizarre or out-of-control behavior (Figure 3).

1. **Male, under the age of 44 years**
2. **Exhibition of bizarre behavior such as:**
   - Various stages of nudity
   - Incoherence and delirium
   - Violence/attacking or breaking glass
   - Running in traffic
   - Paranoia
3. **Use/abuse of illicit drugs**

Figure 3. Profile of individual at high risk for sudden in-custody death event

DISCUSSION

There has been public concern that some less-than-lethal methods of force by law enforcement have contributed or caused ARD events.[6-8] Countering that is evidence from the medical community that underlying health conditions or intoxications play a significant role.[9-19] Because of the high-profile nature and frequent litigation of any ARD, law enforcement administration and personnel must continually justify their actions and role. Research on ARD is surprisingly sparse and the phenomenon is poorly understood.

Much of the misunderstanding stems from the lack of a reliable, comprehensive, publicly available database to track these deaths. There is a federal legislative mandate (DICRA 2000, also called the Death In Custody Reporting Act of 2000)[20] that requires law enforcement agencies to report to a federal repository but, to date, compliance is incomplete and data are unavailable on their website.[21] The latest report shows 42 states have reported data beyond 2003.[22] The DICRA database also does not currently enforce reporting despite its legislative mandate. Additionally, this database catalogues all deaths within the justice system including suicides and expected deaths during long-term incarceration, so it is not well-suited to study sudden ARD occurring during custodial arrest. Finally, this database is intended to collect ARD information from chief law enforcement officers (CLEO) rather than medical authorities. The CLEO may not report an accurate cause of death, as these data may be filed prior to official medical findings or autopsy report. All of the above factors significantly limit the reliability, validity, and usefulness of the DICRA database.

We were unable to assign causation to any single factor using the ARD data reported, and so merely report associations. We could determine factors proximal to the ARD and the incidence in which force options were applied. We believe the universal handcuff use and common use of empty-hand control techniques represent a measure of the deceased subjects' agitated behavior (requiring the use of control techniques and restraints by law enforcement in response to their actions). Additionally, it is generally a universal policy of U.S. law enforcement agencies to handcuff subjects once they have been placed under custodial arrest (regardless of whether deadly or other force has been applied). Since being under arrest was required for inclusion in the study, universal application of handcuffs is expected.

This study is focused on a very narrow subgroup of persons who die while undergoing arrest. Of the 21 subjects who died instantly, 19 died due to law enforcement use of deadly force. The remaining two had remarkably similar histories. They exhibited bizarre, out-of-control behavior (one running naked in traffic attacking cars and the other attacking the exterior of his home with an ax), and, upon law enforcement arrival, the officers ordered the subjects to stop what they were doing because they were under arrest. In both cases, the subjects then charged toward the officers and collapsed prior to reaching the officers, and no force at all was used on the subjects. In the 19 other cases the officers used deadly force primarily because the subject attacked the officers with a potentially deadly weapon after they had been informed of their arrest. We did not find any cases in which a TASER device had been used on a suspect with immediate temporal relation to their time of collapse.

As alcohol use by subjects of ARD was not reliably reported, we did not analyze these partial data. The initial media reports that the search service forwarded to us did not reliably include these data. However, when we reviewed police and autopsy reports on the cases where it was necessary to verify other information, the majority (over 50%) of these reports indicated some degree of alcohol use. However, because we did not review every police or autopsy report, this factor was unable to be reliably recorded.

Previous research concerning ARD events has focused on single causes of death, such as drug intoxication or positional asphyxia.[16,23] It is unlikely that there is a single unifying etiology. Farnham and Kennedy[24] describe the importance

of recognizing in our society that people tend to look for singular, proximate causes to adverse events and often confuse an action most proximate to the time of a death to be the cause of death. This post hoc fallacy can cause other more remote or contributing factors such as medical conditions or drug abuse to be disregarded. It is possible that ARDs result from a cascade of pre-disposing factors (including lifestyle choices, preexisting medical conditions, or profound delirium, leading to significant metabolic acidosis).[13,16,17,25]

The DICRA 2000 database is far from being accurate or complete, as explained above. In this report, we sought to overcome some of these weaknesses. Using an internet search service has been described as an "open source" research technique. This term infers a source of information open to the public. This technique has been used more often in projects related to computer or social science and not often in medicine.[26] This report is a case series identified using this method of data gathering. A limitation of open-source data gathering, however, is that the data are only as accurate as the search terms utilized and as inclusive as the search service itself. We did not attempt to validate our search findings against other available search services, as should be done in future studies.

We believe that this report demonstrates a preliminary baseline of unexplained ARDs for the U.S. Because there is no national repository for ARD data and no motivation for agencies to publicly report, comparisons between agencies are impossible. Single law enforcement or healthcare agencies cannot determine whether there is a trend of ARDs or rather if they are random occurrences. This lack of baseline data makes it difficult to conclude how and why ARD occurs and whether it is preventable. This report allows interested parties to begin to communicate about ARD prevalence.

We recommend enforcement of the federal mandate of DICRA reporting, with the goal of developing an accurate, more comprehensive database to track ARD events as we would for any other cause of death. Furthermore, this database should be publicly accessible to promote open discussion that may contribute to prevention.

LIMITATIONS

Because we used web data from media headlines, our data is less accurate than medical records or coroner reports. Since there are several thousand legal jurisdictions in the U.S., contact with each county official, hospital, or medical examiner was impractical.

Our study relied upon publicly released media, medical examiner and law enforcement reports. It is possible that ARDs occurred that were never reported publicly and, therefore, not included in our data. Furthermore, each report was unique and may not have contained all the data of other ARD reports.

Our report of bizarre behavior and illicit substance use was based on notations of these factors in any one of our three sources of data (media report, law enforcement report, autopsy report). If it was not reported in any of these sources, or we were unable to obtain a needed source due to pending litigation, we did not include it for tabulation. This likely has lead to under-reporting of these factors and therefore strengthens the association between these risks and ARD.

We may have missed cases of ARD because the data were limited by our search terms and search combinations. We believe that our media search was comprehensive and utilized all (11) appropriate singular and combination search terms.

Our search yielded many ARDs that were excluded from this study. For instance, the search term, "in-custody death" yielded many instances of prisoners who died while in long-term incarceration from expected or unexpected means (advanced age, advanced cancer conditions, suicide, etc.). Since we limited our data to subjects that died in the first 48 hours, we may have missed cases where the subject collapsed shortly after arrest, was resuscitated but died days later. The author's anecdotal opinion is that this scenario is fairly common and therefore, this study likely underestimated the number of ARD events in this nation annually.

While we acknowledge the limitations in our foundational database and methodology, it provides a reasonable baseline to begin further research into this important interface between medicine, forensics and law.

CONCLUSION

This study demonstrates factors associated with persons at risk for ARD events, including male gender, age <44 years, illicit drug intoxication, and agitation or confusion at the time of custodial arrest. Law enforcement and emergency medical service agencies, correctional and psychiatric treatment centers, emergency departments, government officials and medical examiners should consider these risk factors when faced with a potential subject, patient or ARD.

We believe that there is an acute need for a reliable, comprehensive, national data collection to validate our preliminary work. Without this, analysis and subsequent preventive measures seem impossible.

Acknowledgement

The authors would like to thank Mr. Mark Johnson, Ms. Bonnie O'Malley and Mr. Andrew Hinz for their diligent help with data collection. This project would not have been possible without their assistance.

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Conflicts of Interest: By the *West*JEM article submission agreement, all authors are required to disclose all affiliations, funding sources, and financial or management relationships that could be perceived as potential sources of bias. S*ources of support*: This project received partial funding by TASER International (Scottsdale, AZ) in the form of payment of the search engine subscription fee.

REFERENCES

1. Mumola CJ. Arrest-related deaths in the United States, 2003-2005. U.S. Dept. of Justice Bureau of Justice Statistics Special Report. Available at: www.ojp.gov/bjs/pub/pdf/ardus05.pdf. Accessed 7-30-2008.
2. Ross DL, Chan TC. *Forensic Science and Medicine: Sudden Deaths in Custody*. Totowa, New Jersey: Humana Press; 2006.
3. DiMaio TG, DiMaio VJM. *Excited Delirium Syndrome: Cause of Death and Prevention*. Boca Raton, Florida: Taylor & Francis Group; 2006.
4. Amnesty International. Excessive and lethal force? Amnesty International's concerns about deaths and ill-treatment involving police use of TASER's. [Amnesty International Library Web site]. November 30, 2004. Available at: http://www.amnesty.org/en/library/info/AMR51/139/2004. Accessed July 29, 2008.
5. American Civil Liberties Union. Citing deaths in police custody, ACLU of Colorado calls for limits on use of electroshock weapons. [ACLU Web site]. February 26, 2004. Available at: http://www.aclu.org/crimjustice/gen/10119prs20040226.html. Accessed July 29, 2008.
6. Berenson A. Demands rise for tighter oversight on use of stun guns. *New York Times*. February 17, 2005; Section A:24.
7. Fahim K and C Moynihan. TASER gun death is part of national pattern. *New York Times*. July 29, 2005; Section B:3.
8. United States Department of Justice, Office of Justice Programs, National Institute of Justice. The effectiveness and safety of pepper spray. *Research for Practice*. April, 2003.
9. Robison D, and S Hunt. Sudden in-custody death syndrome. *Topics in Emerg Med*. 2005; 27:36-43.
10. Maron BJ, WC Roberts and SE Epstein. Sudden death in hypertrophic cardiomyopathy: a profile of 78 patients. *Circulation*. 1982; 65:1388-1394.
11. McKenna WJ, Deanfield JE. Hypertrophic cardiomyopathy: an important cause of sudden death. *Arch Dis Child.* 1984; 59:971-975.
12. Tamburro P, Wilbur D. Sudden death in idiopathic dilated cardiomyopathy. *Am Heart J*. 1992; 124:1035-45.
13. Spirito P, Maron BJ. Relation between extent of left ventricular hypertrophy and occurrence of sudden cardiac death in hypertrophic cardiomyopathy. *J Am Coll Cardiol*. 1990; 15:1521-1526.
14. Maron BJ. Hypertrophic cardiomyopathy: a systematic review. *JAMA*. 2002; 287:1308-1320.
15. Maron BJ. Sudden death in young athletes. *N Engl J Med*. 2003; 349:1064-1075.
16. Mittleman RE, Wetli CV. Cocaine and sudden "natural" death. *J Forensic Sci*. 1987; 32:11-19.
17. Wetli CV, Fishbain DA. Cocaine-induced psychosis and sudden death in recreational cocaine users. *J Forensic Sci*. 1985; 30:873-880.
18. Isner JM, et al. Acute cardiac events temporally related to cocaine abuse. *N Engl J Med*. 1986; 315:1438-1443.
19. Stratton SJ, et al. Factors associated with sudden death of individuals requiring restraint for excited delirium. *Am J of Emerg Med*. 2001; 19:187-191.
20. 106th Congress (H.R. 1800 [106]). Death in-custody reporting act of 2000. [United States Congressional Web site]. Available at http://www.govtrack.us/congress/bill.xpd?bill=h106-1800. Accessed March 24, 2006.
21. Bureau of Justice Statistics, Department of Justice: Deaths in Custody Statistical Tables. Available at: http://ojp.usdoj.gov/bjs/dcrp/dictabs.htm. Accessed July 26, 2008
22. Mumola, C. BJS' Death in Custody Reporting Program: Remaining Challenges, New Findings. [Bureau of Justice Statistics, Department of Justice, United States Web site]. September, 2005. Available at: www.asucrp.org/meeting/Previous%20Conferences/ 2005/Presentations/ASUCRP-DICRA-9-20-05.ppt. Accessed July 30, 2008.
23. Park KS, Korn CS, Henderson SO. Agitated delirium and sudden death: two case reports. *Prehosp Emerg Care*, 2001; 5:214-16.
24. Farnham FR and HG Kennedy. Acute excited states and sudden death: much journalism, little evidence. *Br Med J*. 1997; 315:1107-8.
25. Hick JL, Smith SW, Lynch MT. Metabolic acidosis in restraint-associated cardiac arrest: a case series. *Acad Emerg Med*. 1999; 6:239-43.
26. DiBona C, Ockman S, Stone M. *Open Sources*. Sebastapol, CA: OReilly Media; 1999.

Cervical Spine Motion During Extrication: A Pilot Study

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Supervising Section Editor: Christopher A. Kahn, MD, MPH
Submission history: Submitted May 29, 2008; Revision Received September 29, 2008; Accepted November 02, 2008.
Reprints available through open access at www.westjem.org

Spinal immobilization is one of the most commonly performed pre-hospital procedures. Little research has been done on the movement of the neck during immobilization and extrication. In this study we used a sophisticated infrared six-camera motion-capture system (Motion Analysis Corporation, Santa Rosa, CA), to study the motion of the neck and head during extrication. A mock automobile was constructed to scale, and volunteer patients, with infrared markers on bony prominences, were extricated by experienced paramedics. We found in this pilot study that allowing an individual to exit the car under his own volition with cervical collar in place may result in the least amount of motion of the cervical spine. Further research should be conducted to verify these findings. In addition, this system could be utilized to study a variety of methods of extrication from automobile accidents. [*West*JEM. 2009;10:74-78.]

INTRODUCTION

It is estimated that 3-25% of spinal cord injuries may be significantly worsened during transport or early treatment, and therefore are preventable.[1,2] Because of this concern for subsequent injury, full spinal immobilization remains the standard of care for Emergency Medical Services (EMS) throughout much of the United States.[1] Currently, full spinal immobilization, as recommended by the American College of Surgeons, consists of application of a cervical collar (CC), immobilization on a long backboard, and the addition of lateral immobilizing devices.[3,1] The Kendrick Extrication Device (KED) is also available as an effective adjunct to spinal immobilization.[4,5,6]

However, full spinal immobilization is not without risk. It has been associated with a multitude of complications, including airway compromise, aspiration, increased intracranial pressure, cutaneous pressure ulcers, iatrogenic pain, combativeness of intoxicated patients and increased cost and time of extrication.[7-22] And backboards place most patients in a position of relative cervical extension.[18,23,24] Removal of patients from a spine board is also problematic with studies showing that "log rolling" a patient results in significant motion of the thoracolumbar spine.[25] Given that the majority of patients who are trauma packaged will have no spinal injury, efforts are underway to identify those whom EMS personnel may safely forego spinal immobilization.[26-29] While pre-hospital cervical spine clearance may prove successful, not all patients will be candidates, possibly due to serious or distracting injury, intoxication, or neck pain. Even if EMS medical directors were to adopt pre-hospital cervical spine clearance protocols, they would require considerable effort to institute and maintain.

While immobilization is problematic in itself, a broader question that must be answered is whether the act of immobilizing the spine results in movement of vertebral segments. Spinal motion has been studied with cadavers, using photogrammetry (analysis of multiple photographs recreating a three-dimensional picture by sterotaxis)[30,31] and via radiographic analysis of cervical motion.[4,5]

Previously, no one had the ability to examine spinal movement during immobilization and actual extrication from an automobile. Roozmon[32,33] had suggested a more comprehensive motion-capture system as the best method for further study of motion in the cervical spine. This system has been used to study kinematics and cervical motion.[34,35] Pearcy[36] demonstrated that skin markers reflect the underlying bony structure if they are placed over relatively fixed points in the skin; ie., sternum, acromion and zygoma. (In a previous study, the displacement error in finding bony landmarks has been estimated at less than one degree.)[37] This study[36] also

Table 1. Cervical spine motion in degrees for patients exiting vehicle independently.

	Unassisted, no CC		Unassisted, with CC	
	Mean	**Std Dev**	**Mean**	**Std Dev**
Starting Angle (in degrees)	8	2.8	4.2	3.9
Mean Change (average angle during movement less the starting angle)	8.7	11.9	1.4	4
Variation During Movement (std dev during movement)	10.6	7.5	1.2	0.1
Peak change (range of motion)	39.8	19.3	6.8	1.8

CC, cervical collar; *Std*, standard deviation

defined the orthogonal base vector system for two rotating bodies, which has become the standard for motion-capture systems. By using a group of markers to define a plane, the relative motion of the head as compared to the torso can be determined mathematically. This involves the absolute angles of the orthogonal vectors in each frame, which are determined trigonometrically with respect to a fixed calibration frame. Next, a transformation matrix rotates the coordinate systems to the absolute reference frame by using Euler's angles to translate from one coordinate system to another.

Our goal was to conduct a pilot study using an infrared video motion-capture system to examine, for the first time, extrication from a mock automobile. We will determine feasibility of further studies with the motion-capture equipment and provide preliminary data.

METHODS

The study was approved by the Washington University Institutional Review Board, and written informed consent was obtained from all parties.

Using as our model a 2001 Toyota Corolla that had significant damage to the interior compartment, with significant dash intrusion and steering wheel deformity, we constructed a mockup to scale, including ground height, floorboard space, dash, center console, steering wheel, ceiling, and doors. We included all deformity rendered by the high-speed accident. The actual Toyota seats were removed and placed in the mock vehicle. To allow visualization of markers by the motion analysis system, direct line of sight with two of six cameras had to be established and maintained at all times. Therefore, we removed the seat back cushions and replaced them with plexiglass. The frame of the vehicle was constructed from ½" PVC conduit and a bent-wire frame.

The Motion Analysis Corporation (MAC) six-camera motion-capture system (Santa Rosa, CA) was used to track 0.5 inch reflective markers on the head (forehead, crown, zygomas), C7, and the trunk (acromion, humerus, clavicle, sternum, anterior superior iliac spine, and greater trochanters bilaterally). This allowed the identification of planes defining the head and torso. Calibration of the system involved measuring deviations from known distances between fixed markers and deviations from known angles as measured by the six cameras, using a triangulation system with the EVa Real-Time Software (EVaRT) (MAC, Santa Rosa, CA). We recorded the position of each marker (calibrated accuracy to 0.5mm) using EVaRT at a frame rate of 60/sec. Standard analysis programs (Excel) allowed the calculation of the change of angle between the head and torso. Starting position of the subject was in the driver's seat of the mock automobile.

We recruited three paramedics, each with more than five years EMS experience. One paramedic, acting as the driver, was extricated by the other two using each of four techniques:

1. The "driver" was allowed to exit the vehicle on his/her own volition and lie on a backboard.
2. The "driver" was allowed to exit the vehicle on his/her own volition with a CC in place and lie on a backboard.
3. The "driver" was extricated head first via standard technique by the remaining two paramedics with a CC alone.[29,30] (Standard technique involves turning the driver so that the legs are in the passenger's seat, allowing the driver to lie back and raising the right hip so a long board can be placed under the hip. A second paramedic who enters the front seat passenger's door helps slide the "driver" up on to the board.)
4. The "driver" was extricated head first via standard technique by the remaining two paramedics with a CC and KED.

RESULTS

We were able to calculate the absolute angle of movement of the cervical spine using extrapolated lines connecting the head (forehead, crown, zygomas), C7, and the trunk (acromion, humerus, clavicle, sternum, anterior superior iliac spine, and greater trochanters bilaterally) which created planes of the head and the torso, respectively.

Ultimately, we documented the least movement of the cervical spine in subjects who had a cervical collar applied and were allowed to simply get out of the car and lie down on a stretcher. [mean change 1.4 ± 4.0 deg, and peak change 6.8 ±

Table 2. Cervical spine motion in degrees for patients requiring assistance.

	Assisted, no CC		Assisted, with KED and CC	
	Mean	**Std Dev**	**Mean**	**Std Dev**
Starting Angle (in degrees)	8.6	4.2	3.8	1.8
Mean Change (average angle during movement less the starting angle)	1	4.5	2	2.3
Variation During Movement (std dev during movement)	4.7	2.9	2.9	0.9
Peak change (range of motion)	26.6	14.2	31.1	17.6

CC, cervical collar; *Std*, standard deviation; *KED*, Kendrick Extrication Device

1.8 deg]. See Table 1. Extricating the driver/subject head-first by standard technique to a long spine board was associated with significant cervical spine motion, both with the collar alone [mean change 1.0 ± 4.5 deg, and peak change 26.6 ± 14.2 deg] and even with a cervical collar and KED [mean change 2.0 ± 2.3 deg, and peak change 31.1 ± 17.6 deg]. See Table 2.

DISCUSSION

The American Association of Neurological Surgeons and the Congress of Neurological Surgeons recognized in 2002 that insufficient evidence exists to support treatment standards or guidelines with respect to pre-hospital spinal immobilization.[1] However, they acknowledge that it is unlikely that all trauma patients require full spinal immobilization.[1] Some patients, such as those with neurologic deficits or altered mental status clearly will require full immobilization for transport and protection of the spine. However, full immobilization of patients with isolated neck or back pain may result in more manipulation of the spine than simply allowing those patients to move themselves.

The National Association of EMS Physicians Standards and Clinical Practice Committee[26] states that patients without altered mental status, intoxication, neck or back pain/tenderness, or distracting injury may forego spinal immobilization. Of two recent studies, only 48 of 13,652 patients with spinal injuries were missed by application of this pre-hospital criteria.[28,29] No patient suffered an adverse outcome. At least one retrospective study suggests that ambulatory trauma patients have little/no risk of thoracolumbar fractures.[34] We may never have the capability to discern which movements result in worsening injury, since this is dependent on the type of injury and the specific individual. The best course of action may be to identify those at high risk for possible injuries through clinical criteria and treat them with the method involving the least spinal movement.

LIMITATIONS

We noted several limitations of the motion capture system. Flexion/extension of the cervical spine may not be analyzed correctly if a line drawn through the frontal plane of the head and a second line drawn through the acromia representing the torso both flex forward, causing the relative motion to be zero. We remedied this by creating a three-point plane of the head and a second one for the torso. We also placed a marker on C7 (with a small portion of the CC removed); however, the marker was still only intermittently visible during the extrication process. Ultimately video was needed to exclude the presence of any flexion/extension. We also needed video to exclude the presence of isolated shoulder movement. These errors may be remedied in future studies by placement of additional markers. In addition, the MAC system was unable to provide sufficient data to evaluate movement of the thoracolumbar spine. (Hardware not requiring line of sight for location of markers will prove superior in the future, if markers are small). Neither were we able to obtain sufficient pelvic data from the markers located over the greater trochanters and anterior superior iliac spines to elucidate any movement of the thoracolumbar spine. This was particularly true when the KED was placed.

Other limitations include the use of a mock automobile and our choice of subjects. We involved only healthy, cooperative, EMS-educated personnel, whose depth of medical knowledge was another drawback.

This study was designed to serve as a pilot study. No changes in current treatment protocols should be made based on it alone. Our research was limited by a lack of power to make such determinations.

A more definitive, appropriately powered study should be conducted to demonstrate if allowing ambulatory patients to leave the vehicle independently with CC alone ± an adjunctive device would be superior to standard immobilization on a backboard. It will be necessary to study a larger number of patients. We further hope that, in the future, we may use this technology to study a variety of extrication techniques for those patients who do require full spinal immobilization.

CONCLUSION

In those ambulatory subjects who do not complain of back pain, the least motion of the cervical spine may occur when the subject is allowed to exit the car in a c-collar without

backboard immobilization. This may have implications for decreasing extrication time in the pre-hospital setting and reducing complications of long spine board use.

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

REFERENCES

1. Hadley MN, Walters BC, Grabb PA, Oyesiku NM, Przybylski GJ, Resnick DK, Ryken TC, et al. Guidelines for the management of acute cervical spine and spinal cord injuries. *Clin Neurosurg*. 2002; 49:407-98.
2. Toscano J. Prevention of neurological deterioration before admission to a spinal cord injury unit. *Paraplegia*. 1998; 26:143-150.
3. American College of Surgeons Committee on Trauma. *Advanced Trauma Life Support*, 7th ed. Chicago, IL: American College of Surgeons; 2004:187.
4. Howell JM, Burrow R, Dumontier C, Hillyard A. A practical radiographic comparison of short board technique and Kendrick Extrication Device. *Ann Emerg Med*. 1989; 18:943-6.
5. Graziano AF, Scheidel EA, Cline JR, Baer LJ. A radiographic comparison of pre-hospital cervical immobilization methods. *Ann Emerg Med*. 1987; 16:1127-1131.
6. Kwan I, Bunn F. Effects of prehospital spinal immobilization: a systematic review of randomized trials on healthy subjects. *Prehosp Disast Med*. 2005; 20:47-53.
7. Bauer D, Kowalski R. Effect of spinal immobilization devices on pulmonary function in the healthy, nonsmoking man. *Ann Emerg Med*. 1988; 17:915-8.
8. Schafermeyer RW, Ribbeck BM, Gaskins J, Thomason S, Harlan M, Attkisson A. Respiratory effects of spinal immobilization in children. *Ann Emerg Med*. 1991; 20:1017-9.
9. Jedlicka DS. A comparison of the effects of two methods of spinal immobilization on respiratory effort in the older adult. *Diss Abstra Int*. 1999; 58-05B:2354.
10. Totten VY, Sugarman DB. Respiratory effects of spinal immobilization. *Prehosp Emerg Care*. 1999; 3:347-352.
11. Hamilton RS, Pons PT. The efficacy and comfort of full-body vacuum splints for cervical-spine immobilization. *J Emerg Med*. 1996; 14:553-559.
12. Chan D, Goldberg RM, Mason J, Chan L. Backboard versus mattress splint immobilization: A comparison of symptoms generated. *J Emerg Med*. 1996; 14:293-298.
13. Cordell WH, Hollingsworth JC, Olinger ML, Stroman SJ, Nelson DR. Pain and tissue-interface pressures during spine-board immobilization. *Ann Emerg Med*. 1995; 26:31-36.
14. Lerner EB, Billittier AJ 4th, Moscati RM. The effects of neutral positioning with and without padding on spinal immobilizatoi nof healthy subjects. *Prehosp Emerg Care*. 1998; 2:112-116.
15. Delbridge TR, Auble TE, Garrison HG, Menegazzi JJ. Discomfort in healthy volunteers immobilized on wooden backboards and vacuum mattress splints. *Prehosp Disast Med*. 1993; 8(3 Supplement):S63.
16. Barney R, Cordell W. Pain associated with immobilization on rigid spine boards. *Ann Emerg Med*. 1989; 18:918.
17. Johnson DR, Hauswald M, Stockhoff C. Comparison of a vacuum splint device to a rigid backboard for spinal immobilization. *Am J Emerg Med*. 1996; 14:369-72.
18. Walton R, DeSalvo JF, Ernst AA, Shahane A. Padded vs. unpadded spine board for cervical spine immobilization. *Acad Emerg Med*. 1995; 2:725-8.
19. Chan D, Goldberg R, Tascone A, Harmon S, Chan L. The effect of spinal immobilization on healthy volunteers. *Ann Emerg Med*. 1994; 23(1):48-51.
20. Hauswald M, Hsu M, Stockoff C. Maximizing comfort and minimizing ischemia: a comparison of four methods of spinal immobilization. *Prehosp Emerg Care*. 2000; 4:250-2.
21. Linares HA, Mawson AR, Suarez E, Biundo JJ. Association between pressure sores and immobilization in the immediate post-injury period. *Orthopedics*. 1987; 10:573.
22. Mawson AR, Biundo JJ Jr., Neville P, Linares HA, Winchester Y, Lopez A. Risk factors for early occurring pressure ulcers following spinal cord injury. *Am J Phys Med & Rehabil*. 1988; 67:123-127.
23. De Lorenzo RA, Olson JE, Boska M, Johnston R, Hamilton GC, Augustine J, Barton R. Optimal positioning for cervical immobilization. *Ann Emerg Med*. 1996; 28:301-8.
24. Schriger DL, Larmon B, LeGassick T, Blinman T. Spinal immobilization on a flat backboard: does it result in neutral position of the cervical spine? *Ann Emerg Med*. 1991; 20:878-81.
25. Swartz E, Nowak J, Shirley C, Decoster L. A comparison of head movement during back boarding by motorized spine-board and log-roll techniques. *J Athl Training*. 2005; 40:162-168.
26. Domeier RM. Indications for prehospital spinal immobilization. National Association of EMS Physicians Standards and Clinical Practice Committee. *Prehosp Emerg Care*. 1999; 3:251-3.
27. Domeier RM, Swor RA, Evans RW, Hancock JB, Fales W, Krohmer J, Frederiksen SM, et al. Multicenter prospective validation of prehospital clinical spinal clearance criteria. *J Trauma*. 2002; 53:744-50.
28. Domeier RM, Frederiksen SM, Welch K. Prospective performance assessment of an out-of-hospital protocol for selective spine immobilization using clinical spine clearance criteria. *Ann Emerg Med*. 2005; 46:123-31.
29. Burton JH, Harmon NR, Dunn MG, Bradshaw JR. EMS provider findings and interventions with a statewide EMS spine-assessment protocol. *Prehosp Emerg Care*. 2005; 9:303-9.

30. Yoganandan N, Pintar F, Gennarelli T. High-speed 3-D kinematics from whole-body lateral impact sled tests. *Biomed Sci Instrum*. 2007; 43:40-5.
31. Yoganandan N, Pintar F, Reinartz J, Cusick JF, Maiman DJ, Sances A. Continuous motion analysis of the head-neck complex under impact. *J Spinal Disord*. 1994; 7:420-8.
32. Roozmon P, Gracovetsky SA, Gouw GJ, Newman N. Examining motion in the cervical spine. I: Imaging systems and measurement techniques. *J Biomed Eng*. 1993; 15:5-12.
33. Roozmon P, Gracovetsky SA, Gouw GJ, Newman N. Examining motion in the cervical spine. II: Characterization of coupled joint motion using an opto-electronic device to track skin markers. *J Biomed Eng*. 1993; 15:13-22.
34. Nigg BM. Measuring techniques. In: Nigg BM, Herzog W, eds. *Biomechanics of the Musculo-Skeletal System*. New York, NY: Wiley; 1994:268-78.
35. Richards, J. The measurement of human motion: a comparison of commercially available systems. *Hum Mov Sci*. 1999; 18:589-562.
36. Pearcy MJ. Measurement of human back movements in three dimensions by opto-electronic devices. *Clin Biomech*. 1987; 20:943-9.
37. Plamondon A, Gagnon M. Evaluation of Euler's angles with a least squares method for the study of lumbar spine motion. *J Biomed Eng*. 1990; 12:143-9.
38. Tamir E, Anekstein Y, Mirovsky Y, Heim M, Dudkiewicz I. Thoracic and lumbar spine radiographs for walking trauma patients--is it necessary? *J Emerg Med*. 2006; 31:403-5.

Factors Associated with Complications in Older Adults with Isolated Blunt Chest Trauma

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Supervising Section Editor: Teresita M. Hogan, MD
Submission history: Submitted October 28, 2007; Revision Received March 29, 2009; Accepted April 01 2009.
Reprints available through open access at www.westjem.org

Objective: To determine the prevalence of adverse events in elderly trauma patients with isolated blunt thoracic trauma, and to identify variables associated with these adverse events.

Methods: We performed a chart review of 160 trauma patients age 65 and older with significant blunt thoracic trauma, drawn from an American College of Surgeons Level I Trauma Center registry. Patients with serious injury to other body areas were excluded to prevent confounding the cause of adverse events. Adverse events were defined as acute respiratory distress syndrome or pneumonia, unanticipated intubation, transfer to the intensive care unit for hypoxemia, or death. Data collected included history, physical examination, radiographic findings, length of hospital stay, and clinical outcomes.

Results: Ninety-nine patients had isolated chest injury, while 61 others had other organ systems injured and were excluded. Sixteen patients developed adverse events [16.2% 95% confidence interval (CI) 9.5-24.9%], including two deaths. Adverse events were experienced by 19.2%, 6.1%, and 28.6% of those patients 65-74, 75-84, and ≥85 years old, respectively. The mean length of stay was 14.6 days in patients with an adverse event and 5.8 days in patients without. Post hoc analysis revealed that all 16 patients with an adverse event had one or more of the following: age ≥85, initial systolic blood pressure <90 mmHg, hemothorax, pneumothorax, three or more unilateral rib fractures, or pulmonary contusion (sensitivity 100%, CI 79.4-100%; specificity 38.6%, CI 28.1-49.9%).

Conclusion: Adverse events from isolated thoracic trauma in elderly patients complicate 16% of our sample. These criteria were 100% sensitive and 38.5% specific for these adverse events. This study is a first step to identifying variables that might aid in identifying patients at high risk for serious adverse events.
[*West*JEM. 2009;10:79-84.]

INTRODUCTION

Increasing age has been found to be an independent risk factor for a poor outcome after traumatic injury.[1] Elderly patients (defined as 65 years and older) have up to four-fold greater morbidity and mortality compared with injury severity score-matched younger patients, especially due to thoracic and head injuries.[1-11] The Glasgow Coma Scale assesses the severity and probability of survival in an elderly trauma patient with head injury, yet there is currently no reliable method to prospectively determine severity of thoracic injuries in elderly patients with blunt thoracic trauma. Further, little is known about the incidence of complications from isolated thoracic injury in the elderly, as well as the variables that may predict them.

As thoracic injury is second only to head injury as a factor contributing to death in the elderly trauma victim, reliable assessment is essential.[9] Rib fractures are the most common injury found in elderly blunt chest trauma patients, and each additional rib fracture increases the odds of dying by 19% and of developing pneumonia by 27%.[11,12] Elderly trauma patients also have a higher incidence of respiratory complications and infections.[13] Without reliable factors associated with complications and mortality, fear of adverse events [(including pneumonia, acute respiratory distress syndrome (ARDS), unanticipated intubation, transfer to the intensive care unit (ICU) for hypoxemia, and death secondary to pulmonary sequelae], may dictate an overly conservative approach to management, resulting in routine admission for observation.

The goal of this study was to determine if the conservative approach to elderly trauma victims with thoracic injury can be modified. To accomplish this, we first describe the incidence of adverse events in elderly trauma patients with isolated thoracic injuries, and then identify a set of patient variables that are associated with adverse events.

METHODS

Our project was reviewed by the local institutional review board. We identified subjects from an American College of Surgeons Level I Trauma Center patient registry. The trauma registry prospectively collects data on all trauma team activations including age; sex; mechanism of injury; abbreviated injury scale (AIS) for head and neck, face, thorax, abdomen/pelvis extremity and external injury; number of days in the hospital; and whether the patient was transferred to another facility. AIS describes the severity of injury to one body region on a six-point scale: 1 minor, 2 moderate, 3 serious, 4 severe, 5 critical, 6 unsurvivable.[14]

Using the trauma registry, we identified 160 patients age ≥65 with AIS of 1-5 in the thoracic region between January 1998 and December 2002. Patients with serious injury to other body areas (AIS ≥3) were excluded to limit confounding the cause of adverse events. Ninety-nine patients had isolated chest injury, and their charts underwent a structured review by one researcher who was blinded to the purpose of the study. The data was recorded using a Microsoft Access 2000 structured data form.

Outcome Variables

The outcome variables of interest were the following adverse events: pneumonia, ARDS, unanticipated endotracheal intubation, need to transfer the patient to the ICU for hypoxemia, and death from pulmonary sequelae. The cause of death was determined from the death certificate.

Candidate Predictor Variables

To find the variables associated with the adverse events of interest, 60 candidate predictor variables were collected in the categories of historical information, radiography, physical examination, and laboratory findings.

Historical information: Age; sex; weight; height; body mass index; mechanism of injury; the presence of a seatbelt sign; tobacco use (current, past use, or never); need for home oxygen; past medical history of coronary artery disease; heart failure; cardiac valvular disease; arrhythmia; pacemaker or defibrillator; coronary artery bypass graft; asthma; chronic obstructive pulmonary disease; diabetes; kidney disease; liver disease; cancer; and current use of aspirin, warfarin, clopidogrel (Plavix), or steroids.

Radiography: Identification by plain radiograph or computed tomography of hemothorax; pneumothorax; pulmonary contusion; flail chest; widened mediastinum; long bone, pelvic, clavicle, scapula, sternum, cervical, thoracic, lumbar spine, or rib fractures; spinal cord injury; and where appropriate, whether injuries were unilateral or bilateral.

Physical exam information: Systolic blood pressure (SBP) in the field; emergency department (ED) vital signs including initial Glasgow Coma Scale score, SBP, heart rate, and respiratory rate with or without assistance, oxygen saturation on room air and/or with supplementation and the amount of supplemental oxygen given both at the time of arrival to the ED as well as 24 hours later; presence of injury as well as the AIS score for the head/neck, face, thorax, abdomen/pelvis, extremity, and external injury.

Laboratory information: Alcohol level; toxicology screen results; presence of an abnormal ECG; presence of sinus tachycardia; anion gap; lactate level; and presence of metabolic acidosis.

RESULTS

Characteristics of the sample are summarized in Table 1 (viewable under related files at: http://repositories.cdlib.org/uciem/westjem/vol10/iss2/art4/). Mean age was 75 years. Most (75%) were victims of a motor vehicle crash, and many had co-morbid medical conditions. Sixteen of the 99 patients developed one of the five pre-defined adverse events [16.2% 95% Confidence Interval (CI) 9.5-24.9%] including two deaths [Table 2 (viewable under related files at: http://repositories.cdlib.org/uciem/westjem/vol10/iss2/art4/)]. Adverse events were experienced by 19.2%, 6.1%, and 28.6% of those patients 65-74, 75-84, and ≥85 years old, respectively. All 99 patients were admitted and 68.7% went to the ICU. The mean length of hospital stay was 5.8 days in patients without

Table 1. Characteristics of patients with isolated blunt chest trauma (N=99).*

Characteristics	Percentage*	Characteristics	Percentage*
Age, mean (Standard Deviation)	74.9 (7.4)	Hemothorax	13
Male	59	Pneumothorax, unilateral	26
Weight, mean (lbs)	166.9	Pneumothorax, bilateral	3
Height, mean (inches)	66.4	Clavical fx	11
Auto vs. Pedestrian	8	Scapula fx	3
Motor vehicle accident	75	Multiple rib fx	48
Fall	14	Bilateral rib fx	10
Other mechanism of injury	3	Left sided rib fx	38
Seatbelt sign	12	Right sided rib fx	27
Systolic blood pressure in the field, mean	151	Sternum fx	6
GCS on admission, mean	14.6	Cervical spine fx	3
GCS less than 12	3	Thoracic spine fx	7
Systolic blood pressure in the ED, mean	143.4	Lumbar spine fx	9
Heart rate in the ED, mean	89.3	Spinal cord injury	1
Respiratory rate in the ED, mean	21.9	Pulmonary contusion, unilateral	15
Alcohol leve, mean	8.0	Pulmonary contusion, bilateral	3
Negative toxicology screen	90	Flail chest	7
Toxicology positive for opiates	6	Long bone fx	14
Toxicology positive for benzodiazepines	2	Abnormal mediastinum	37
Toxicology positive for barbituates	1	Pelvic fx	11
Toxicology positive for multiple drugs	1	Thoracostomy	26
Base deficit, mean	3.4	PRBC transfusion in the first 24 hours	22
Anion gap, mean	8.0	Exploratory laporatomy	2
Lactate level, mean	2.5	Thoracotomy	1
Oxygen saturation on arrival to ED, mean	97	ISS, mean	10.6
History of CAD	25	Unanticipated Intubation	4
History of CHF	3	Transfer to ICU for hypoxemia	3
History of CABG	4	Pneumonia	12
History of Asthma	5	ARDS	1
History of COPD	5	Death secondary to pulmonary sequelae	0
History of diabetes	5	Ventilator days, mean	1.4
Present use of aspirin	16	ICU length of stay	4.3
Present use of coumadin	9	Hospital length of stay	7.4
Present use of plavix	1	Death	2
		Presence of any of the adverse outcomes	16

GCS, Glasgow Coma Scale; *ED*, emergency department; *CAD,* coronary artery disease; *CHF,* congestive heart failure; *CABG,* coronary artery bypass graft; *COPD*, chronic obstructive pulmonary disease; *fx,* fracture; *PRBC,* packed red blood cells; *ISS,* injury severity score; *ICU,* intensive care unit; *ARDS,* acute respiratory distress syndrome.

* All values are the percentage unless otherwise noted.

an adverse event and 14.6 days with an adverse event. Post hoc data analysis revealed that the presence of any one of the following were identified in all 16 cases that developed an adverse event: age ≥ 85, initial SBP < 90 mm Hg, hemothorax, pneumothorax, three or more unilateral rib fractures, or pulmonary contusion on chest radiograph (Table 3). The sensitivity and specificity of this decision rule is shown in Table 4.

DISCUSSION

According to the US Census Bureau, during the last century the number of people over age 65 has increased 11-

Table 2. Candidate predictor variables: univariate analysis.

Variable	No Adverse Outcomes (%) N=83	Adverse Outcomes (%) N=16	Variable	No Adverse Outcomes (%) N=83	Adverse Outcomes (%) N=16
Age 65-74	51	62.5	Present use of aspirin	16	13
Age 75-84	37	12.5	Present use of coumadin	8	6
Age ≥ 85	12	25	Present use of plavix	1	0
Weight, mean (lbs)	163.2	186.4	Clavicle fx	11	13
Height, mean (inches)	66.3	66.5	Scapula fx	4	0
Auto vs. Pedestrian	7	12.5	Multiple rib fx	31	56
Motor vehicle accident	75	69	Left sided rib fx	23	19
Fall	14	12.5	Right sided rib fx	17	6
Other mechanism of injury	4	6	Bilateral rib fx	6	31
Seatbelt sign	12	12.5	Sternum fx	6	6
Systolic blood pressure in the field, mean	145.3	187	Cervical spine fx	2	6
			Thoracic spine fx	6	13
GCS on admission, mean	14.8	13.9	Lumbar spine fx	7	19
Heart rate in the ED, mean	89.3	89.1	Spinal cord injury	1	0
Systolic blood pressure in the ED, mean	144.7	136.6	Pulmonary contusion, unilateral	14	19
Respiratory rate in the ED, mean	21.4	24.5	Pulmonary contusion, bilateral	1	13
Alcohol level, mean	7	13.2	Long Bone fx	14	13
Base deficit, mean	3.2	3.7	Pelvic fx	8	25
Anion gap, mean	8.1	7.4	Flail chest	2	31
Lactate level, mean	2.1	2.8	Abnormal mediastinum	33	63
Negative toxicology screen	80	63	Hemothorax	11	25
Toxicology (+) for opiates	4	13	Pneumothorax, unilateral	24	38
Toxicology (+) for benzodiazepines	1	6	Pneumothorax, bilateral	1	13
Toxicology (+) for barbituates	0	6	Thoracostomy	20	56
Toxicology (+) for multiple drugs	1	0	Exploratory laporatomy	2	0
History of CAD	22	38	Thoracotomy	1	0
History of CABG	5	0	ISS, mean	9.7	15.3
History of asthma	4	13	ICU Length of stay, mean	2.9	11.6
History of COPD	4	13	Hospital length of stay, mean	5.8	14.6
History of diabetes	25	13			

GCS, Glasgow Coma Scale; *ED*, emergency department; *CAD,* coronary artery disease; *CABG,* coronary artery bypass graft; *COPD*, chronic obstructive pulmonary disease; *fx,* fracture; *ISS,* injury severity score; *ICU,* intensive care unit

fold, and this number will double over the next 25 years.[8,15] The elderly population has the highest hospitalization rate after injury.[9,15] Currently, the approximately 13% of the U.S. population over 65 accounts for almost one-third of all deaths from injury, and incurs a higher population-based death rate than any other age group.[9] This makes the ability to effectively treat and manage elderly patients of extreme importance, especially as this group continues to grow.

Unfortunately, we lack the data to predict complications in this patient group. In fact, prior studies have not characterized the risk of complications in isolated thoracic trauma patients. Without the ability to predict complications, physicians have adopted conservative management, often admitting even in the absence of visible injuries.[17] We found

Table 3. Performance of criteria on predicting adverse outcomes. (N=99)

	Adverse Outcome	
Decision Rule	**Yes**	**No**
Yes	16	49
No	0	34

Table 4. Sensitivity and specificity of this decision rule.

Sensitivity:	100%	79.4%	100%
Specificity:	34.9%	24.8%	46.2%
Likelihood ratio (+):	1.54	1.31	1.8
Likelihood ratio (-):	0	0	0.33
Positive predictive value:	22.9%	13.7%	34.4%
Negative predictive value:	100%	88.1%	100%

that 16.2% of elderly thoracic trauma patients developed an adverse event, most commonly pneumonia and rarely respiratory failure or death, which suggests the possibility of developing prediction instruments to identify groups at high and low risk. However, the small proportion of people who developed delayed complications highlights the difficulty in developing such an instrument. Generally, one would require 10-15 adverse events per candidate predictor variable. We had far fewer than this. On the basis of this study depending on the number of variables in the model and the confidence interval desired one can calculate the sample size needed to determine a reliable set of criteria. If we can assume that 16% will get complications, the decision rule to be 95% accurate and accept a lower limit of the 90% CI, then we would require a prospective study that finds 150 elderly thoracic trauma patients with adverse outcomes, which would require 1000 elderly thoracic trauma patients for enrollment.

In the second part of our study, we identified a set of patient variables that may predict complications. The presence of these variables -- age $\geq$ 85, initial systolic blood pressure < 90 mm Hg, hemothorax, pneumothorax, three or more unilateral rib fractures, or pulmonary contusion -- were 100% sensitive and 38.5% specific for predicting the development of one of the predefined outcome variables. This sensitive set of criteria may aid in modifying the current conservative approach, because the absence of these findings may identify patients at a sufficiently lower risk for a serious adverse event who may require only limited observation. While these criteria are intriguing, the small numbers of patients who suffered adverse events with the large number of candidate predictor variables should cause readers to interpret the results with extreme caution. We intend these results to imply that developing a set of criteria is worthwhile and feasible.

LIMITATIONS

Our study has several important limitations. The major limitation was the small number of adverse events and the large number of candidate variables used to determine a set of low-risk criteria. As such, this study can only be viewed as a first, exploratory step to identify criteria capable of predicting delayed complications. It should be noted that the criteria that we report: 1) age $\geq$85; 2) initial SBP < 90 mm Hg; 3) hemothorax, pneumothorax; 4) three or more unilateral rib fractures; and 5) pulmonary contusion have significant face validity. Still, we would admonish readers to consider these results as definitive. Our data were collected at a single institution, yielding a small sample with limited external generalizability. In addition, the small sample size yields a point estimate of sensitivity with wide confidence intervals. External validation with a large data set, then prospective validation will be required before these results should be used to supplant usual care in the management of elderly thoracic trauma patients.

CONCLUSION

This study reports that 16.2% of elderly thoracic trauma patients suffer a delayed adverse event. A post hoc set of predictor variables, if absent, identified patients less likely to develop an adverse event. These were: 1) age$\geq$85, 2) initial SBP < 90, 3) hemothorax, pneumothorax, 4) three or more unilateral rib fractures, 5) pulmonary contusion. This represents the first step in the lengthy process of validating a decision rule. In its current form readers should not adopt these criteria to make significant clinical decisions. If these criteria are validated in a much larger data set, perhaps a national trauma registry, these criteria could be used to aid in the management of elderly trauma patients and help modify the current conservative approach to their treatment.

Acknowledgements

We would like to thank Dr. Michael E. Lekawa and Ms. Stephanie Lush for providing the data from the University of California, Irvine Medical Center Trauma registry.

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

REFERENCES

1. Evans, L. Age and fatality risk from similar severity impacts. *Journal of Traffic Medicine*. 2001; 29:10-19.

2. Holcomb JB, McMullin NR, Kozar RA, Lygas MH, Moore FA. Morbidity from rib fractures increases after age 45. *J Am Coll Surgeons*. 2003; 196:549-555.
3. Khattak, AJ, Pawlovich, MD, Souleyreete RR, Hallmark SL. Factors related to more severe older driver traffic crash injuries. *J Transp Eng*. 2002; May/June:243-249.
4. Kulshrestha P, Munshi I, Wait R. Profile of chest trauma in a level 1 trauma center. *J Truama*. 2004; 57:576-581.
5. Li G, Braver ER, Chen L. Fragility versus excessive crash involvement as determinants of high death rates per vehicle-mile of travel among older drivers. *Accident Anal Prev*. 2001; 35:227-235.
6. Linman ST, Kuzucu A, Tastepe AI, Ulasan GN, Topcu S. Chest injury due to blunt trauma. *Eur J Cardio-Thorac*. 2003; 23:374-378.
7. Stawicki SP, Grossman, MD, Hoey BA, et al. Rib fractures in the elderly: a marker of injury severity. *J Am Geriatr Soc*. 2004; 52:805-808.
8. Victorino GP, Chong, TJ, Pal JD. Trauma in the elderly patient. *Arch Surg-Chicago*. 2003; 138:1093-1098.
9. Wang SC, Schneider L. An aging population: fragile, handle with care. *Proceedings of the National Highway Traffic Safety Administration*. 1999.
10. Zhang J, Lindsay J, Clarke K, Robbins G, Mao Y. Factors affecting the severity of motor vehicle traffic crashes involving elderly drivers in Ontario. *Accident Anal Prev*. 2000; 32:117-125.
11. Bulger EM, Arneson MA, Mock CN, Jurkovich GJ. Rib fractures in the elderly. *J Trauma*. 2000;48:1040-1046
12. Shorr RM, Rodriguez A, Indeck MC, Crittenden MD, Hartunian S, Cowley RA. Blunt chest trauma in the elderly. *J Trauma*. 1989; 29:234-237
13. Schiller WR, Knox R, Chleborad W. A five-year experience with severe injuries in elderly patients. *Accident Anal Prev*. 1995; 27:167-174
14. Association for the Advancement of Automotive Medicine. *The Abbreviated Injury Scale (AIS) 1985 revision*. AAAM: Des Plaines, IL; 1985.
15. Bergman M, Farrer S, Joy L. Dramatic changes in U.S. aging highlighted in new census, NIH Report. U.S Census Bureau web site. Available at: http://www.census.gov/Press-Release/www/releases/archives/aging_population/006544.html. Accessed October 2007.
16. Hall MJ, Owings MF. Hospitalizations for Injury: United States, 1996. *Advanced Data*. 2000; 318:1-12.
17. DeMaria EJ. Evaluation and treatment of the elderly trauma victim. *Clin Geriatr Med*. 1993; 9:461-71.

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

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Supervising Section Editor: Tareg Bey, MD
Submission history: Submitted August 09, 2007; Revision Received November 08, 2008; Accepted December 03, 2008.
Reprints available through open access at www.westjem.org

Objective: To determine the point prevalence of urine bilirubin, urine hemoglobin and urobilinogen in blunt trauma patients, and to evaluate its utility as a screening tool for intra-abdominal injury.

Methods: Data analysis of 986 consecutive trauma patients of which 698 were adult blunt trauma patients. Five-hundred sixteen subjects had a urinalysis and a CT scan of the abdomen/pelvis or exploratory laparotomy. We reviewed initial urinalysis results from trauma patients in the emergency department (ED) for the presence of urine hemoglobin, uroblinogen and urine bilirubin. Computed tomography (CT) scan results and operative reports were reviewed from the trauma registry for evidence of liver laceration, spleen laceration, bowel or mesenteric injuries.

Results: There were 73 injuries and 57/516 patients (11%) with intra-abdominal injury. Urinalysis was positive for urobilinogen in 28/516 (5.4%) patients, urine bilirubin in 15/516 (2.9%) patients and urine hemoglobin in 313/516 (61%) patients. Nineteen/forty-seven (4%) subjects had liver lacerations, 28/56 (5%) splenic lacerations, and 15/5 (3%) bowel or mesenteric injury. Comparing the proportion of patients that had urobilinogen detected in the group with and without intra-abdominal injury, 8/28 (29%) subjects with urobilinogen, 5/15 (33%) subjects with bilirubin and 47/313 (15%) subjects with urine hemoglobin were found to have liver lacerations, spleen lacerations, or bowel/mesenteric injuries. Preexisting liver or biliary conditions were not statistically associated with elevation of urine bilirubin, urine hemoglobin or urobilinogen on initial urinalysis after blunt abdominal trauma. Point prevalence for urobilinogen, urine bilirubin and urine hemoglobin are 5.43% (28/516), 2.91% (15/516) and 60.7% (313/516) respectively.

Conclusions: The utility of the initial routine urinalysis in the ED for adult blunt abdominal trauma patients should not be used as a screening tool for the evaluation of intra-abdominal injury.
[*West*JEM. 2009;10:85-88.]

INTRODUCTION

Multiple studies in the emergency medicine (EM) and pathology literature in the late 1980s showed a quantitative correlation between urobilinogen and serum liver enzymes [aspartate aminotransferase (AST) and alanine aminotransferase (ALT)] that demonstrated urobiliogen as a useful screening marker of liver dysfunction in non-trauma medical patients presenting to the emergency department (ED).[1,2] The presence of urine bilirubin is described as highly specific for elevated serum bilirubin due to hepatocellular or biliary tree injury, rather than intravascular hemolysis.[1,2] It follows that there may be a similar association in trauma patients as a screening tool for liver injury after blunt abdominal trauma. The value of routine screening laboratory tests in trauma patients has been debated repeatedly in the literature.[3,4] Many studies have attempted to establish an association between abnormal lab test results and occult injury as a way to target imaging studies more effectively.[5,6,7] In 2002

Holmes et al.[4] demonstrated an association between elevated serum aminotransferases and liver injury in pediatric trauma patients.[4] Conversely, in a study conducted in 2004 Keller et al.[3] refuted the association reported by Holmes, thereby casting doubt on the predictive value of routine organ-specific laboratory studies in trauma patients.[3] The urinalysis (UA) is routinely obtained on all trauma victims who present to the ED primarily as a screening tool for renal or bladder injury. Apart from the red blood cell counts, the remainder of the UA is not routinely used as markers of potential solid or hollow organ injury. The utility of urobilinogen and urine bilirubin in blunt abdominal trauma has not been studied in a systematic fashion.

The objective of this study was to determine the point prevalence of urobilinogen, urine bilirubin and urine hemoglobin in adult blunt abdominal trauma patients with liver, spleen, bowel or mesenteric injuries. The secondary outcome was to evaluate the utility of the routine UA in blunt trauma patients as a screening tool for intra-abdominal injury.

METHODS

A cross-sectional study was conducted on consecutive patients with blunt abdominal trauma that presented to a university tertiary care Level I trauma center with an annual census of 50,000. All patients were identified from the existing trauma registry. Inclusion criteria included all blunt abdominal trauma patients, ≥18 years who presented to the ED and required trauma team activation. This was determined by mechanism of injury, vital signs and Glascow Coma Scale score. In addition, subjects must have received an initial UA in the ED and a CT scan of the abdomen/pelvis or exploratory laparotomy. Subjects excluded were patients less than 18 years old, penetrating trauma patients, anuric (i.e. dialysis-dependent) patients, and those subjects that did not receive a CT scan of the abdomen/pelvis or exploratory lapartomy.

We identified the study cohort through the existing trauma database and obtained basic demographic data on each patient. From this database we determined the types of radiographic studies and lab tests performed and obtained the operative reports. Patient medical record numbers were used to link specific radiographic and laboratory results for subjects of interest and abstracted from existing electronic patient medical records onto a data collection instrument. The individual patients were not contacted, and there was no patient follow up data available after the initial trauma evaluation. We reviewed UA results for the presence of urine hemoglobin, urobilinogen and urine bilirubin, and also collected data on urine specific gravity, pH, red blood cells, white blood cells, and protein ("0" to "500 mg/dL"). After CT scan results were obtained from dictated radiology reports and operative findings from operative reports, we reviewed them for evidence of liver or spleen lacerations, and bowel or mesenteric injury. Patient medical history was obtained from dictated "trauma run" reports, and were based on information gathered from patients, family members, and Emergency Medical Services (EMS) personnel. We also reviewed patient medical records for history of preexisting hepatobiliary pathology.

The study was approved by the hospital institutional review board. We used standard measures of diagnostic accuracy using the Stata program (version 10, College Station, TX).[8]

Table 1. Urinalysis findings in patients with intra-abdominal injuries identified on CT or at surgery.

	OR	95% CI	p
Urobilinogen	3.58	1.29, 9.03	0.0024
Urine bilirubin	4.32	1.11, 14.45	0.0052
Urine hemoglobin	3.41	1.65, 7.75	0.0004

	No injury	Injury	Total
No urobilinogen	439 (90%)	49 (10%)	488
Urobilinogen	20 (71%)	8 (29%)	28
Total	459	57	516

	No injury	Injury	Total
No bilirubin	449 (90%)	52 (10%)	501
Bilirubin	10 (67%)	5 (33%)	15
Total	459	57	516

	No injury	Injury	Total
No hemoglobin	193 (95%)	10 (5%)	203
Hemoglobin	266 (85%)	47 (15%)	313
Total	459	57	516

OR, odds ratio*; CI*, confidence interval

RESULTS

We reviewed 986 consecutive trauma patients' medical data and identified 698 (71%) blunt abdominal trauma subjects. From this database 516/986 (52%) subjects met inclusion criteria: 343 (66%) males and 173 (34%) females. Subjects were 18-99 years (mean = 58). There were 291 motor vehicle collisions (56.4%), 65 falls (12.6%), 55 automobile vs. pedestrian accidents (10.7%), 38 motorcycle accidents (7.4%), 37 assaults (7.2%), four crush injuries (0.8%), two quadruped accidents (0.4%) and one sports injury (0.2%). There were 57 patients (11.1% of 516 study patients) with 73 different intra-abdominal injuries. Forty-three subjects had documented hepatobiliary disease, which consisted of one subject with Hepatitis B and four with Hepatitis C, while eight had a prior cholecystectomy and 16 had incidental findings of

Table 2. Test characteristics results for urobilinogen, urine bilirubin and urine hemoglobin for intra-abdominal injury in blunt trauma victims.

	Urobilinogen	Urine Bilirubin	Urine Hemoglobin
Sensitivity (95% CI)	0.14 (0.07, 0.26)	0.09 (0.03, 0.20)	0.82 (0.70, 0.91)
Specificity (95% CI)	0.96 (0.93, 0.97)	0.98 (0.96, 0.99)	0.42 (0.38, 0.47)
PPV (95% CI)	0.29 (0.14, 0.49)	0.33 (0.13, 0.61)	0.15 (0.11, 0.20)
NPV (95% CI)	0.90 (0.87, 0.92)	0.90 (0.87, 0.92)	0.95 (0.91, 0.97)
+ LR (95% CI)	3.22 (1.49, 6.97)	4.03 (1.43, 11.36)	1.42 (1.23, 1.64)
- LR (95% CI)	0.90 (0.81, 1.00)	0.93 (0.86, 1.01)	0.42 (0.24, 0.74)

PPV, positive predictive value; *NPV,* negative predictive value *LR,* likelihood ratio*; CI,* confidence interval

cholelithiasis. Past medical history was unknown in 433(84%) subjects. UA was positive for urobilinogen in 28 (5.4%) subjects, urine bilirubin in 15 (2.9%), and urine hemoglobin in 313 (61%). There were 19 (3.7 %) liver lacerations, 28 (5.4%) splenic lacerations, and 15 (2.9%) bowel or mesenteric injury. Eight of 28 (29%) subjects with urobilinogen, five of 15 (33%) with urine bilirubin and 47 of 313 (15 %) with urine hemoglobin had blunt abdominal injury with documented liver or spleen lacerations, or bowel injuries (Table 1).

The presence of urobilinogen, urine bilirubin and urine hemoglobin on initial UA after blunt abdominal trauma appears to be a predictor of intra-abdominal injury. See Table 2 for sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (+LR) and negative likelihood ratio (-LR) and associated confidence intervals (CI).

DISCUSSION

Urinalysis has long been considered an essential part of standard trauma adjunctive testing for possible renal or bladder injury. This is the first study to examine the utility of UA with the presence of urobilinogen, urine bilirubin and urine hemoglobin as an indicator in the acute evaluation of blunt abdominal trauma patients for intra-abdominal injury. It demonstrates a statistically significant association between the presence of urine bilirubin, urobilinogen, and urine hemoglobin and intra-abdominal injury. However, the utility of routine UA of the blunt abdominal trauma patient as a predictor of intra-abdominal injury is not strong enough to be clinically useful. The sensitivities and PPV for urobilinogen and urine bilirubin are low, while the specificity and NPV are high. These high specificities and NPVs are deceptive as they are a consequence of low prevalence of injury in the sample population and are accompanied by poor sensitivity with many false negative test results. The converse is true for urine hemoglobin, which is a non-specific indicator of injury with many false positive results.

The utility of the initial routine UA in the ED for adult blunt abdominal trauma patients is a poor predictor for intra-abdominal injury. The LRs found here are not sufficient to change patient management in a resource-rich environment. However, under austere conditions where CT imaging or surgery is less available, these findings, if possible, might be useful to increase suspicion of injury.

LIMITATIONS

This retrospective study from a trauma patient registry data suffers from incomplete information on past medical history, as injured patients are unable to provide medical history and are often not accompanied by family members. This registry data was not supplemented by patient follow up. We had a small number of patients with documented injuries from which to draw conclusions. Additionally, blunt abdominal trauma patients may suffer from hypovolemic shock, which may have reduced renal perfusion and thus urine output leading to false negative results.[2] Furthermore, we did not assess the effects of prerenal azotemia and metabolic acidosis on the metabolism of bilirubin and urobilinogen. Finally, short EMS transport times and rapid initial trauma assessment, with urine taken immediately on ED presentation, may have led to samples being obtained before bilirubin breakdown products were present in urine in sufficient quantities for detection.

CONCLUSIONS

The presence of urobilinogen, urine bilirubin or urine hemoglobin in the initial routine UA in the adult blunt abdominal trauma patient, although statistically associated with intra-abdominal injury, is not a useful clinical adjunct to standard evaluation.

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

REFERENCES

1. Brenner B, Rector F. *Brenner & Rector's The Kidney*. 7th edition. Philadelphia, PA: Sanders Publication; 2004:1121-1123.
2. Chowdhury J, Chowdhury N. Conjugation and excretion of bilirubin. *Seminars in Liver Disease*. 1983; 3:11-23.
3. Keller MS, Coln CE, Trimble JA, Green MC, Weber TR. The utility of routine trauma laboratories in pediatric trauma resuscitations. *Am J Surg*. 2004; 188:671-678.
4. Holmes JF, Sokolove P, Brant W. Identification of children with intra-abdominal injuries after blunt trauma. *Ann Emerg Med*. 2002; 39:500-509.
5. Cotton BA, Beckert B, Smith M. The utility of clinical and laboratory data for predicting intraabdominal injury among children. *J Trauma*. 2004; 56:1068-1075.
6. Holmes JF, Sokolove P, Land C. Identification of intra-abdominal injuries in children hospitalized following blunt torso trauma. *Acad Emerg Med*. 1999; 6:799-806.
7. Puranik SR, Hayes J, Long J. Liver Enzymes as predictors of liver damage due to blunt abdominal trauma in children. *South Med J*. 2002; 95:203-206.
8. Newcombe RG. Two-sided confidence intervals for the single proportion: comparison of seven methods. *Stat Med*. 1998; 17:857-872.

Pseudoaneurysm of the Radial Artery Diagnosed by Bedside Ultrasound

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Supervising Section Editor: Bharath Chakravarthy, MD, MPH
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Reprints available through open access at www.westjem.org

A 42-year-old male presented to the emergency department with pain and swelling of his distal right wrist. Bedside ultrasound placed over the swelling revealed a pseudoaneurysm of the radial artery. The patient received percutaneous thrombin injection of the aneurysm sac followed by direct ultrasound compression therapy of the pseudoaneurysm neck, resulting in thrombosis of the sac. The use of bedside ultrasound by the emergency physician led to appropriate care and proper disposition for definitive management.
[*West*JEM. 2009;10:89-91.]

INTRODUCTION

Pseudoaneurysms of the radial artery are uncommon. The emergency medicine literature has never reported penetrating trauma as a cause. We discuss a case in which a patient developed a pseudoaneurysm of the radial artery following a penetrating stab wound to the volar aspect of his right wrist. We suggest that physical examination of a pseudoaneurysm is unreliable, and the use of a bedside ultrasound machine in the emergency department (ED) is justified and diagnostic. We also introduce several modalities to repair a pseudoaneurysm to aid the physician in proper disposition for definitive management.

CASE REPORT

A 42-year-old male patient presented to a tertiary care academic medical center ED complaining of pain and swelling to his right distal radius. Twenty-six days prior to his current visit, the patient had suffered an accidental self-inflicted stab wound to the volar aspect of his right wrist while skinning deer. During his initial visit at another ED following his laceration, no artery or nerve damage was noted, and the patient was discharged home on oral antibiotics following primary closure of the linear laceration.

On presentation to our ED, the patient stated that he experienced continuous discomfort since the trauma but has now noticed increased pain and swelling on his right volar wrist. The patient now complained of paresthesias to his first, second and third digits on the dorsal aspect. The patient denied fevers, chills, or any other constitutional symptoms that would suggest a possible osteomyelitis or other disease process.

Physical examination revealed a prominent swelling over the volar aspect of his right distal wrist but no overlying erythema (Figure 1A). Palpation of the swelling revealed a discrete pulsatile mass 4cm by 3cm. Distal to the swelling, the radial artery pulse could be palpated deeper and Allen's test was negative for arterial insufficiency to the palm.

Using our bedside ultrasound machine, a linear vascular probe placed directly over the mass revealed a classic "yin-yang" pattern of turbulent blood flow directly over the radial artery (Figure 1B). This classic swirling pattern of blood flow has been characterized to be highly suggestive of arterial pseudoaneurysms.[1]

Subsequently, the patient was admitted to the hospital where the interventional radiologist performed ultrasound-guided percutaneous thrombin injection of the sac with 200 units of thrombin, obtaining complete thrombosis of the pseudoaneurysm. On the first post-procedural day, a repeat ultrasound visualized recanalization of the pseudoaneurysm. The patient then underwent ultrasound compression therapy for 30 minutes at the neck of the pseudoaneurysm, successfully obtaining complete thrombosis. Afterwards, the patient's paresthesias had resolved, and serial neurovascular examinations and ultrasounds of the area revealed persistent thrombosis of the pseudoaneurysm sac. The patient was discharged without further complications. Following up on the patient six months later confirmed resolution of the

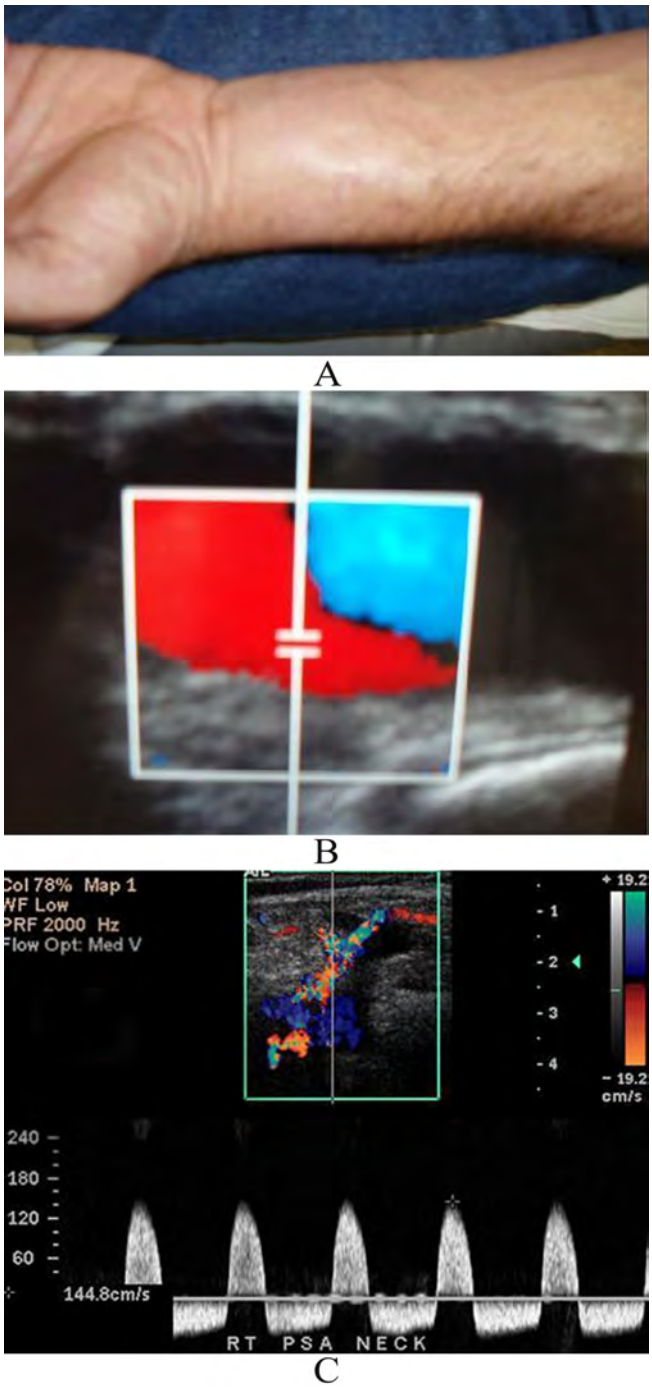

Figure 1. *A*) Pulsatile swelling on right distal wrist, *B*) Color doppler view showing classic "yin-yang" pattern of turbulent blood flow of a pseudoaneurysm and *C*) "To-and-fro" spectral waveform of a pseudoaneurysm neck not depicted in our study.

pseudoaneurysm, and neurovascular status of his hand remained intact.

DISCUSSION

An arterial pseudoaneurysm can be caused by trauma, usually penetrating, of a native vessel. Although the detection of such complications may result within hours from the time of insult, they may occur one to several months afterwards.[2]

There has been no documentation in the emergency medicine literature regarding formation of arterial pseudoaneurysms after penetrating trauma. The trauma literature has described one case where a pseudoaneurysm formed after laceration from a piece of glass.[2] There have been documented cases of pseudoaneurysm formation following vascular access into arteriovenous fistulae, and Komorowska et al.[3] have noted 16 cases of radial artery pseudoaneurysms following infected catheters in the distal radial artery.

Due to its rarity in clinical practice, detection of a pseudoaneurysm in the ED is difficult. Depending on the size of the aneurysm sac, a mass might not be palpated leaving pain as the only symptom. If a mass can be palpated, it may be pulsatile, but it may not have a thrill. Since physical examination is unreliable in diagnosing pseudoaneurysms, bedside ultrasound is necessary and is the most useful adjunct in the diagnosis of a pseudoaneurysm. Due to the high number of arterial cannulations conducted in intensive care units, bedside ultrasound already is utilized in the ICU to assess for pseudoaneurysms.[4]

There are three characteristic features of pseudoaneurysms on ultrasound: the presence of expansile pulsatility, detection of turbulent flow that appears as a classic "yin-yang" sign, and a hematoma with variable echogenicity. The variable echogenicity may represent separate episodes of bleeding and rebleeding.[4] Although not demonstrated in our case report, identification of a "to-and-fro" spectral waveform within the neck is considered pathognomonic for a pseudoaneurysm[1] (Figure 1C).

With physical examination of a pseudoaneurysm, Allen's test is generally negative and arterial pulses are usually palpated distal to the mass. Morbidity can be severe and is related to distal embolization from microemboli, venous compression or even frank rupture.[1,2] For this reason, it is important for the ED physician to correctly diagnose pseudoaneurysms and provide appropriate definitive care. Older literature stated that arterial aneurysms of the upper extremity should be treated surgically,[2] but current research suggests other modalities of correction.

Ultrasound compression therapy involves direct ultrasound-guided compression of a pseudoaneurysm to obstruct the inflow tract of blood. The stasis of blood promotes coagulation causing occlusion and resolution of the pseudoaneurysm. Unfortunately, compression must be maintained for over an hour to obtain occlusion – sometimes longer for anticoagulated patients. Patients can experience extreme discomfort from the prolonged compression. Moreover, the failure rate is significantly high, and surgical intervention may need to be considered if complete occlusion is not achieved. Manghat et al.[5] present a case where a radial artery pseudoaneurysm followed cannulation of the radial

artery during coronary catheterization. Direct compression of the artery did not achieve occlusion and surgical ligation was subsequently necessary. On the other hand, Witz et al.[6] have studied three case reports of patients who developed pseudoaneurysms following vascular access into arteriovenous fistulae in hemodialysis-dependent patients. Patients were all treated with ultrasound compression therapy with complete occlusion of the sac, and no further therapy was needed.

Another option for occlusion of pseudoaneurysms involves ultrasound-guided thrombin injection into the sac. Contrary to compression therapy which may take over an hour, introduction of thrombin starts clot formation instantaneously, but the procedure is not without risks. If thrombin escapes the pseudoaneurysm, a clot can propagate into the affected artery, resulting in embolization or thrombosis of peripheral branch vessels. This may cause extremity paresthesias, pain, or frank necrosis with cases of limb loss being reported.[7] D'Achille et al.[8] describe a case where thrombin injection led to distal skin changes suggesting embolization of a vessel more distally.

Failure to occlude pseudoaneurysms with thrombin injection occurs, but at a lower rate as compared to ultrasound compression therapy. Corso et al.[9] describe a case where two subsequent attempts to occlude a false aneurysm with different concentration of thrombin failed, and Komorowska[3] reports a case where thrombin failed occlusion thereby requiring surgical ligation. In our case study, our patient recanalized his pseudoaneurysm after a failed attempt at thrombin injection, but he did manage to obtain complete occlusion after direct compression therapy for 30 minutes the following post-operative day. The combination of both thrombin injection while performing direct compression of the vascular neck with the ultrasound vascular probe, as proposed by Pozniak,[7] may increase the effectiveness of therapy.

CONCLUSION

Pseudoaneurysms following arterial injuries are rare occurrences, but they have been described in the literature following vascular access attempts to arteriovenous fistulae, catheterization of arteries, arterial blood gas analysis, and other invasive procedures. This is the first case in the emergency medicine literature to report a pseudoaneurysm following penetrating trauma. This case demonstrates that bedside ultrasound supplements careful history-taking and physical examination in making this difficult diagnosis in the ED.

Acknowledgments

We would like to acknowledge Julie Gorchynski, MD for her support and guidance.

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

REFERENCES

1. Rozen G, Samuels D, Blank A. The to and fro sign: the hallmark of pseudoaneurysms. *IMAJ.* 2001; 3:781-782.
2. Kerr C, Duffey T. Traumatic false aneurysm of the radial artery. *J Trauma*. 1988; 28:1603-1604.
3. Komorowska-Timek E, Teruya T, Abou-Zamzam A, Papa D, Ballard J. Treatment of radial and ulnar artery pseudoaneurysms using percutaneous thrombin injection. *J Hand Surgery.* 2004; 29:936-942.
4. Bouch D, Hall A. Ultrasound diagnosis of a false radial artery aneurysm in ICU. *Anaesthesia*. 2006; 61:1018.
5. Manghat N, Ellwood F, Roobottom C. Radial artery pseudoaneurysm post-cardiac catheterization: Imaging with multidetector row CT peripheral angiography. *Heart*. 2006; 9:872.
6. Witz M, Werner M, Bernheim J, Shnaker A, Lehmann J, Korzets Z. Ultrasound-guided compression repair of pseudoaneurysms complicating a forearm dialysis arteriovenous fistula. *Nephrology Dialysis Transplant.* 2000; 15:1453-1454.
7. Pozniak M, Mitchell C, Ledwidge M. Radial artery pseudoaneurysm: a maneuver to decrease the risk of thrombin therapy. *J Ultrasound Medicine*. 2005; 24:119-122.
8. D'Achille A, Sebben R, Davies R. Percutaneous ultrasound-guided thrombin injection for coagulation of post-traumatic pseudoaneurysms. *Australian Radiology.* 2001; 45:218-221.
9. Corso R, Rampoli A, Vercelli R, Leni D, Vanzulli A. Percutaneous repair of radial artery pseudoaneurysm in a hemodialysis patient using sonographically guided thrombin injection. *Cardiovascular and Interventional Radiology*. 2006; 29:130-132.

Subtalar Dislocation

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Supervising Section Editor: Rick A. McPheeters, DO
Submission history: Submitted July 16, 2008; Revision Received August 12, 2008; Accepted August 19, 2008.
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[*West*JEM. 2009;10:92.]

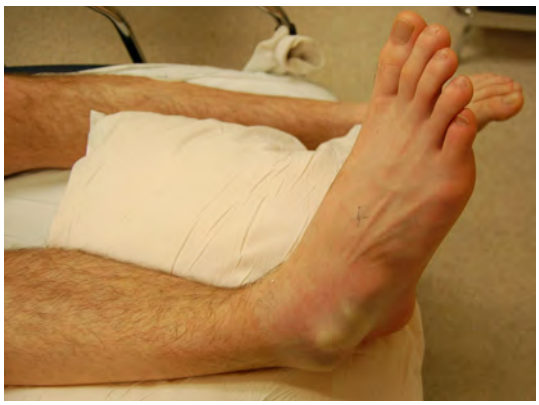

Figure 1. Right foot of a 26-year-old male with a medial subtalar dislocation

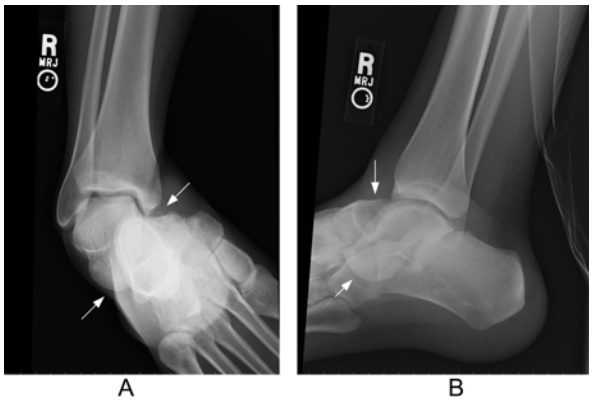

Figure 2. Anteroposterior (panel A) and lateral (panel B) radiographs of the right ankle from a 26-year-old male, demonstrating a medial subtalar dislocation.

A 26-year-old male presented to the emergency department for right foot pain and deformity after inverting his foot while base running playing baseball. Examination revealed a medial deformity of the right foot (Figure 1). The foot was neurovascularly intact without wounds. Radiographs of the ankle demonstrated a medial subtalar dislocation (Figure 2). The dislocation was reduced using procedural sedation with longitudinal-lateral distraction of the foot, resulting in anatomic reduction of the talocalcaneal and talonavicular joints. The patient was placed in a short leg splint, instructed to remain non-weight-bearing on the right foot, with follow-up in the orthopedic clinic the following day.

Subtalar dislocations are rare injuries accounting for approximately 1% of all dislocations.[1] They result from high-energy trauma (e.g., fall from a height or a motor vehicle collision), and certain athletic injuries.[1] Inversion of the foot results in a medial subtalar dislocation (80-85% of these injuries), whereas eversion produces a lateral dislocation.[2,3] In either case, the talonavicular and talocalcaneal joints are involved simultaneously, while the tibiotalar and calcaneocuboid joints remain intact.[3] Optimal management of subtalar dislocations is immediate closed reduction with procedural sedation.[1-3] Medial dislocations have a better prognosis compared to lateral, anterior or posterior injuries, which are often associated with fractures, require open reduction and fixation, and frequently result in instability and arthritis.[1] A CT scan is sometimes recommended to evaluate for associated osteochondral lesions, although these are uncommon with medial dislocations.[1,2] Following reduction, the foot should be immobilized with a short leg cast for 4-6 weeks with the patient remaining non-weight-bearing.[3]

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REFERENCES

1. Wagner R, Blattert TR, Weckbach A. Talar dislocations. *Injury*. 2004; 35: SB36-SB45.
2. Jerome JTJ, Varghese M, Sankaran B. Anteromedial subtalar dislocation. *J Foot Ankle Surg*. 2007; 46:52-54.
3. Biswas S, Murphy M. Subtalar dislocations. *Internet J Orthoped Surg*. 2006; 3:1-5. Available at http://www.ispub.com/ostia/index.php?xmlFilePath=journals/ijos/vol3n2/subtalar.xml. Last accessed July 16, 2008.

Higher Inpatient Medical Surgical Bed Occupancy Extends Admitted Patients' Stay

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Submission history: Submitted December 04, 2007; Revision Received November 20, 2008; Accepted December 01, 2008.
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Objective: Determine the effect that increased medical surgical (med/surg) bed occupancy has on the time interval from admission order to arrival in the bed for the patients admitted from the emergency department (ED).

Methods: This retrospective observational study compares the total hospital bed occupancy rate and the medical surgical inpatient bed occupancy rate to daily averages for the time interval from admission order (patient posting for admission) to the patient's arrival in the inpatient bed. Medical surgical inpatient bed occupancy of 92% was chosen because beyond that rate we observed more frequent extended daily transfer times. The data is from a single large tertiary care institute with 590 beds and an annual ED census of 80,000.

Results: Group 1 includes 38 days with (med/surg) inpatient bed occupancy rate of less than 92%, with an average ED daily wait of 2.5 hrs (95% confidence interval 2.23-2.96) for transfer from the ED to the appropriate hospital bed. Group 2 includes 68 days with med/surg census greater than 92% with an average ED daily wait of 4.1 hours (95% confidence interval 3.7-4.5). Minimum daily average for the two groups was 1.2 hrs and 1.3 hrs, respectively. The maximum average was 5.6 hrs for group 1 and 8.6 hrs for group 2. Comparison of group 1 to 2 for wait time to hospital bed yielded $p < 0.01$. Total reported hospital occupied capacity shows a correlation coefficient of 0.16 to transfer time interval, which indicates a weak relationship between total occupancy and transfer time into the hospital. Med/surg occupancy, the beds typically used by ED patients, has a 0.62 correlation coefficient for a moderately strong relationship.

Conclusions: Med/surg bed occupancy has a better correlation to extended transfer times, and occupancy over 92% at 5 AM in our institution corresponds to an increased frequency of extended transfer times from the ED. The process of ED evaluation, hospital admission, and subsequent transfer into the hospital are all complex processes. This study begins to demonstrate one variable, med/surg occupancy, as one of the intervals that can be followed to evaluate the process of ED admission and hospital flow.
[*West*JEM. 2009;10:93-96.]

INTRODUCTION

Emergency departments (EDs) nationwide are encountering extended delays in evaluating patients.[1-3] Solutions have included attempts to improve the ED patient evaluation process, additional ED beds, additional hospital beds, and improved patient stay times through earlier discharges. However, little research has been done to evaluate the effect of hospital capacity on ED patient length of stay (LOS). In the 1990s managed care focused on controlling hospital LOS, decreasing ED visits, and moving patient care into the outpatient and home care settings. Delaware Healthcare Association data from 1997-2001 showed a

Table 1. Baseline department characteristics

	Total	Occupancy < 92%	Occupancy ≥ 92%
Days	106	38	68
Average hospital occupancy	90.20%	87.40%	92.10%
Average medical/surgical occupancy	93.90%	89.00%	96.90%
Average number of admitted patients (daily)	50.9	51.4	50.54
Range of patients admitted daily	35-70	35-70	38-66
Average number of patients treated and released	169.00	167.00	170.00
Average number of patients seen daily	220.60	219.00	221.50

resultant 6.5% increase in hospital discharges and a 13% increase in emergency visits. Medicare had a 1.2% increase in hospital LOS, and private carriers had a 7.8% increase in LOS.[4] Hospitals anticipating managed care's increased efficiency and decreased utilization did little in expanding inpatient and emergency care services during the 1990s, instead striving to increase efficiency by increasing occupied capacity in the hospital.

Nationwide, metropolitan areas with high health maintenance organization (HMO) penetration showed a greater reduction in beds per capita than areas with less HMO penetration.[5] Current attempts to optimize beds have resulted in 85-100% hospital occupancy and the subsequent difficulty transferring patients from the ED to inpatient beds.[6] Modeling of the dynamics for such a hospital system supports the occurrence of bed shortages and crisis at these occupancy levels.[6] In the Toronto area, for example, area hospitals closed 30% (2,890) of their acute care beds through 1997, which resulted in minimal crowding. When 943 additional beds were closed between 1998 and 2000 and occupancy rates exceeded 90% with a peak at 96% for acute care beds in the region, ED crowding became a frequent occurrence.[7]

We hypothesized that hospital occupancy has an effect on ED admission transfer time. We compared hospital occupancy with the time interval from notification of an ED admission to eventual arrival in the inpatient bed. The study allowed us to see what level of occupancy starts to impact ED patient transfer times.

METHODS

Data for this observational study were drawn from several manual databases used in tracking patients presenting to the ED on a daily basis. Over a four-month period, we tracked ED length of stay, hospital occupancy, and transfer times from the time the patient was posted in the ED to his or her arrival in the hospital bed. The study setting was a 590-bed tertiary care referral center with an annual ED census of 80,000. All patients presenting to the ED were tracked. We obtained the time interval from patient posting for admission (decision by the emergency physician to admit with approval from the admitting attending) in the ED to the time the patient arrived to the appropriate hospital bed ("ED transfer wait time" or transfer time interval.)

The hospital tracked the bed occupancy for publication on a daily institution report card. The hospital occupancy was determined at 5 AM daily and entered into a Microsoft Corporation, Excel 2000 database based on manual bed count. The time was chosen secondary to convenience and represented a stable hospital-census time. Medical surgical (med/surg) occupancy was determined at 5 AM using the same Excel database. Beds not used routinely for ED admission, such as pediatric and obstetrical beds, were removed for a total of 480 med/surg beds. The data was collected from December 2000 to March 2001. The data were analyzed using SPSS inc., version 10, Chicago Illinois, statistical program. Tables incorporate summary statistics, using average daily time intervals and 5 AM occupancy rates. We arbitrarily divided the two occupancy data groups at 92% occupancy. We used Student's *t*-test to compare numerical data and linear regression to determine the relationship of the published total hospital occupancy and med/surg occupancy to the "ED transfer wait time" or transfer time interval.

RESULTS

The analysis was done on a total of 106 days (Table 1), during which 38 days had med/surg bed occupancy <92% (Group 1), 68 days had ≥92% (Group 2), and the remaining 15 days had incomplete time intervals. The baseline data shows an expected lower average occupancy in Group 1 compared to Group 2. Patient census for the department as well as the number of admissions did not vary between groups (Table 1). Student's *t*-test analysis showed no statistically significant difference between daily ED census, patients treated and released, or admitted patients. ED staffing did not vary by day of the week. There was an increase of five patients seen on the weekends, but three fewer patients were admitted.

Group 1 had an average transfer wait time interval of 2.5 hrs (95% confidence interval (CI) 2.23-2.96) to be transferred

Table 2. Emergency department (ED) hospital posting to actual arrival in inpatient bed length of stay data, "ED wait time"

	Average Wait	95% Confidence Interval	Minimum Daily Average Wait Time	Maximum Average Daily Wait Time
Group 1 (< 92% occupancy)	2.5 hours	2.23-2.96 hours	1.2 hours	5.6 hours
Group 2 (≥ 92% occupancy)	4.1 hours	3.7-4.5 hours	1.3 hours	8.6 hours

from the ED to the floor. Group 2 had an average transfer wait time interval of 4.1 hours (95% CI 3.7-4.5). The minimum transfer wait time for the two groups was 1.2 and 1.3 hours, supporting the possibility of more efficient patient transfer. The maximum transfer wait time was 5.6 hours for Group 1 and 8.6 hours for Group 2, demonstrating the wide range in average daily times for transfer.

Comparison of Group 1 and Group 2 for wait time to hospital bed by Student's *t*-test yielded $p<0.01$. Overall hospital occupancy linear regression analysis showed a correlation coefficient of 0.16, indicating a weak relationship for total inpatient occupancy to transfer wait time, versus 0.62 for a moderately strong relationship to med/surg bed occupancy.

DISCUSSION

Dangerous ED crowding nationally has resulted in numerous attempts to increase the ED flow process. Departmental efficiency has some effect on LOS. Hoffenberg et al.[8] evaluated 291 EDs, shared the best-demonstrated processes and showed an improvement of 29 minutes in LOS for the slowest one-third of the hospitals. A study comparing time intervals showed that when the department had an ED bed immediately available there was a 36-minute decrease in LOS.[9] The study also showed a significant decrease in the time to initial physician evaluation of 29 minutes when an ED bed was immediately available. Schneider et al.[10] conducted a descriptive analysis of overcrowding in Rochester, New York, based on ED-only strategies versus system wide strategies and showed little effect on ED crowding from intramural ED strategies versus system wide strategies. In this same study, efforts to provide inpatient resources, float nurses, and a transition team to care for patient waiting for beds in the ED was successful in helping the crowding.

Our data demonstrate significant delays in effective transfer of patients from ED beds to inpatient beds when med/surg inpatient areas exceed 92% occupancy. Kyriacou et al.[9] showed delays in ED patient evaluation from lack of inpatient bed availability. Beth Israel Deaconess Medical Center in Boston, in combination with 150 hospitals in New York, found that using target occupancy levels as a determinant of bed capacity was inadequate and lead to excessive delays for beds.[11]

Our study shows an additional 100-minute delay in transferring patients from the ED if 5 AM med/surg bed occupancy is greater than 92%, representing the effect inpatient bed occupancy had on the ED. The med/surg bed occupancy information at 5 AM can be used to establish available capacity for that day and allow for earlier implementations of processes to increase efficient inpatient flow or capacity increases.

LIMITATIONS

The hospital occupancy data is collected at 5 AM and based on a single institution, so it does not represent ongoing crowding in the ED. The actual delays in transfers are not individually evaluated; the data represent a broad measure of bed availability. The study is retrospective and has the associated potential errors, including incomplete data collection on 14% of the days. The data are older but still represent one of the major outside effects on ED crowding. The 92% med/surg occupancy represents the occupancy level where we start to see an increased frequency of transfer delays. Each hospital will have variation in process and hospital efficiency and will need to determine their best occupancy for anticipated delays in inpatient flow. It remains unclear the effect patient management systems, communication and other factors can have on the point at which med/surg bed occupancy will cause delays in transfer from the ED.

The objective of the study was to determine the effect increasing hospital occupancy had upon ED transfer time. The data were analyzed after collection to determine the med/surg occupancy at which we started to see increased frequency of significant delays in the throughput system. The 92% occupancy rate was chosen based on the point prior to consistently seeing increased delay in transfer times, administratively representing the optimal point to start initiating focused protocols for intervention in the admission process. The post hoc analysis potentially skews the conclusions, but the results match the logical expectation of increasing occupancy and provide a framework for looking at your own hospital admission system.

CONCLUSION

In our institution a predictor of flow for admitted patients from the ED was the occupancy of beds predominantly used for the ED (med/surg beds). Our study showed a 100-minute average daily increase in transfer time when the 5 AM med/

surg occupancy was over 92%. Med/Surg bed occupancy at 5 AM can give hospital administration the opportunity to plan for interventions earlier in the admission process to keep ED patient flow optimal.

Future Directions

Best predictions available show that the increasing ED census is a predictor of increased numbers of patients needing admission, as shown in Lambe et al.[12] Emergency care will require paradigmatic shift ideas, as well as efficient staff, ancillary service, and space utilization to care for the increasing numbers of patients. At the same time, a similar focus on increasing efficiencies in the hospital admission and discharge process is needed. Future process evaluation and analysis of hospital admissions times and activity within the hospital around admission and discharge can be used to understand the impact on ED crowding and delays in admission. This can be used to evaluate changes in staffing and to focus on inpatient process and the effect on the transfer time from the ED. Future proposals include the early morning focus from the staff providing care to the patient and earlier discharge planning on the patients being discharged to make beds available earlier. With the measurements of these intervals we can see the effect on the admission wait time.

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

REFERENCES

1. Shute N, Marcus MB. Code blue crisis in the ER. Turning away patients. Long delays. A surefire recipe for disaster. *US New & World Report*. 2001; 131:54-61.
2. Richards JR, Navarro ML, Derlet RW. Survey of directors of emergency departments in California on overcrowding. *Western Journal of Medicine*. 2000; 172:385-8
3. Derlet R, Richards J, Kravitz R. Frequent overcrowding in U.S. emergency departments. *Acad Emerg Med*. 2001; 8:151-5.
4. Delaware Healthcare Association. Statistics and reports. Dover, Delaware. Available at: www.deha.org/navbar.htm.
5. Worzala C, Zhang N, Anderson GF. The effect of HMOs on hospital capacity. *Managed Care Interface*. 2000; 13:51-61.
6. Bagust A, Place M, Posnett JW. Dynamics of bed use in accommodating emergency admissions: stochastic simulation model. *BMJ*. 1999; 319:155-8.
7. Schull MJ, Szalai J, Schwartz B, Remdelmeier DA. Emergency department overcrowding following systematic hospital restructuring: trends at twenty hospitals over ten years. *Acad Emerg Med*. 2001; 8:1037-1043.
8. Hoffenberg S, Hill BH, Houry D. Does sharing process differences reduce patient length of stay in the emergency department? *Acad Emerg Med*. 2001; 8:578.
9. Kyriacou DN, Ricketts V, Dyne PL, et al. A 5-year time study analysis of emergency department patient care efficiency. *Ann Emerg Med*. 1999; 34:326-335.
10. Schneider S, Zwemer F, Doniger A, et al. Rochester, New York: A decade of emergency department overcrowding. *Acad Emerg Med*. 2001; 8:1044-50.
11. Green LV, Nguyen V. Strategies for cutting hospital beds: impact on patient services. *Health Services Research*. 2001; 36:421-424.
12. Lambe S, Washington DL, Fink A, et al. Trends in the use and capacity of California's emergency departments, 1990-1999. *Ann Emerg Med*. 2002; 39:389-39.

Routine Laboratory Testing to Evaluate for Medical Illness in Psychiatric Patients in the Emergency Department Is Largely Unrevealing

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Reprints available through open access at www.westjem.org

Objectives: This is a prospective study of psychiatric patients presenting to the emergency department (ED) to determine the value of routine laboratory studies used to attempt to exclude concomitant medical illness.

Methods: Physical exams and laboratory tests were performed on 375 psychiatric patients presenting for "medical clearance" in the ED. Upon completion of these tests, the percentage and impact of abnormal physical exams and laboratory results were assessed.

Results: Fifty-six of 375 patients (14.9%) had a non-substance-induced laboratory abnormality. Forty-two of these 56 patients (75.0%) also had abnormal history or physical exam findings indicating laboratory screening. Ten had normal history and physical exams with insignificant laboratory abnormalities. The four (1.1% [95% CI 0.3-2.7%]) remaining patients with normal history and physical exams had abnormal urinalyses which did not affect final disposition or contribute to altered behavior.

Conclusion: Patients presenting to the ED with psychiatric chief complaints, benign histories and normal physical exams have a low likelihood of clinically significant laboratory findings.
[*West*JEM. 2009;10:97-100.]

INTRODUCTION

In the United States, 4.3 million psychiatric-related emergency department (ED) visits occur each year.[1] This constitutes 5.4% of ED patients and is the fastest growing segment, increasing 15% over the last decade.[2] The emergency physician (EP) excludes significant medical illness that might cause or contribute to these patients' abnormal behavior prior to psychiatric hospitalization. This process is termed "medical clearance."

Historically, EPs have ordered many diagnostic tests to screen for medical conditions.[3] One of the first studies of routine medical screening by Hall[4] showed that 46% of psychiatric inpatients had a medical problem that accompanied, exacerbated or caused their psychiatric condition. Henneman[5] reported similarly that 63% of patients with new onset psychosis had an organic rather than a functional cause. Conversely, lower rates of organic illness have been reported by Koran[6] in 1988 and Dolan[7] in 1985. These suggested organic illness rates of 12% and 4%, respectively. In a retrospective chart review of 80 patients with a prior history of psychiatric illness and an isolated psychiatric chief complaint, Korn[8] reported that routine laboratory studies did not change final disposition on any patient. The clinical significance of laboratory or radiographic findings has not been reported in a prospective series, to our knowledge.

A commonly held belief has been the presumed inability of psychiatric patients to relate an accurate history or report signs and symptoms to guide testing; however, there is no literature to support this view. Conversely, Korn[8] demonstrated that the patient's initial complaint correlated directly with the need for laboratory and radiographic testing. Nevertheless, this belief persists and is used as rationale to continue performing routine laboratory screening.

The purpose of this study is to determine the value of routine laboratory testing in the "medical clearance" of

patients with known psychiatric disorders who present to the ED with a normal history and physical exam. Our hypothesis was that in the absence of abnormal vital signs, history or chart review reflecting significant medical problems, or abnormal physical exam, laboratory testing rarely yields significant findings.

METHODS

The study hospital ED evaluates approximately 53,000 patients per year and serves as the regional psychiatric facility. Approximately 3,000 (5.6%) are psychiatric patients. We performed a prospective, unblinded study of a convenience sample of patients from December 2004 through September 2006. Inclusion criteria were: 1) primary psychiatric complaint (i.e., homicidal, gravely disabled, delusional, hallucinating or agitated/bizarre behavior), 2) documented pre-existing psychiatric disorder, 3) alert and oriented mental status, and 4) laboratory tests were performed. We excluded suicidal patients with or without intentional medication overdoses. The local Institutional Review Board approved the study protocol.

All potential psychiatric patients were initially evaluated by an emergency medicine (EM) resident under supervision of a board-certified emergency physician (EP). The assessment included a history from the patient, corroborated by family, friends, or their psychiatrist, a report from the referring agency, a chart review history, as well as a physical exam. A general physical exam with focus on neurological and psychiatric systems was done. The physician noted whether abnormalities in history or physical exam indicated laboratory testing. Regardless of whether these were indicated laboratory panels, they were performed as agreed upon by the psychiatric and ED services. These included a combination of the following: complete blood count, basic metabolic panel, urine analysis, urine toxicology screen, thyroid panel, liver panel, and urine pregnancy test. Additional laboratory testing or radiographic workup was performed at the discretion of the individual physician.

After "medical clearance," patients were admitted to the psychiatry service or discharged home, dependent on their psychiatric evaluation. Significant abnormal laboratory values, medical intervention, and final disposition were noted. We defined "significant" operationally as resulting in change in management or prompting further investigations. These data were confirmed by chart and laboratory review, by the primary investigator and entered into a custom database (FilemakerPro 7.0), and analyzed using Excel 2002. Confidence intervals were calculated using STATA 9.2 statistical software (Statacorp, College Station TX).

RESULTS

Four hundred patients were enrolled by 21 EM residents (Post Graduate Year 2-4). We recorded data on 375 (93.7%) patients due to incomplete data forms. The age distribution of psychiatric patients demonstrated by the National Hospital Ambulatory Medical Care Survey, 2000 (NHAMCS)[1] compared to our study population are as follows: age 18-24 (11.6% NHAMCS, 20.8% study), 25-44 (47.2% NHAMCS, 47.5% study), 45-64 (26.2% NHAMCS, 30.4% study), 65+ (15.1% NHAMCS, 1.3% study). Our study population was younger than the national benchmark. All of the patients in our study were alert, oriented and able to give a history. The spectrum of psychiatric disturbance in these patients ranged from normal mental status to florid psychosis.

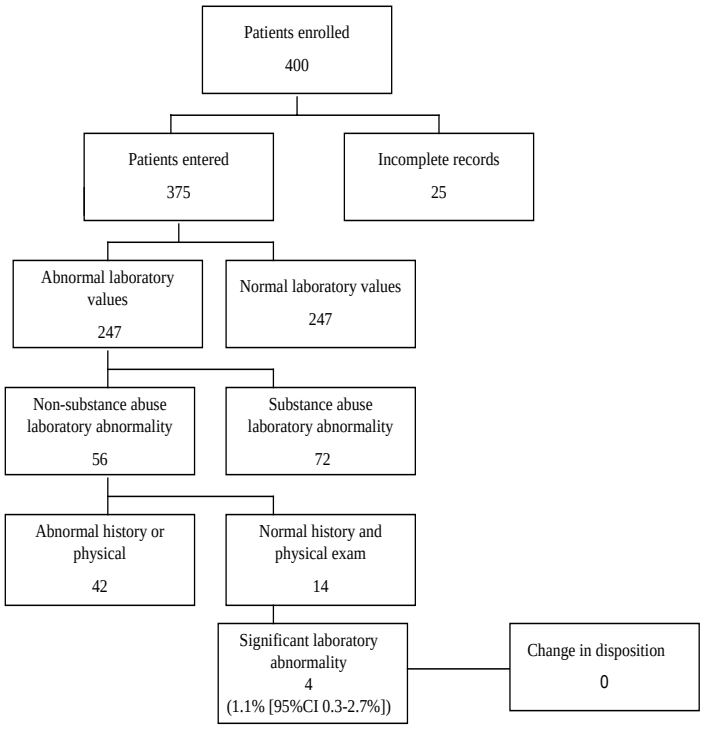

Figure 1. Flowchart of study patients

One hundred twenty-eight of 375 patients (34.1% [95%CI 29 - 39%]) had abnormal laboratory values. Seventy-two (56.2%) of these abnormal values were positive urine drug screens, managed by observation and, hydration. Of the 56 other patients with abnormal laboratory values (14.9% [95%CI 10 - 17%]), 42 had indications for further testing due to abnormal history (16/42, 38.1%) or physical exam including vital signs (26/42, 61.9%). Of the remaining 14 patients, only four (1.1% [95% CI 0.3 - 2.7%]) had a significant laboratory abnormality which received medical treatment. See Figure 1.

The lab abnormality in each of these four patients was a positive urine analysis suggesting infection (bacteria, white blood cells, leukocyte esterase). Three patients were female, age 35, 57 and 60. The fourth patient was a 60-year-old male. All four received oral antibiotics. Urine cultures

were obtained only on one of these patients, and it was a contaminated sample. After evaluation by psychiatry, none of these patients' dispositions were altered by results of their laboratory tests.

DISCUSSION

Our results demonstrate that, in a selected group of patients presenting with behavioral complaints, physical examination and history are effective screening methods for significant laboratory abnormalities. We suggest that the high percentages of missed organic diagnosis reported in other studies may be due to the lack of a complete history and physical exam as reported by Reeves,[9] Tintinalli,[10] and Riba.[11] Only 1.1% of our patients had results that would not have been suggested by a focused clinical evaluation. All four of these had positive urine analyses. The significance of this laboratory finding, asymptomatic pyuria, is not relevant as it has been shown to neither require nor benefit from treatment.[12,13] Furthermore, the U.S. Preventive Services Task Force does not recommend screening non-pregnant women or men for asymptomatic bacteriuria.[14] Hence, it is unlikely that significant morbidity would have occurred, if these findings were not discovered.

Korn[8] reported similar findings to our study in their retrospective chart review. Our study was the first prospective study to address this issue. Hall[4] and Henneman[5] reported higher rates of organic illness than our study because they included patients presenting with psychosis without prior psychiatric illness. Henneman only studied patients with new onset psychosis. For that reason cranial computed tomography (CT) was a standard part of his study protocol. In our study only two patients underwent cranial CT.

Chronic conditions such as hypertension, migraine headaches and acne vulgaris were reported by Koran,[6] resulting in an organic illness rate of 12%. Koran may have reported lower rates of physical illness if a distinction were made between acute and chronic medical conditions. In Dolan's study patients were initially admitted to the psychiatric ward without a physical examination or medical history.[7] Dolan also may have reported lower rates of organic illness if patients were first medically evaluated for organic verses psychiatric illness. Furthermore, these studies did not fully distinguish between abnormal laboratory findings and those significant enough to require treatment or change in disposition.

LIMITATIONS

Our study was not randomized or blinded, and enrolled a convenience sample with inherent potential for selection bias. The level of training of physicians varied. Our study population was significantly younger than those described by NHAMCS, and therefore, these results may not apply to older patients. The depth of history and completeness of physical examination was not proscribed by the protocol, and likely varied. Furthermore, after "medical clearance" a psychiatrist also evaluated the patient. That is uncommon in most community EDs. Lastly, although our study population was small, this is the largest prospective study to date addressing medical clearance. A large multi-centered study is needed to derive and then validate a clinical decision rule.

CONCLUSION

Our study demonstrates that patients presenting to the ED with a primary psychiatric complaint, a documented previous psychiatric history and normal medical history and physical exam, have a very low likelihood of clinically significant laboratory findings. Therefore, mandatory laboratory testing may not be necessary.

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

REFERENCES

1. Ly N, McCaig LF. National Hospital Ambulatory Medical Care Survey: 2000 emergency department summary. *Advance data from vital and health statistics*. Hyattsville, Maryland: National Center for Health Statistics; 2002: No. 326.
2. Hazlett B, McCarthy ML, Londer MS, Onyike CU. Epidemiology of adult psychiatric visits to US emergency departments. *Acad Emerg Med*. 2004; 11:193-195.
3. Lagomasino I, Daly R, Stoudemire A. Medical assessment of patients presenting with psychiatric symptoms in the emergency setting. *Psychiatr Clin North Am*. 1999; 22:819-850.
4. Hall RCW, Gardner ER, Popkin MK, et al. Unrecognized physical illness prompting psychiatric admission: A prospective study. *Am J Psychiatry*. 1981; 138:629-635.
5. Henneman PL, Mendoza R, Lewis RJ. Prospective evaluation of emergency department medical clearance. *Ann Emerg Med*. 1994; 24:672-677.
6. Koran LM, Sox HL, Martin KI et al. Medical evaluation of psychiatric patients: Results in a state mental health system. *Arch Gen Psychiatry*. 1989; 46:733-740.
7. Dolan JG, Mushlin AI. Routine laboratory testing for medical disorders in psychiatric patients. *Arc Intern Med*. 1985; 145:2085-2088.

8. Korn CS, Currier GW, Henderson SO. Medical clearance of psychiatric patients without medical complaints in the emergency department. *J Emerg Med*. 2000; 18:173-176.
9. Reeves RR, Pendarvis EJ, Kimble R. Unrecognized Medical Emergencies Admitted to the Psychiatric Units. *American J of Emerg Med*. 2000; 18:390-393.
10. Tintinalli JE, Peacock FW, Wright MA. Emergency medical evaluation of psychiatric patients. *Ann Emerg Med*. 1994; 23:859-862.
11. Riba M, Hale M. Medical clearance: fact or fiction in the hospital emergency room. *Psychosomatic*. 1990; 31:400-404.
12. Colgan R, Nicolle LE, McGlone A, Hooton TM. Asymptomatic bacteriuria in adults. *Am Fam Physician*. 2006; 74:985-990.
13. Nicolle LE, Bradley S, Clogan R, et al. Infectious Diseases Society of America guidelines for the diagnosis and treatment of asymptomatic bacteriuria in adults. *Clin Infect Dis*. 2005; 40:643-654.
14. U.S. Preventative Services Task Force. Screening for asymptomatic bacteriuria in adults: U.S. Preventive Service Task Force Reaffirmation Recommendation Statement. *Ann Intern Med*. 2008; 149:43-47.

Male Patient Visits to the Emergency Department Decline During the Play of Major Sporting Events

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Supervising Section Editor: Scott E. Rudkin, MD, MBA
Submission history: Submitted April 18, 2008; Revision Received October 20, 2008; Accepted October 24, 2008.
Reprints available through open access at www.westjem.org

Objectives: To study whether emergency department (ED) visits by male patients wane simultaneously with the play of scheduled professional and college sports events.

Methods: Retrospective cohort analysis looked at ED male patient registration rates during a time block lasting from two hours before, during, and two hours after the play of professional football games (Monday night, Sundays, post-season play), major league baseball, and a Division I college football and basketball team, respectively. These registration rates were compared to rates at similar times on similar days of the week during the year devoid of a major sporting contest. Games were assumed to have a play time of three hours. Data was collected from April 2000 through March 2003 at an urban academic ED seeing 33,000 male patients above the age of 18 years annually.

Results: A total of 782 games were identified and used for purposes of the study. Professional football game dates had a mean of 17.9 males (95% confidence interval [CI] 17.4-18.4) registering vs. 26.8 males (95% CI 25.9-27.6) on non-game days. A registration rate for major league baseball was 18.4 patients (95% CI 17.6-18.4). The mean for registration on comparable non-game days was 23.9 patients (95% CI 22.8-24.3). For the regional Division I college football team, the mean number of patients registering on game days and non-game days was 21.7 (95% CI 20.9-22.4) and 23.4 (95% CI 22.9-23.7), respectively. Division I college basketball play for game and non-game days had mean rates of registration of 14.5 (95% CI 13.9-15.1) and 15.5 (95% CI 15.1-15.9) patients, respectively. For all sports dates collectively, a comparison of two means yielded a mean of 18.2 patients (95% CI 17.4-18.8) registering during the study hours on game days vs. 23.3 patients (95% CI 22.0-23.7) on non-game days. The mean difference was 5.1 patients (95% CI 3.7 to 7.0) with $p < .000074$.

Conclusion: Male patient visits to the ED decline during major sporting events.
[*West*JEM. 2009;10:101-103.]

INTRODUCTION

Emergency physicians may anecdotally recall that major sporting events such as the Super Bowl or the World Series have historically meant lower ED census during the times or days of game play. Although few in number, some studies have shown that on very specific game dates (Super Bowl and post-season play in baseball) a periodicity is seen on game day with respect to patients seeking care in the emergency department (ED).[1,2,3] These studies showed this is particularly pronounced for those dates and regions where the home team is playing (Super Bowl, World Series). In addition, fewer visits have been reported before and after a game.

We investigated this phenomenon during the play of regular season games. Specifically, we looked at the rate of male patient ED registrations at a Veteran's Administration hospital during scheduled regular season professional and collegiate sporting events (professional football, regional professional baseball and regional college basketball and

football, respectively) over a three-year period of time.

METHODS

A retrospective cohort analysis looked at ED male patient registrations from two hours before, during, and two hours after the play of regular season professional football (regional and national games; Monday night and Sundays), major league baseball games involving the local team, and Division I college football and basketball contests, respectively. These registrations were compared to similar times on similar days of the week devoid of a major sporting contest. All games were assumed to have a play time of three hours. We collected data from April 2000 through March 2003 at an urban academic ED seeing 33,000 male patients above the age of 18 years annually. Investigational review board approval was obtained. Epi Calc 2000 (http://www.myatt.demon.co.UK/epicalc.htm) was employed for statistical analysis.

RESULTS

We assessed 782 game dates. Professional football game dates had a mean of 17.9 male patients (95% confidence interval [CI] 17.4-18.4)] registering vs. 26.8 patients (95% CI 25.9-27.6) on non-game days. For major league baseball, registrations were 18.4 patients (95% CI 17.6-23.9) compared with 23.9 patients (95% CI, 22.8-24.3) on non-game dates. For the regional Division I college football team, the mean numbers of patients registering on game days and non-game days were 21.7 (95% CI 20.9-22.4) and 23.4 (95% CI 22.9-23.7), respectively. Division I college basketball play for game and non-game days had mean rates of registration of 14.5 (95% CI 13.9-15.1) and 15.5 (95% CI 15.1-15.9) patients, respectively. For all sports dates taken collectively, a comparison of two means yielded a mean of 18.2 patients (95% CI, 17.9-18.5) registering during the study hours on game days vs. 23.3 patients (95% CI, 23.0-23.7) on non-game days. The mean difference was 5.1 patients (95% CI 5.00-5.20) over a seven-hour period (Table).

DISCUSSION

Our study demonstrates that even for regular season games, ED use by male patients decreases just before, after, and during the contest. For the seven-hour time period, ED census was significantly lower than during comparable days without a sports contest. Previous studies have looked at how ED volumes are impacted by the play of sporting contests.[1,2] These studies have shown that sporting contest play is associated with a significant decrease in numbers of patients seeking emergency care; however, these studies have looked at sporting event dates with tremendous national or regional significance, namely post-season play. Reich, et al.[1] looked at successive Januaries from 1988-1992 during Super Bowl Sunday in Buffalo, New York. The local team (Buffalo Bills) played in the Super Bowl for two of the five years studied. In addition, the Bills made the playoffs during four of the five years studied. This study revealed that ED census during these Super Bowl Sundays significantly decreased from the usual. Through 1991, five of the top 10 rated shows of all time were Super Bowls.[4] It was expected that over 130 million people watched the 2006 Super Bowl in the U.S. alone.[5] Reis et al.[2] looked at the impact on ED flow in Boston during the playoff and World Series run of the Red Sox in the fall of 2004. The effect on ED registration was remarkable.

Rather than look at post-season games we looked at the impact of ED patient registration rates (specifically, male) during regular season games as well. We sought to show that even relatively insignificant (in most cases) regular season game for four regional teams and professional football teams would be associated with decreased male patient registrations.

Of great interest is that our results show strong association with statistically significant decreases in male patient registrations for much of the day or evening simultaneous with the play of regular season games. That each regular season game – presumed to have much less impact and fan interest vs. that of postseason play – could still significantly decrease ED census during play time and beyond has not been studied before. We did not study if there was a compensatory increase in registrations after the game which might imply there was increased acuity of these patients. Similarly, we did not study female patients.

These data cannot be extrapolated to other regions of the U.S.. Different areas may pursue sports with differing zeal. Earlier studies have made the unsupported statement that, on dates with major sport events such as Super Bowl games, consideration be given to decreasing ED staffing in anticipation of lower patient volumes.[1] We make no such claim. Although we found fewer male patients registering in the ED, the declines were not sufficient or consistent enough to drive lowered staffing levels.

Emergency physicians are aware of the reasons why patients use the ED. What has been less well studied are the reasons why patients do not go to the ED when they might otherwise. Studies like this may corroborate that patients delay or avoid ED care because of spectator events and this

Table. Impact of regular season sporting event play on emergency department male patient registration (2000-2003).

Sport	Games	Mean Difference in Male Patient Registration
Pro football	178	8.9 fewer (95% CI, 8.8-9.1)
Pro baseball	486	5.5 fewer (95% CI, 5.4-5.6)
College football	36	1.7 fewer (95% CI, 1.3-2.1)
College baseball	82	1.0 fewer (95% CI, 0.8-1.2)
Total	**782**	**5.1 fewer (95% CI, 5.0-5.2)**

might affect planning for staffing levels.

LIMITATIONS

Our study did not consider weather during the hours or the days of the study dates. Adverse weather might have the largest impact on ED census during the latter part of football season (snow, sleet, cold temperatures). In addition, traffic conditions around Baltimore might have affected new patient flow into the ED. We did not attempt to correlate the decrease in male patients with broadcast ratings of the various media venues (radio or television) broadcasting the games being monitored. Regular season game Nielsen ratings are not published routinely as they are not considered sufficiently high enough to be of general interest.

We could not control for the seasonal variation in patient volume when the sports season spanned an entire year. For instance, there are no Sundays in October without football that can then be compared against football-filled Sundays of the same calendar month. We found a consistent negative association between the game days and ED registrations, adding credence to our findings despite possible seasonal variation. Only with Division I college basketball did we find a slight increase in male patient registrations in any of the games and even that was nominal compared to other types of games.

CONCLUSION

Fewer male patients seek care in the ED during the seven-hour period before, during and after regional and national sporting events during the regular season. We recommend studying outcomes for those apparently delaying emergent care.

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

REFERENCES

1. Reich N, Moscati R, Jehle D, et al. The impact of a major televised sporting event on emergency department census. J Emerg Med. 1994; 22:15-17.
2. Reis B, Brownstein J, Mandl K. Running outside the baselines: Impact of the 2004 major league baseball postseason on emergency department use (correspondence). Ann of Emerg Med 2005; 46: 386-387.
3. Redelmeier D, Stewart C. Driving fatalities on Super Bowl Sunday. N Engl J Med. 2003; 348:368-369.
4. Hoffman M, Foley J, Maguire T, eds. The World Almanac and Book of Facts 1992. New York: Pharos Books; 1991:317-318.881-884.
5. Greenfield K. The big man. Sports Illustrated. January 23, 2006; 104: 58-64.

Analysis of the Literature on Emergency Department Throughput

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Introduction: The purpose of this paper was to review and analyze all the literature concerning ED patient throughput. The secondary goal was to determine if certain factors would significantly alter patients' ED throughput.

Methods: A MEDLINE search was performed from 1966 to 2007 using the terms "turnaround," "emergency departments," "emergency medicine," "efficiency," "throughput," "overcrowding" and "crowding." Studies were graded using a scale of one to four based on the ACEP paper quality criteria. Inclusion criteria were English language and at least a level four or better on the quality scale. An analysis of successful procedures and techniques was performed.

Results: Literature search using the key terms found 29 articles on turnaround times, 129 on ED efficiency, 3 on throughput, 64 on overcrowding and 52 on crowding. Twenty-six articles were found to meet the inclusion criteria. There were three level I studies, thirteen level II studies, five level III studies and five level IV studies. The studies were categorized into five areas: determinants (7), laboratories processes (4), triage process (3), academic responsibilities (2), and techniques (10). Few papers used the same techniques or process to examine or reduce patient throughput precluding a meta-analysis.

Conclusions: An analysis of the literature was difficult because of varying study methodologies and less than ideal quality. EDs with combinations of low inpatient census, in-room registration, point of care testing and an urgent care area demonstrated increased patient throughput.
[*West*JEM. 2009;10:104-109.]

INTRODUCTION

Improving efficiency and throughput in the emergency department (ED) has multiple benefits. Better efficiency should increase patient satisfaction, enhance revenue and reduce ambulance diversion. The need to focus on ED efficiency has become more acute in recent years due to increasing litigation, including a case where a patient in Chicago died while waiting for care.[1]

EDs across the U.S. struggle to provide efficient care in a timely fashion. Increasing patient volumes, a reduction in the number of EDs, higher inpatient census and ED staff reduction all exacerbate the struggle. The purpose of this paper is to review the literature and summarize strategies used nationwide to deal with this crisis. Proven techniques could be used by hospital and ED managers.

METHODS

We searched MEDLINE from 1966 to March 2007 for English language articles using the keywords *turnaround*, *efficiency*, *throughput*, *overcrowding* and *crowding.* No other restrictions in the search fields were used. We also reviewed references from these articles to ensure that we included all possible studies.

We required one or more factors related to throughput to

Table 1. Literature classification schema*

Class	Design	Diagnosis	Prognosis
1	Randomized, controlled trial	Prospective cohort using standard metrics	Population prospective cohort
2	Nonrandomized	Observational	Case control
3	Case series, case report, consensus	Case series, case report, consensus	Case series, case report, consensus
4	Expert opinion, design flaws, incomplete data	Expert opinion	Expert opinion

* Adapted from: American College of Emergency Physicians/Physician Consortium: Emergency medicine physician performance measurement set.[2]

include an article in further analysis. We used a classification system modified from the American College of Emergency Physicians to assess the study's methodology and quality.[2] To be more inclusive in the review, a fourth parameter was added to the classification system (Table 1). Each article was graded one to four based on this classification scheme. Those studies with confounding variables, problematic study design, limited data or poor presentations were downgraded to the next lower class. Due to the lack of uniformity and consistency within the literature, studies of similar design and technique could only be identified and grouped into five broad categories: throughput determinates, academic responsibilities, laboratories, triage, and techniques. A table of the findings was produced to summarize the class, design, analysis, conclusion and limitations of each study (Table 2).

RESULTS

The literature search using the keywords crossed with "emergency departments" and "emergency medicine" (EM) found 29 articles related to *turnaround*, 129 articles related to *efficiency*, four articles related to *throughput*, 52 articles related to *crowding* and 64 articles related to *overcrowding*.

Twenty-six articles were found to meet the inclusion criteria. Studies that lacked data, had poor scientific design or provided limited information were not rated. There were three level I studies, 13 level II studies, five level III studies and five level IV studies (Table 2). We then sorted them, using the five broad categories throughput determinants (seven articles), laboratories processes (four articles), academic responsibilities (two articles), triage process (three articles), and throughput reduction techniques (10 articles).

Throughput Determinants

Several articles focused on the correlation between throughput time and ED factors. The articles showed that ED length of stay (LOS) increased substantially with increased admissions, number of ambulance arrivals, number of pediatric patients and ED census.[3-8] Rathlev et al.[8] found that daily mean LOS was increased not only by number of ED admission and hospital occupancy but also by elective surgical admission. Interestingly, two of the studies did not find a significant correlation between the throughput time and hours of nursing coverage, day of the week or urgent care hours.[3,4] Saunders et al.[9] performed a computer simulation study of ED operations and found that throughput times correlated directly with laboratory service times and inversely with number of physicians and nurses. This latter relationship had a ceiling where a continued increase in providers demonstrated no change in throughput time.[9]

Academic

Two studies examined the effect of teaching on ED throughput. Chan et al.[10] examined how medical students affected ED throughput and found that fourth year medical students' precepting for four weeks in the ED did not change the LOS for patients. A similar study[11] looking at the effects of adding EM residents found that the residents increased the total throughput time an average of seven to 39 minutes.

Laboratories

In a study of 11 hospital EDs, Holland et al.[12] found that addressing the laboratory outliers rather than the mean turnaround time can reduce the ED LOS. In a study of 690 hospital laboratories, Steindel and Howanitz[13] found that faster throughputs were related to lab control of the specimen handling and rapid transport times. Murray et al.[14] performed a randomized controlled trial comparing point-of-care testing to central laboratory testing and found that point-of-care testing reduced the median stay by 54 minutes. Study supplies and equipment but not grant funding were provided for this potentially biased study. In a comparison study of the use of a pneumatic tube delivery system versus human couriers, Fernandes et al.[15] found that a tube system reduced lab reporting time by 8-10 minutes.

Triage

Partovi et al.[16] compared the LOS in triage with and without an emergency physician, and found an 18% reduction in LOS when a physician began patient evaluation and treatment in triage. This paper reported a significant cost of physicians in triage, which may outweigh the benefits of reduced LOS. Choi and Claudius[17] studied the use of pulse oximetry on bronchiolitis patients in triage and found that it could reduce throughput by 50 minutes. The authors did not

study the reason for decreased throughput time nor describe how the evaluation and treatment may have been altered with pulse oximetry measurement; however, they suggested that identification of hypoxia changes management, and proper patient placement to urgent care or main ED may have accounted for this time reduction.

Techniques

Multiple studies described techniques used to reduce ED LOS. Spaite et al.[18] examined one ED that employed a rapid process redesign, and found that it led to a 76-minute reduction in average patient LOS. The rapid redesign focused on staffing and internal processes, triage and registration procedures and diagnostic radiology, laboratory and bed availabilities. This rapid improvement process occurred over three months and cost the hospital over $1 million annually. This cost was offset by increased revenue, providing a net annualized profit of $300,000. Purnell et al.[19] surveyed 185 hospitals and found that an urgent care unit reduced patient wait times by 20%. This limited survey study performed in 1989 found that the mean wait time was 72 minutes in EDs with fast track and 90 minutes for those without.

In a comparison of multiple interventions, Cardin et al.[20] found that increased emergency physician (EP) coverage, designation of a physician coordinator and changes in hospital policies on laboratory, consultations and admission procedures could reduce ED mean LOS from 13.8 hours to 5.9 hours. The article focused on the effect of the interventions on return visits and hospital readmissions and not on the interventions used and associated costs. There were ten total interventions noted in the appendix with transfer-to-ward within one hour of bed assignment having the most impact.

Patel and Vinson[21] used an ED team concept, which joined an EP with two nurses and one technician. This novel change lead to improved patient satisfaction with an increase of 3.1% in reported "very good" or "excellent" ratings, a reduction in the time required to see a physician, a 7.7% increase in number of patients seen within one hour, and a 0.7% decrease in patients who left without being seen.

Another published approach to reducing the ED LOS was to use a 72-hour admission unit on an existing medical unit with 16 beds designated for ED overflow patients.[22] This study, which used a short-stay, 72-hour unit found that chest pain and asthma patients had a significant reduction in ED throughput times. Mean ED time was reduced from 7.3 to 5.5 hours per chest pain patient, and 5.0 to 2.9 hours per patient with asthma; however, patients with sickle-cell disease or seizures showed no decrease. The article notes that no other changes in protocols, staffing or processes occurred during the study period. Although this study examined the effect of a short stay unit, in essence it was evaluating the effect of increased inpatient capacity on LOS in the ED. Gorelich, Yen and Yun[23] found that in-room registration reduced the length of ED stay by 15.0 minutes or 9.3%.

DISCUSSION

After a thorough review of the literature, we were unable to find consensus on techniques to improve ED efficiency and thereby decrease LOS. This is most likely due to environmental, demographic, or institutional variations. One could conjecture that there are significant differences between teaching and non-teaching, small community versus large university, trauma versus non-trauma centers, and large-volume versus small-volume hospitals that prevent agreement on specific techniques. In other studies, the conclusions were not intuitive or widely accepted. For instance, two studies found that residents slowed patient throughput but medical students did not. Unfortunately, there are no comparisons of those institutions with both medical students and residents, level of student or residents, or the effect of residents from other services.

Despite a lack of consensus, this analysis demonstrates that there are a number of scientifically-based procedures to reduce ED patient LOS that could be useful. Certain strategies appear to be universally accepted. These include pulse oximetry determination in triage, bedside registration, point-of-care testing, use of an urgent care area, and efficient lab, radiograph and hospital admission processes. Furthermore, the use of physicians in triage was found to be effective, although a cost versus benefit analysis is needed. The ability to apply and implement many of these procedures in other EDs is dependent on local factors, politics and resources.

Many other articles were reviewed that were not included in this study either because they did not meet the study requirements or were not found in MEDLINE. The study required that the article include some type of research rather than a description of process improvement techniques. Valuable information on throughput is frequently published in hospital or management journals that discuss process improvement.

Based on a review of the literature on reducing patient LOS in the ED, the best means for improvement is first to select the appropriate determinants that drive patient throughput at the local level, such as number of admissions, number of ambulance arrivals and ED census, and then review and revise the processes that drive the throughput determinants and monitor the data to ensure that the changed processes accomplish the goal to improve throughput.

In the author's experience, the critical success factors to implement the necessary changes were to obtain accurate and timely throughput data to review, obtain buy-in to the process from senior management as well as staff who will have to implement the changes, and determine what the cost/benefit ratio will be. At the author's hospital, LOS was reduced by 31% and the left-without-treatment rate was reduced from 10% to 2% without any additional costs in a three-month time period. The keys to success were a rapid redesign process involving all hospital departments and services, as well as senior management and line staff, using accurate and correct ED data and having managers focus on a self–initiated process improvement methodology.

Table 2. Analysis of literature

Reference	Study Class	Study Design/ Operational Area	Analysis	Conclusion	Comments/Limitations
Chan, Kass; 1999.	1	Prospective consecutive Academic	Compared days with students to those without	Medical students do not alter the throughput times.	Average throughput was 145 minutes with and 151 without students. Multiple biases limited the study.
Murray et al.; 1999.	1	Randomized, controlled study Laboratory	Compared central lab to point-of-care testing	Point-of-care testing significantly reduced LOS.	Average LOS for central lab was four hours 22 minutes and point-of-care testing was three hours 28 minutes. Reduced time was found only in discharged patients.
Partovi et al.; 2001.	1	Comparison study Triage	Compared impact of faculty doing triage to nurse only	Moderate reduction in LOS.	Average LOS with faculty was 363 minutes and 445 minutes with nurses. Faculty was added to complement nurses.
Asaro, Lewis, Boxerman; 2006.	2	Observational trial Determinants	Twenty-seven month analysis of input/ output variables for ED throughput	Determine process outcomes and ED inputs and bottlenecks.	Average main LOS 445 minutes, urgent 265 minutes, entire 385 minutes. Significant differences found between 20 and 80 percentile ED arrivals
Chan et al.; 2005.	2	Before and after trial Determinants	Compared before and after change in IT, staff revisions and culture change	Value in rapid ED entry process.	Pre to post reduction of 31 minutes. Average LOS was five hours. Process change was not well described.
Fernandes et al; 2006.	2	Cross-sectional study of an institution with and without tube system	Compared two EDs, one with pneumatic tube system and one with human couriers	Reduced lab turnaround from 8-10 minutes for Hgb and K with pneumatic tube system.	Average turnaround time varied from 33 to 72 minutes. Courier was called to transport specimens. Limited by two EDs in Canada.
Liew et al.; 2003.	2	Retrospective review Determinants	Compared ED LOS to hospital	ED LOS correlates strongly with inpatient LOS.	Average ED LOS was 7.96 hours and hospital LOS was 5.63 days. Austrailian study.
Lammers et al.; 2003.	2	Before and after observational Academic	Compared before residents versus after residents	Weak correlation between presence of PY-3s and LOS.	Average LOS before residents was 123 minutes and 162 minutes at year three.
Choi, Claudius; 2006.	2	Before and after study with and without triage pulse oximetry. Triage	Compared pre-intervention versus post intervention	Reduced throughput by 50 minutes.	Average turnaround for pediatric bronchiolitis patients pre-intervention 159 minutes and post-intervention was 89 minutes.
Cardin et al; 2003.	2	Before and after study of multiple interventions. Techniques	Compared change in increased MD coverage, MD coordinators, and new policies	Multiple interventions reduced the mean LOS by 7.9 hours.	ED LOS reduced from 13.8 hours to 5.9 hours. Limited by multiple interventions in Canada.
Patel, Vinson; 2005.	2	Before and after comparison Techniques	Team assignments effect on patient throughput	Throughput times reduced by 9.5 minutes.	Average throughput varied from 239-257 minutes. Limited by multiple personnel changes during study periods.

Table 2. Analysis of literature

Reference	Study Class	Study Design/ Operational Area	Analysis	Conclusion	Comments/Limitations
Rathlev et al.; 2007.	2	Retrospective review Determinants	Moving averages and independant variables	Additional elective surgery - 21 minutes, additional admission - 2.2 minutes, every 5% increase in hospital occupancy - 4.1 minutes.	Mean LOS 241 minutes. Limited number of variables examined.
Bazarian, et al.; 1996.	2	Before and after study Techniques	Effectiveness of short stay unit	Reduced number of patients waiting to go up from 9.6 to 2.3 patients per day.	Average LOS reduced from 6.5 hours to 5.6 hours. One hospital trial.
Gorelick, Yen, Yun; 2005.	2	Before and after study Techniques	Compared ED LOS to in-room registration.	In-room registration reduced LOS.	Average LOS was reduced by an average of 15 minutes. Average length of ED LOS 2.2-3.8 hrs.
Chan, Reilly, Salluzo; 1997.	3	Observational study Determinants	Tracked eight variables	Throughput times dependent on inpatients, daily census, pediatric volume, ambulances.	Average throughput 330 minutes for admitted and 123 for discharged. The correlation coefficients ranged from .54-.32.
Steindel, Howanitz; 2001.	3	Survey study of physicians done by pathologists Laboratory	Compared turnaround time for 690 hospital laboratories	Reduced turnaround times for labs correlated with lab-controlled specimen handling and rapid transport time.	Average order to reporting time mean was 50-60 minutes. Limted by survey study.
Foster et al.; 2003.	3	Retrospective database review Determinants	Daily hospital occupancy	Daily ED LOS increased by 18 minutes with a 10% increase in occupancy.	Average throughput was 354 minutes for admitted patients. Canadian sudy limited by lack of correlation coefficients.
Spaite et al.; 2002.	4	Before and after comparison Techniques	Multiple factors very varied and the effect on throughput studied.	Throughput times decreased by 76 minutes.	Average throughput time was 175 minutes. Limited by multiple factors and descriptive study design.
Saunders, Kaens, Leblanc; 1989.	4	Computer simulation Determinants	Varied number of nurses, physicians, treatment beds and blood turnaround time.	Increasing number of nurses and physicians increased throughput. Number of exam rooms had no effect. Laboratory time had a direct effect.	A number of variables not taken into account. Computer simulation.
Holland; 1991.	4	Observational study Laboratory	Surveyed 11 hospitals	ED LOS was correlated with total lab outliers rather than lab turnaround times.	No throughput times provided for the ED.
Purnell; 1991.	4	Survey study techniques	Analyzed hospitals throughput time with and without fast track	Facilities with a Fast Track had reduced waiting time by 18 minutes.	Average waiting time with Fast Track was 72 minutes and without Fast Track was 90 minutes. Unvalidated survey sent to some east coast hospitals.

ED, emergency department; *LOS,* length of stay; *IT*, information technology.

LIMITATIONS

These data could not be tabulated to perform a meta-analysis because of diverse study designs and the marginal quality of the papers. In general, the research methodology in these administrative studies was not as rigorous as other scientific research. Most were observational or before-and-after studies, which included potential confounding variables. Additional factors to explain the problems with this type of research include lack of external funding, difficulty in isolating specific techniques to reduce LOS, or difficulty performing randomized interventions. The analysis of each article was scientifically based, but there was always the possibility of rater bias. Lastly, the grouping of study topics was arbitrary but necessary to determine trends and commonalities.

CONCLUSIONS

The world's ED throughput literature is limited in applicability from one institution to another; however, there do appear to be some overarching alterations in behavior that will serve to speed patients through the ED. Useful strategies include improvements in triage, urgent care centers, point-of-care testing and bedside registration.

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

REFERENCES

1. Sorrel, AL. Woman's death in hospital emergency department ruled a homicide. *AMNews*. October 16, 2006.
2. American College of Emergency Physicians/Physician Consortium. Emergency Medicine Physician performance measurement set. Available at: www3.acep.org/WorkArea/showcontent.aspx?id=31584. Accessed November 07, 2007.
3. Chan L, Reilly KM, Saluzzo RF. Variables that affect patient throughput times in an academic emergency department. *Am J Med Quality*. 1997; 12:183-186.
4. Chan TC, Killeen JP, Kelly D, Guss DA. Impact of rapid entry and accelerated care at triage on reducing emergency department patient wait times, lengths of stay, and rate of left without being seen. *Ann Emerg Med*. 2005; 46:491-497.
5. Foster AJ, Steill I, Wells G, et al. The effect of hospital occupancy on emergency department length of stay and patient disposition. *Acad Emerg Med*. 2003; 10:127-33.
6. Liew D, Liew D, Kennedy MP. Emergency department length of stay independently predicts excess inpatient length of stay. *Med J Australia*. 2003; 179:524-526.
7. Asaro PV, Lewis LM, Boxerman SB. The impact of input and output factors on emergency department throughput. *Acad Emerg Med*. 2007; 14:235-42.
8. Rathlev NK, et al. Time series analysis of variables associated with daily mean emergency department length of stay. *Ann Emerg Med*. 2007; 49:265-271.
9. Saunders CE, Makens PK, Leblanc LJ. Modeling emergency department operations using computer simulation systems. *Ann Emerg Med*. 1989; 18:134-140.
10. Chan L, Kass LE. Impact of medical student preceptorship on ED patient throughput time. *AM J Emerg Med*. 1999; 17:41-43.
11. Lammers RL, Roiger M, Rice L, et al. The effect of a new emergency medicine residency program on patient length of stay in a community hospital emergency department. *Acad Emerge Med*. 2003; 10:725-730.
12. Holland LL, Smith LL, Blick KE. Reducing laboratory turnaround time outliers can reduce emergency department patient length of stay. *Am J Clic Pathol*. 2005; 124:672-674.
13. Steindel SJ, Howanitz PJ. Physician satisfaction and emergency department laboratory test turnaround time: Observations based on College of American Pathologists Q-Probes Studies. *Arch Pathol Lab Med*. 2001; 125:863-871.
14. Murray RP, Leroux M, Sabga E, Palatnich W, Ludwig L. Effect of point-of-care testing on length of stay in an adult emergency department. *J Emerg Med*. 1999; 17:811-814.
15. Fernandes CM, Worster A, Eva K, Hill S, McCallum C. Pneumatic tube delivery system for blood samples reduces turnaround times without affecting sample quality. *J Emerg Nurs*. 2006; 32:139-143.
16. Partovi SN, Nelson BK, Bryan ED, et al. Faculty triage shortens emergency department length of stay. *Acad Emerg Med*. 2001; 8:990-995.
17. Choi J, Claudius I. Decrease in emergency department length of stay as a result of triage pulse oximetry. *Ped Emerg Care*. 2006; 22:412-414.
18. Spaite DW, Bartholomeaux F, Guisto J, Lindberg E, et al. Rapid process redesign in a university-based emergency department: Decreasing waiting time intervals and improving patient satisfaction. *Ann Emerg Med*. 2002; 39:168-177.
19. Purnell LD. A survey of emergency department triage in 185 hospitals: physical facilities, fast track systems, patient-classification systems, waiting times, and qualification, training and skills of triage personnel. *J Emerg Nurs*. 1991; 17:402-407.
20. Cardin S, Afilalo M, Lang E, Collet JP, et al. Intervention to decrease emergency department crowding: does it have effect on return visits and hospital readmissions? *Ann Emerg Med*. 2003; 41:173-185.
21. Patel PB, Vinson DR. Team assignment system: expediting emergency department care. *Ann Emerg Med*. 2005; 46:499-506.
22. Bazarian JJ, Schneider SM, Newman VJ, Chodosh J. Do admitted patients held in the emergency department impact the throughput of treat-and-release patients? *Acad Emerg Med*. 1996; 3:1113-1118.
23. Gorelick MH, Yen K, Yun HJ. The effect of in-room registration on emergency department length of stay. *Ann Emerg Med*. 2005; 45:128-133.

Supraclavicular Subclavian Vein Catheterization: The Forgotten Central Line

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Supervising Section Editor: Jeffrey Sankoff, MD
Submission history: Submitted August 15, 2008; Revision Received September 04, 2008; Accepted September 12, 2008.
Reprints available through open access at www.westjem.org

While the supraclavicular approach to the subclavian vein has been described since 1965, it is generally employed much less often than the "traditional" infraclavicular approach. Although randomized trials are lacking, the best evidence suggests that the supraclavicular approach has a number of important advantages to the infraclavicular approach. The landmarks and relative merits of the procedure are described in this paper.
[*West*JEM. 2009;10:110-114.]

INTRODUCTION

Central venous catheterization is a vital intervention in critically ill patients for a variety of purposes, including volume resuscitation, central venous pressure monitoring, transvenous cardiac pacing, hemodialysis access, and hypertonic or irritant substance infusion. Central lines are typically introduced into the internal jugular, subclavian, or femoral veins. The proper choice of insertion site is essential for success. Various methods of placement have evolved, each with its own advantages and potential complications.

Several anatomic advantages of the subclavian vein for central access include its large diameter, absence of valves, and ability to remain patent and in a relatively constant position.[1,2] Subclavian catheterization also carries a lower risk of catheter-related infection and thrombosis than femoral or internal jugular vein catheterization.[3]

Since Aubaniac's original description in 1952,[4] subclavian vein catheterization via the infraclavicular approach has become a well-established technique. In 1965 an alternate supraclavicular approach was described by Yoffa.[1] This supraclavicular route to the subclavian vein has some distinct advantages over the infraclavicular approach; however it is less often taught and utilized for reasons that are not clear.

Advantages of the Supraclavicular Approach

Advantages of the supraclavicular approach over the infraclavicular technique include: a well-defined insertion landmark (the clavisternomastoid angle); a shorter distance from skin to vein; a larger target area; a straighter path to the superior vena cava; less proximity to the lung; and fewer complications of pleural or arterial puncture.[1,2,5-8] In addition, the supraclavicular approach less often necessitates interruption of CPR or tube thoracostomy than the infraclavicular method.[9,10]

Approach

The objective of the supraclavicular technique is to puncture the subclavian vein in its superior aspect just as it joins the internal jugular vein. The key to success, according to Yoffa,[1] is correct identification of the clavisternomastoid angle formed by the junction of the lateral head of the sternocleidomastoid muscle and the clavicle. Active raising of the patient's head may make this landmark more apparent. The needle is inserted 1 cm lateral to the lateral head of the sternocleidomastoid muscle and 1 cm posterior to the clavicle and directed at a 45-degree angle to the sagittal and transverse planes and 15 degrees below the coronal plane aiming toward the contralateral nipple.[5] The needle bisects the clavisternomastoid angle as it is advanced in an avascular plane, away from the subclavian artery and the dome of the pleura, entering the junction of the subclavian and internal jugular veins.[1,5,6] See Figures 1 and 2.

The right side is preferred because of the lower pleural dome, more direct route to the superior vena cava, and absence of thoracic duct. The Trendelenberg position is recommended to decrease risk of air embolus and to

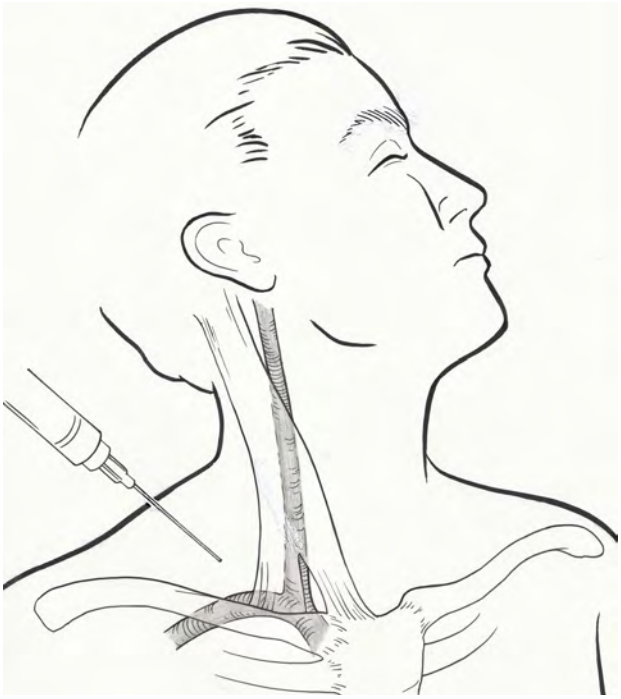

Figure 1.

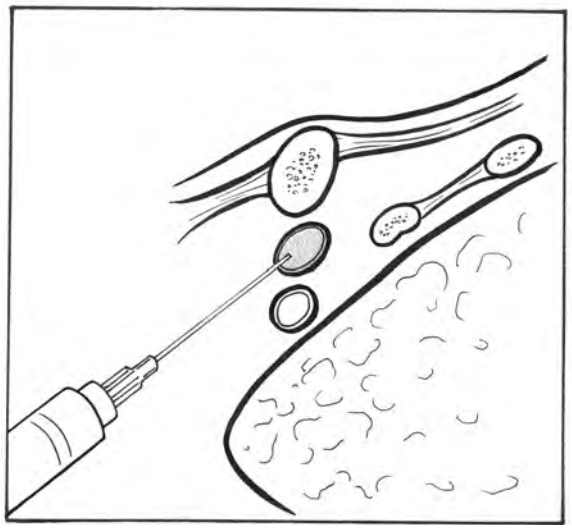

Figure 2.

potentially help distend the vein, as the subclavian vein is not bound by fascia on its superior aspect.[5] To further minimize complications the needle bevel should be facing down prior to insertion, attempts should cease after 2-3 unsuccessful tries, and most importantly, the clavisternomastoid angle must be clearly identified prior to insertion.[11]

THE DATA

Most clinical studies on the supraclavicular approach are in the form of prospective case series. Only a few well designed, randomized prospective trials comparing the infraclavicular and supraclavicular methods have been described in the literature.

Dronen et al.[9] conducted a randomized prospective comparison of the supraclavicular and infraclavicular techniques in 76 patients undergoing CPR. Forty-four supraclavicular attempts and 45 infraclavicular attempts were evaluated. Rates of successful cannulation with the two approaches were comparable (90% with the supraclavicular approach and 84% with the infraclavicular approach, $p>0.05$). The mean number of needle sticks for cannulation was similar with both techniques (1.38 +/- 0.69 with the supraclavicular approach and 1.46 +/- 0.89 with the infraclavicular approach, $p>0.05$). The incidence of technical difficulties in threading the catheter also did not differ significantly (18% and 21% with the supraclavicular and infraclavicular approaches, respectively, $p>0.05$). However, the incidence of malpositioning or kinking of the catheter was significantly higher with the infraclavicular technique (26% versus 7% in the supraclavicular group, $p<0.05$). In addition, excessive interruption of CPR (five seconds or greater) occurred in 20% of supraclavicular attempts and in 40% of infraclavicular attempts ($p<0.025$). No patient had CPR interrupted for more than 10 seconds with the supraclavicular method, while CPR interruption exceeded 10 seconds in 9% of cases with the infraclavicular method. There were no major complications with either approach. According to this small study, the supraclavicular approach to subclavian vein catheterization is probably the technique of choice when central venous access is required during CPR.[9]

In a larger study, Sterner et al.[12] conducted a randomized, prospective comparison of the supraclavicular and infraclavicular approaches in 500 patients. Two hundred forty-five patients were in the supraclavicular group and 255 patients in the infraclavicular group. The rates of successful cannulation were similar between the two groups (84.5% for the supraclavicular group and 80% for the infraclavicular group, $p=0.23$). When catheterization by the designated approach failed, catheterization by the alternate approach was successful in all but seven cases, resulting in an overall success rate of 98.6%. The incidence of catheter malpositioning was significantly higher in the infraclavicular group (9% vs. 0.5% in the supraclavicular group, $p<0.01$). Overall there were 18 complications (3.6%), and no differences were observed between the groups in the instances of pneumothorax, arterial punctures, or kinked catheters ($p=0.13$). According to this study, using an alternate approach to subclavian vein catheterization if the initial approach is unsuccessful yields a very high overall success rate and a very low overall complication rate. Sterner concluded that familiarity with both approaches is the key to successful subclavian vein catheterization.

Lu et al.[13] conducted a prospective comparison of

four different approaches to subclavian catheterization in 91 infants. There were 21 right supraclavicular (RSC), 24 left supraclavicular (LSC), 24 right infraclavicular (RIC), and 22 left infraclavicular (LIC) catheterization attempts. The operator decided on the site of skin puncture. The success rate was 95.2% in the RSC group, 91.7% in the LSC group, 87.5% in the RIC group, and 86.4% in the LIC group. No statistically significant differences were detected in the rates of success or complications. There were six cases of arterial puncture (five supraclavicular and one infraclavicular, p=0.09), two cases of pneumothorax (one RSC and one RIC), and two cases of malpositioned catheter (one RSC and one RIC). Authors concluded that subclavian vein catheterization is a safe procedure for infants.

OTHER METHODS

Numerous permutations of Yoffa's original supraclavicular technique have been developed and tested in cadaver studies and prospective case series. The modifications range from simply changing the angle of needle insertion to using a completely different set of anatomical landmarks than the "clavisternomastoid angle."

Garcia et al.[14] evaluated 83 attempts at subclavian vein catheterization using a modified supraclavicular approach. Successful catheterization was achieved in 98.6% of the attempts. The complication rate was 6% with two pneumothoraces and three subclavian artery punctures. This modification used the same landmarks as Yoffa;[1] however, the needle was directed at a 5-degree angle from the coronal plane, 50 degrees from the sagittal plane and 40 degrees from the transverse plane. This adaptation was based on a cadaver study in which authors noted that a wider "sling" target formed by the confluence of the internal jugular and subclavian veins could be easily cannulated with a more superficial needle trajectory than the original approach.[14]

In a large case series published in 1974, Haapaniemi and Slatis[15] introduced an alternative technique with a puncture site 2-3 cm above the clavicle near the posterior border of the sternocleidomastoid muscle. The needle was then advanced caudad at an angle of 35 degrees towards the sagittal plane and slightly upwards from the coronal plane between the sternocleidomastoid and anterior scalene muscles. The site of venipuncture was the confluence of the subclavian and internal jugular veins. In a series of 600 patients, this technique had a 94% success rate and a 5% complication rate with two cases of pneumothorax, four arterial punctures, and six thoracic duct punctures.

Over a decade later, Conroy et al.[16] studied the supraclavicular junctional or "central" approach in which the needle pierced the skin 1 cm medially and superiorly to the midpoint of the clavicle at a 20-degree angle from the transverse plane and a 20-degree angle from the coronal plane and was advanced toward the sternoclavicular joint. In the study population of 100 patients, only two failures and no complications occurred.

Using the approach described by Conroy et al.,[16] Jones and Walters[17] reported successful cannulation in 27 of 34 patients (79%) requiring temporary hemodialysis access. Two arterial punctures transpired and no pneumothorax or hemothorax occurred.

In 1992, MacDonnell et al.[18] evaluated another modification of the supraclavicular technique in 35 human cadavers. The new landmark for needle insertion was the junction of the middle and medial thirds of the clavicle. The needle entered the skin at this point just posterior to the clavicle and was advanced parallel to the coronal plane toward the ipsilateral sternoclavicular joint. Cannulation was successful in 33 cases (94%) with one subclavian artery cannulation.

In 1997, Muhm et al.[7] studied an adaptation of Yoffa's approach in 175 patients requiring hemodialysis access. With this method, the needle was introduced at the lateral margin of the clavicular insertion of the sternocleidomastoid muscle and was then directed toward the sternal end of the right-sided second intercostal space 20 degrees cephalad to the transverse plane and 20 degrees anterior to the coronal plane. During an 18-month period, 208 large bore catheters were successfully placed in 164 patients (success rate, 93.8%). Complications included one pneumothorax, seven arterial punctures, two thoracic duct punctures, and two catheter malpositions without sequelae.

Gorchynski et al.[10] evaluated another variation of the supraclavicular technique in 2004. With the "pocket approach," the needle was inserted at the midpoint between the sternal and clavicular heads of the sternocleidomastoid muscle just posterior to the clavicle and was then advanced toward the ipsilateral nipple at a 45-degree angle. In the initial phase of this study, the "pocket approach" was attempted in 28 cadavers with a 100% success rate. The second phase, a chart review of 68 patients who underwent attempted central venous access using the "pocket approach," yielded a 90% success rate. There were two cases of catheter misplacement. No pneumothoraces, arterial punctures, or other complications were reported. The "pocket shot" has been used by intravenous drug users when they have exhausted their peripheral veins.[19]

Supraclavicular Central Lines in The Ultrasound Era

The use of ultrasound guidance during internal jugular catheterization has been shown to reduce the time required for insertion, the number of complications and the rates of unsuccessful catheterization.[20,21] However, evidence supporting its use in subclavian venous access is sparse.[22] Real-time ultrasound guidance with the supraclavicular approach is technically difficult because little room is available to position the transducer while inserting the needle. One alternative is to identify the vessel with ultrasound and

Table. Summary of current evidence for supraclavicular approach to the subclavian vein.

Year/Author	Total cases	Method	Versus infraclavicular	Success rate	Complication rate
1965 Yoffa[1]	130	Yoffa	No	97.7%	0.8%
1972 Garcia[14]	72	Garcia	No	98.6%	6.0%
1972 James[25]	3000	Yoffa	No	95.0%	1.2%
1974 Haapaniemi[15]	600	Other	No	94.0%	5.0%
1976 Neale[26]	64	Garcia	No	97.0%	3.0%
1977 Brahos[5]	100	Yoffa	No	95.0%	2.0%
1981 Brahos[6]	250	Yoffa	No	95.0%	1.2%
1982 Dronen[9]	89	Yoffa	Yes	90.0% supra 84.o% infra	2.2% supra 0.0% infra
1985 Helmkamp[11]	99	Yoffa	No	91.0%	3.0%
1986 Sterner[12]	500	Yoffa	Yes	84.5% supra 80.0% infra	2.0% supra 5.1% infra
1990 Conroy[16]	100	Central	No	98.0%	0.0%
1992 Jones[17]	34	Central	No	79.0%	7.0%
1992 MacDonnell[18]	35	Other	No	94.0%	2.9%
1997 Muhm[7]	219	Other	No	93.8%	8.2%
1997 Nevarre[27]	128	Yoffa	No	97.8%	0.6%
1998 Apsner[8]	81	Yoffa	No	97.5%	4.9%
2000 Laczika[28]	17	Yoffa	No	100.0%	0.0%
2004 Gorchynski[10]	68	Pocket	No	90.0%	0.0%
2006 Lu[13]	91	Other	Yes	93.3% supra 87.0% infra	13.3% supra 4.3% infra

mark the puncture site on the skin overlying the center of the vessel.[23] Another option is the ultrasound-guided low internal jugular vein approach in which the inferior portion of the internal jugular is cannulated approximately 2 cm above the clavicle between the sternal and clavicular insertions of the sternocleidomastoid muscle. Silberzweig and Mitty[24] evaluated 116 ultrasound-guided low internal jugular vein approaches in 109 patients. Successful catheterization occurred in 100% of the attempts with an average of 1.2 passes (range 1-3) to obtain access. One common carotid artery puncture occurred with no adverse outcome. Another potential alternative described in a recent article by Maeken and Grau[22] is the "notch position" for ultrasound-guided central venous puncture of the innominate vein; although this procedure has not been studied in detail.

While ultrasound is an enormous advance in the placement of central lines, it is not always available. For this reason alone landmark based central line access will remain a skill physicians need to have in their armamentarium. The supraclavicular line offers another approach that appears at least as safe and possibly easier to perform with less misplacement than more frequently used lines.

CONCLUSIONS

The literature clearly demonstrates the effectiveness of the supraclavicular approach using Yoffa's original technique as well as modifications to landmarks, angles, and patient position (see Table). No central venous access is without potential complications and no one technique is ideal for every patient. In conclusion, a thorough knowledge of anatomy and familiarity with multiple approaches is the route to successful central venous catheterization.

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

REFERENCES

1. Yoffa D. Supraclavicular subclavian venepuncture and catheterization. *Lancet*. 1965; 2:614-7.
2. Defalque R. Subclavian venipuncture: A review. *Anesth Analg*. 1968; 47:677-82.
3. McGee DC, Gould MK. Preventing complications of central venous catheterization. *N Engl J Med*. 2003; 348:1123-33.
4. Aubaniac R. A new route for venous injection or puncture: the subclavicular route, subclavian vein, brachiocephalic trunk. *Sem Hop*. 1952; 28:3445-7.
5. Brahos GJ. Central venous catheterization via the supraclavicular approach. *J Trauma*. 1977; 17:872-7.
6. Brahos GJ, Cohen M. Supraclavicular central venous catheterization: technique and experience in 250 cases. *Wisconsin Med J*. 1981; 80:36-8.
7. Muhm M, Sunder-Plassmann G, Apsner R, Kritzinger M, Hiesmayr M, Druml W. Supraclavicular approach to the subclavian/innominate vein for large-bore central venous catheters. *Am J Kidney Dis*. 1977; 30:802-6.
8. Apsner R, Schulenburg A, Sunder-Plassmann G, Muhm M, Keil F, Malzer R, Kalhs P, Druml W. Routine fluoroscopic guidance is not required for placement of Hickman catheters via the supraclavicular route. *Bone Marrow Transplant*. 1998; 21:1149-52.
9. Dronen S, Thompson B, Nowak R, Tomlanovich M. Subclavian vein catheterization during cardiopulmonary resuscitation: a prospective comparison of the supraclavicular and infraclavicular percutaneous approaches. *JAMA*. 1982; 247:3227-30.
10. Gorchynski J, Everett WW, Pentheroudakis E. A modified approach to supraclavicular subclavian vein catheter placement: The pocket approach. *Calif J Emerg Med*. 2004; 5:50-4.
11. Helmkamp BF, Sanko SR. Supraclavicular central venous catheterization. *Am J Obstet Gynecol*. 1985; 153:751-4.
12. Sterner S, Plummer DW, Clinton J, Ruiz E. A comparison of the supraclavicular approach and the infraclavicular approach for subclavian vein catheterization. *Ann Emerg Med*. 1986; 15:421-4.
13. Lu WH, Yao ML, Hsieh KS, Chiu PC, Chen YY, Lin CC, Huang TC, Chen CC. Supraclavicular versus infraclavicular subclavian vein catheterizatin in infants. *J Chin Med Assoc*. 2006;69:153-6.
14. Garcia JM, Mispireta LA, Pinho RV. Percutaneous supraclavicular superior vena caval cannulation. *Surg Gynecol Obstet*. 1972; 134:839-41.
15. Haapaniemi L, Slatis P. Supraclavicular catheterization of the superior vena cava. *Acta Anaesth Scand*. 1974; 18:12-22.
16. Conroy JM, Rajagopalan PR, Baker JD, et al. A modification of the supraclavicular approach to the central circulation. *South Med J*. 1990; 83:1178-81.
17. Jones CE, Walters GK. Efficacy of the supraclavicular route for temporary hemodialysis access. *South Med J*. 1992; 85:725-8.
18. MacDonnell JE, Perez H, Pitts SR, et al. Supraclavicular subclavian vein catheterization: Modified landmarks for needle insertion. *Ann Emerg Med*. 1992; 21:421-4.
19. Cherubin CE, Sapira JD. The medical complications of drug addiction and the medical assessment of the intravenous drug user: 25 years later. *Ann Intern Med*. 1993; 119:1017-28.
20. Teichgraber UK, Benter T, Gebel M, et al. A sonographically guided technique for central venous access. *Am J Roentgenol*. 1997; 169:731-3.
21. Randolph AG, Cook DJ, Gonzalez CA, et al. Ultrasound guidance for placement of central venous catheters: a meta-analysis of the literature. *Crit Care Med*. 1996; 24:2053-8.
22. Maecken T, Grau T. Ultrasound imaging in vascular access. *Crit Care Med*. 2007; 35:S178-85.
23. Abboud PA, Kendall JL. Ultrasound guidance for vascular access. *Emerg Med Clin N Am*. 2004; 22:749-73.
24. Silberzweig JE, Mitty HA. Central venous access: low internal jugular vein approach using imaging guidance. *AJR*. 1998; 170:1617-20.
25. James PM, Myers RT. Central venous pressure monitoring: Misinterpretation, abuses, indications and a new technique. *Ann Surg*. 1972; 175:693-701.
26. Neale TJ. Experience in the use of central venous cannulation. *N Z Med J*. 1976; 83:13-14.
27. Nevarre DR, Domingo OH. Supraclavicular approach to subclavian catheterization: review of the literature and results of 178 attempts by the same operator. *J Trauma*. 1997; 42:305-9.
28. Laczika K, Thalhammer F, Locker G, et al. Safe and efficient emergency transvenous ventricular pacing via the right supraclavicular route. *Anesth Analg*. 2000; 90:784-9.

Hemopericardium and Cardiac Tamponade in a Patient with an Elevated International Normalized Ratio

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Supervising Section Editor: David E. Slattery, MD
Submission history: Submitted May 09, 2008; Revision Received July19, 2008; Accepted July 28, 2008.
Reprints available through open access at www.westjem.org

This case report describes a 54-year-old male on warfarin for atrial fibrillation who presented to the emergency department (ED) following a syncopal episode with persistent hypotension. The patient's International Normalized Ratio (INR) returned elevated at 6.0, and a rapid bedside cardiac ultrasound revealed a large pericardial effusion consistent with cardiac tamponade. The anticoagulation was reversed and the patient underwent successful pericardiocentesis with removal of 1,100 mL of blood. [*West*JEM. 2009;10:115-119.]

INTRODUCTION

Cardiac tamponade is a life-threatening condition in which the accumulation of fluid within the pericardial sac causes compression on the heart chambers and impairs their filling.[1] Pericardial effusions resulting in cardiac tamponade can occur from a number of causes, including pericarditis, malignancy, acute myocardial infarction, end-stage renal disease, congestive heart failure, collagen vascular disease, and both viral and bacterial infection.[2] Hemopericardium and resulting tamponade can result from any form of chest trauma, free wall rupture following myocardial infarction, retrograde bleeding into the pericardial sac following a type A aortic dissection, and as a complication of any invasive cardiac procedure.[3-5] In this report, we describe a rare case of cardiac tamponade as a result of hemopericardium in a patient with a markedly elevated International Normalized Ratio (INR), which was rapidly diagnosed using bedside emergency department (ED) ultrasound.

CASE REPORT

A 54-year-old male with a medical history significant for diabetes, hypertension, and atrial fibrillation on warfarin presented to the ED following a syncopal episode, while having his blood drawn in an outpatient laboratory located within the hospital. The patient reported feeling light-headed and dizzy during the procedure, followed by a witnessed loss of consciousness occurring while seated and lasting for one minute. The patient did not fall nor sustain any trauma. Upon regaining consciousness, he continued to feel lightheaded and weak. He denied chest pain, shortness of breath, or palpitations prior to the event. He was transported from the laboratory to the ED by wheelchair, arriving approximately 15 minutes after the syncopal episode.

On physical examination, the patient appeared well-hydrated, awake and alert and in no acute distress. Vital signs revealed an oral temperature of 97.9° F, a pulse of 92 beats per minute, a blood pressure of 100/60 mm Hg, and respirations of 22 breaths per minute with an oxygen saturation of 97% on room air. Jugular venous distension was noted on neck examination. Examination of the chest did not reveal ecchymosis or evidence of trauma. The lungs were clear to auscultation, and cardiac exam revealed distant heart sounds. Peripheral pulses were palpable but weak. A peripheral intravenous line was placed and blood was sent for laboratory testing, which was significant for a creatinine of 2.1 mg/dL (normal range <1.3), lactic acid 2.7 mmol/L (normal range 0.7-2.1), hematocrit 36%, and INR 6.0 (therapeutic range 2.0-3.0). A 12-lead ECG demonstrated low-voltage most prominent in leads I, II, III, aVL, aVF, and V_1 (Figure 1). A portable chest radiograph was remarkable for cardiomegaly (Figure 2, panel A), compared to a portable chest radiograph obtained from the same patient four months earlier during an ED evaluation for chest pain (Figure 2, panel B). The emergency physician (EP) performed a bedside cardiac ultrasound, which revealed a large pericardial effusion (Figure 3; echo-free space >20 mm, corresponding to >700 mL effusion).

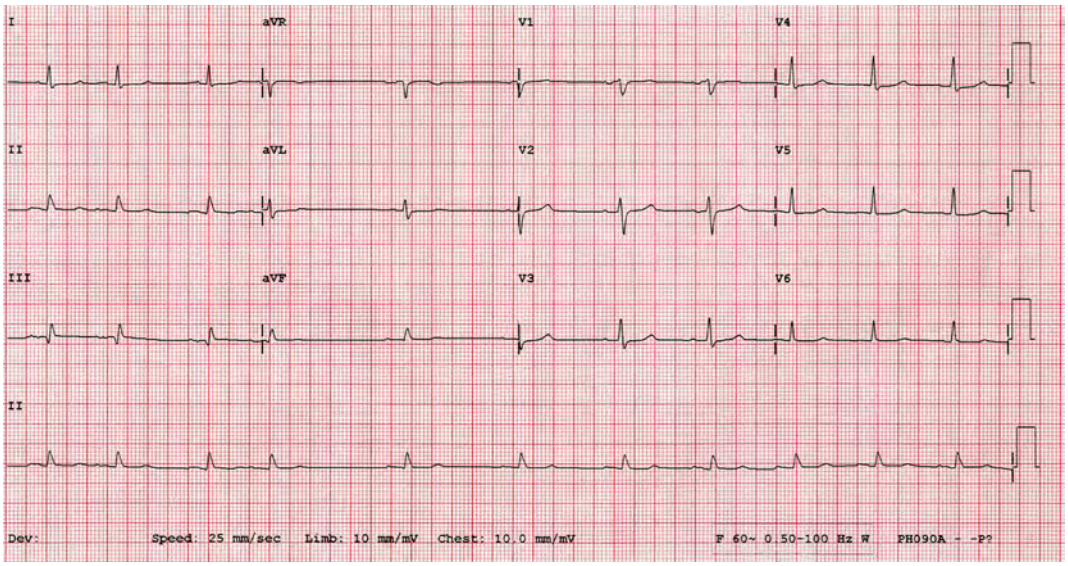

Figure 1. 12-lead ECG from a 54-year-old male with syncope and hypotension.

While in the ED, the patient was given one liter normal saline intravenously, vitamin K 10 mg subcutaneously and an infusion of 2 units of fresh frozen plasma were administered to reverse the coagulopathy. A portable echocardiogram was performed, which again demonstrated a pericardial effusion along with right ventricular collapse, indicative of cardiac tamponade. The patient was admitted to the Intensive Care Unit (ICU) and stabilized, and on the following day the cardiologist performed a pericardiocentesis in the cardiac catheterization laboratory. Pericardiocentesis resulted in the removal of a 1,100 mL of bloody fluid from the pericardium and marked improvement in the patient's hemodynamic status. Pericardial fluid analysis showed no evidence of infection or malignancy. The patient was discharged home on hospital day #8, with instructions to discontinue warfarin therapy. Repeat echocardiograms at discharge and three weeks later both demonstrated a very small pericardial effusion without signs of tamponade.

DISCUSSION

In this report, we describe a rare case of cardiac tamponade caused by hemopericardium in a patient with a markedly elevated INR, presenting to the ED as syncope. Hong et al.[6] described the case of a 70-year-old male on warfarin for mitral valve replacement presenting to the ED with cardiac tamponade. The patient's INR was 7.5, and urgent pericardiocentesis and pericardiotomy resulted in the drainage of 1,300 ml of pericardial blood. Katis[7] reported a case of hemopericardium in a patient on warfarin therapy for pulmonary embolus, with the hemopericardium initially diagnosed by computed tomography of the thorax. In this case, the patient's initial

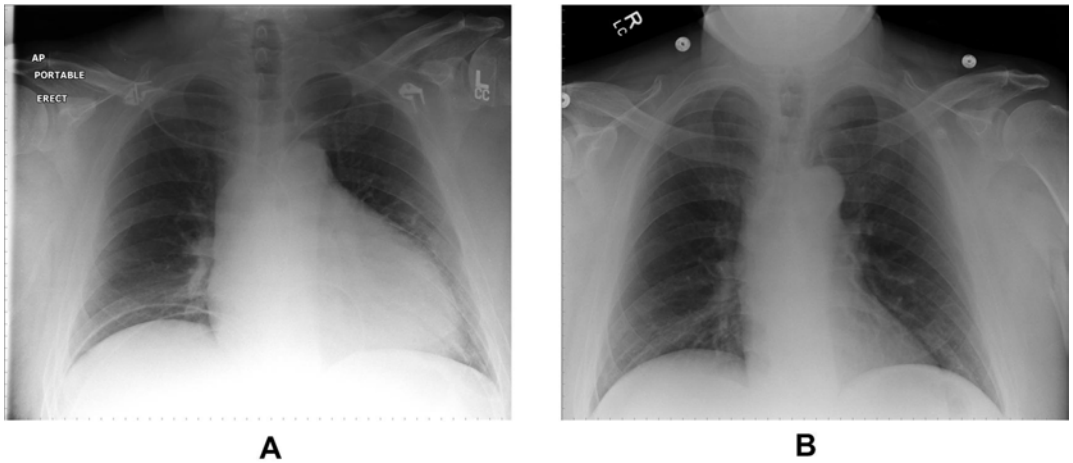

Figure 2. Portable chest radiograph from a 54-year-old male with syncope and hypotension (panel A), compared to a portable chest radiograph obtained from the same patient four months earlier (panel B).

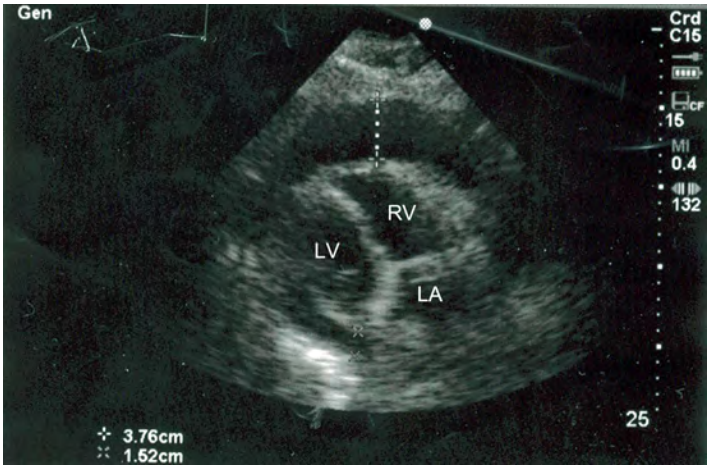

Figure 3. Portable cardiac ultrasound from a 54-year-old male with syncope and hypotension, obtained during early systole. LV = left ventricle, RV = right ventricle, LA = left atrium. Echo-free space (effusion) 37 mm (vertical dashed line).

INR was 3.5, and the patient was hemodynamically stable on presentation (blood pressure 150/80 mm Hg) with a bedside echocardiogram later confirming presence of a large pericardial effusion and right atrial inversion with right ventricular diastolic collapse (suggestive of cardiac tamponade). Finally, Lee et al.[8] described the case of a 67-year-old male receiving warfarin therapy for vertebral basilar insufficiency with hemopericardium, an elevated prothrombin time and transthoracic echocardiographic-evidence of cardiac tamponade. These cases demonstrate that over-anticoagulation with warfarin may contribute to certain complications, including hemopericardium. To our knowledge, our case is the first report of cardiac tamponade from hemopericardium in a patient on warfarin for atrial fibrillation without a history of cardiac surgery, with the resulting pericardial effusion initially diagnosed by bedside ED ultrasound.

Cardiac tamponade is a true emergency that occurs when accumulation of fluid within the pericardium causes intrapericardial pressure to exceed cardiac chamber diastolic pressure, preventing cardiac filling.[9] Three factors determine the acuity of the clinical presentation: volume of fluid, rate at which the fluid accumulates, and pericardial compliance. If the fluid accumulates rapidly or if the pericardium is pathologically stiff, then relatively small amounts of fluid can result in marked elevations in pressure.[9] Rapidly evolving hemopericardium (200 to 300 ml) is more likely to cause death from cardiac tamponade than slowly evolving pericardial fluid accumulation (500 to 2000 ml), the latter allowing for accommodation of greater volumes due to gradual distension of the pericardial sac.[10] The normal volume of pericardial fluid (30 to 50 ml) reflects a balance between production and reabsorption.[10]

Symptoms of tamponade include but are not limited to dyspnea, tachypnea, and fatigue, while common signs include tachycardia, jugular venous distension, a quiet precordium, hypotension, and *pulsus paradoxus* (inspiratory drop in systolic blood pressure of 10% or 10 mm Hg).[9,11] Although a pericardial rub typically disappears when an effusion develops, a rub caused by pericardial-pleural friction may still be present and is typically heard best on inspiration.[9] The Kussmal sign, a paradoxical rise in jugular venous pulse with inspiration, may also be seen but is not specific for tamponade, as it is also present in cases of constrictive pericarditis, restrictive cardiomyopathy, and right ventricular infarction.[11] A relatively easy way to detect pulsus paradoxus at the bedside is to see if the pulse oximeter wave amplitude decreases with inspiration.[12]

Chest radiographs and ECGs cannot be relied upon to make the diagnosis of cardiac tamponade, as findings are not specific or may not even exist.[13] Chest radiograph may demonstrate cardiomegaly or a cardiac silhouette in the shape of a water bottle. Electrocardiograms in cardiac tamponade may show low-amplitude QRS complexes signifying low voltage, or in up to 10-20% of cases may reveal the more specific finding of electrical alternans caused by "swinging" of the oscillating heart in the buoyant pericardial sac.[13]

Echocardiography is the primary diagnostic method for initial detection of pericardial effusion, and can be rapidly carried out at the bedside by EPs.[14,15] Pericardial fluid first accumulates posterior to the heart, when the patient is examined in the supine position.[13] As the effusion increases, it extends laterally and with large effusions the echo-free space expands to surround the entire heart. The size of the effusion may be graded as small (echo-free space in diastole <10 mm, corresponding to approximately 300 ml), moderate (10-20 mm, corresponding to 500 ml), and large (>20 mm, corresponding to >700 ml).[16] When the ability of the pericardium to stretch is exceeded by rapid or massive accumulation of fluid, any additional fluid causes the pressure within the pericardial sac to increase. When the increasing intrapericardial pressure exceeds the intracardiac pressure, the positive transmural pressure gradient compresses the adjacent cardiac chamber or chambers.[14] Right atrial inversion (during ventricular systole, while the atrium is relaxed) is usually an early sign of compression, followed by diastolic compression of the right ventricular outflow tract.

There is no effective medical therapy for cardiac tamponade; however, intravenous fluids may be of transient benefit if the patient is hypovolemic.[9] Inotropic agents do not add to the intense endogenous adrenergic stimulation since the heart rate and cardiac contractility will already be at a maximum.[9] If the patient is unstable, immediate relief of tamponade by percutaneous subxiphoid aspiration is required. This procedure, which has been studied using a percutaneous pericardial catheter drainage (PCD) technique in the ED for patients with nontraumatic hemopericardium,[17] uses an 8-cm,

18-gauge needle inserted between the xiphoid process and the left costal margin, aimed toward the left shoulder under ultrasound guidance. When the pericardial sac is entered a guide wire is advanced through the needle, followed by an 8.5 French pericardial catheter.[17] In hemodynamically-stable patients, echocardiography-guided pericardiocentesis or pericardiocentesis performed in the cardiac catheterization lab under fluoroscopy is the treatment of choice.[9,11] A catheter is usually left in the pericardium to continue draining any recurrent effusion. Surgical drainage employing either a subxiphoid window or an open thoracotomy is also an option.

Vitamin K and fresh frozen plasma are useful agents in achieving reversal of a supratherapeutic INR in patients who have active bleeding or require invasive procedures. The use of vitamin K in patients with warfarin over-anticoagulation lowers excessively elevated INR faster than withholding warfarin alone. As vitamin K administration via the intravenous route may be complicated by anaphylactoid reactions, and via the subcutaneous route by cutaneous reactions, oral administration is preferred.[18] A dose of 1-2.5 mg of oral vitamin K reduces the range of INR from 5.0-9.0 to 2.0-5.0 within 24-48 hours, while for an INR>10.0, a dose of 5 mg may be more appropriate.[18] The usual dose of fresh frozen plasma for reversal of an elevated INR is 15 mL/kg (approximately 3-4 units of plasma in the average-sized adult).[19] Potential drawbacks to the use of fresh-frozen plasma include prolonged period of time to thaw and administer, increased risk of volume overload, and a potential carrier of infective agents.[19]

One complicated facet of the management of cardiac tamponade involves the timing of pericardiocentesis.[20] In our case, the patient was stable enough to allow for reversal of the coagulopathy with fresh frozen plasma and vitamin K prior to pericardiocentesis. But if the patient had decompensated more quickly in the ED, an emergent pericardiocentesis may have been necessary, with the associated bleeding risk due to the markedly elevated INR. Although only anecdotal reports exist regarding the use of recombinant factor VII and prothrombin complex concentrates (PCC) to rapidly reverse coagulopathy in the setting of life-threatening hemorrhage, the use of these novel agents could have been considered in the scenario described above.[21,22]

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

REFERENCES

1. Spodick DH. Current concepts: Acute cardiac tamponade. *N Engl J Med.* 2003; 349:684-90.
2. Roy CL, Minor MA, Brookhart MA, et al. Does this patient with a pericardial effusion have cardiac tamponade? *JAMA.* 2007; 297:1810-18.
3. Krejci CS, Blackmore CC, Nathens A. Hemopericardium: An emergent finding in a case of blunt cardiac injury. *Amer J Roentgen.* 2000; 175:250.
4. Pretre R, Chilcott M. Current concepts: Blunt trauma to the heart and great vessels. *N Engl J Med.* 1997; 336:626-32.
5. LeWinter MM. Chapter 70 – Pericardial disease. In: Libby P, Bonow RO, Mann DL, eds. *Braunwald's Heart Disease: A Textbook of Cardiovascular Medicine.* 8th ed. Philadelphia PA: Saunders Elsevier; 2008:1851.
6. Hong YC, Chen YG, Hsiao CT, et al. Cardiac tamponade secondary to haemopericardium in a patient on warfarin. *Emerg Med J.* 2007; 24:679-80.
7. Katis PG. Atraumatic hemopericardium in a patient receiving warfarin therapy for a pulmonary embolus. *Can J Emerg Med.* 2005; 7:168-70.
8. Lee KS, Marwick T. Hemopericardium and cardiac tamponade associated with warfarin therapy. *Cleve Clin J Med.* 1993; 60:336-8.
9. Shiber JR. Purulent pericarditis: Acute infections and chronic complications. *Hosp Physician.* 2008; 44:9-18.
10. Swaminathan A, Kandaswamy K, Powari M, et al. Dying from cardiac tamponade. *World J Emerg Surg*. 2007; 2:22.
11. Force T. Chapter 85 – The cancer patient and cardiovascular disease. In: Libby P, Bonow RO, Mann DL, eds. *Braunwald's Heart Disease: A Textbook of Cardiovascular Medicine,* 8th ed. Philadelphia PA: Saunders Elsevier; 2008:2105.
12. Tamburro R, Ring J, Womback K. Detection of pulsus paradoxus associated with large pericardial effusions in pediatric patients by analysis of the pulse-oximetry waveform. *Pediatrics.* 2002; 109:673-77.
13. Ariyarajah V, Spodick DH. Cardiac tamponade revisited: A postmortem look at a cautionary case. *Tex Heart Inst J.* 2007; 34:347-51.
14. Wann S, Passen E. Echocardiography in pericardial disease. *J Am Soc Echocardiogr.* 2007; 21:7-13.
15. Mandavia DP, Hoffner RJ, Mahaney K, et al. Bedside echocardiography by emergency physicians. *Ann Emerg Med.* 2001; 38:377-82.
16. Pepi M, Muratori M. Echocardiography in the diagnosis and management of pericardial disease. *J Cardiovasc Med*. 2006; 7:533-44.
17. Wang R-F, Chao C-C, Wang T-L, et al. The effect of different relieving methods on the outcome of out-of-hospital cardiac arrest patients with nontraumatic hemopericardium in the ED. *Am J Emerg Med*. 2008; 26:425-32.
18. Hanslik T, Prinseau J. The use of vitamin K in patients on anticoagulation therapy: a practical guide. *Am J Cardiovasc Drugs*. 2004; 4:43-55.

19. Dentali F, Ageno W, Crowther M. Treatment of coumarin-associated coagulopathy: a systemic review and proposed treatment algorithms. *J Thromb Haemost*. 2006; 4:1853-63.
20. Cooper JP, Oliver RM, Currie P, et al. How do the clinical findings in patients with pericardial effusion influence the success of aspiration? *Heart.* 1995; 73:351-54.
21. Leissinger CA, Blatt PM, Hoots WK, et al. Role of prothrombin complex concentrates in reversing warfarin anticoagulation: A review of the literature. *Amer J Hematol*. 2007; 83:137-43.
22. Ingerslev J, Vanek T, Culic S. Use of recombinant factor VIIa for emergency reversal of anticoagulation. *J Postgrad Med.* 2007; 53:17-22.

Turning Your Abstract into a Paper: Academic Writing Made Simpler

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Submission history: Submitted October 07, 2008; Revision Received November 16, 2008; Accepted December 10, 2008.
Reprints available through open access at www.westjem.org

Academic writing is a critical skill distinct from creative writing. While brevity is vital, clarity in writing reflects clarity of thought. This paper is a primer for novice academic writers.
[*West*JEM. 2009;10:120-123.]

INTRODUCTION

Academic writing is distinct from creative writing. While the latter involves detailed description of feelings, situations and scenes, the former requires only facts without editorial comment or extraneous detail. That which we learned in primary school must be modified substantially for scientific communication. The purpose of this paper is to provide a primer for inexperienced academic writers, mentor this important academic skill, and minimize the potential for harsh critique that will crush the intellectual curiosity needed to pursue clinical research.

Choosing a target journal

There are 35 general and subspecialty journals related to emergency medicine (EM). Twelve of these publish general EM papers and are included in Index Medicus, supported by the National Library of Medicine. These can be found at ftp://ftp.ncbi.nih.gov/pubmed/J_Medline.txt by searching for the term "emergency." These 12 are some of the most discriminating and most-desired by authors, and do not require the author to pay for publication. There are other journals where the author pays for publication, on the order of $1600-1800 per article, while others exist in electronic form only. Also included in Index Medicus are subspecialty EM journals for pediatrics, pre-hospital care, emergency department (ED) management, and emergency nursing. Your paper may be appropriate for these journals as well.

When writing a scientific paper, it is critical to choose and then write for a target journal, following their instructions to authors carefully. Examine the "Aims and Scope" of the target journal from its website, and assure the topic of the paper fits the journal's focus. First-time authors or resident research projects may not be accepted to top tier journals. Be realistic about the importance and quality of your project and try to match it with an appropriate journal. This is a situation where the advice of a research mentor can be valuable.

Be aware of EM conventions of the target journal. In general, use the terms emergency physician (EP), emergency department (ED) and emergency medicine (EM). Do not use emergency room physician, emergency room, emergency medicine physician, ER physician, EM physician or even ED physician. The first time you use these and any other common terms, spell them out and abbreviate them in parentheses. Thereafter, to save space, use the abbreviation. Tables and figures are exceptions to this requirement. Most journals require these to stand alone, with all terms spelled out or defined, so these could be taken out of the paper and still be clear. Similarly, the abstract must stand alone, with all abbreviations defined first, and then again defined in the body of the paper. Readers will often perform literature searches and retrieve abstracts independent of the full text electronic version of the article.

Brevity Rules

The overriding principle of academic writing is brevity. The journal editor wants to include as much scientific content in each issue as possible, within constraints of publishing cost. This was said best by Strunk's 1918 classic, The Elements of Style:[1]

> Vigorous writing is concise. A sentence should contain no unnecessary words, a paragraph no unnecessary

> sentences, for the same reason that a drawing should have no unnecessary lines and a machine no unnecessary parts. This requires not that the writer make all his sentences short, or that he avoid all detail and treat his subjects only in outline, but that every word *tell*."

A prime illustration of this principle is that the landmark paper, "Molecular Structure of Nucleic Acids" by Watson and Crick[2] was only a bit over one page. A paper need not be verbose to be important.

Scientific writing should be intelligible to educated non-scientists. Avoid complicated medical terms and jargon, using medical terminology only when the shorter lay term is not precise enough. For example, it is appropriate to use "myocardial infarction" rather than heart attack, as the latter has many meanings, but "intestinal" has little advantage over, "bowel" or even, "gut." A few characters do make a difference to the reviewer and editor. The goal should be to communicate a concept in the fewest possible words. Frequently, submitted papers can be trimmed by more than 30% without sacrificing meaning.

Use active voice almost all the time, even if it means referring to authors as "we," or "I," to employ it. This is not only more direct, but also shorter. Consider: "Scientists conduct experiments to test hypotheses" vs. "Experiments are conducted by scientists to test hypotheses." The former is 15% shorter (49 characters vs. 58). "The survey was administered by the research assistants" is longer and vaguer than, "Research assistants administered the survey." (54 vs. 43, or 20% shorter).

The corollary to "brevity rules" is "avoid redundancy." Unless hyperbole is absolutely required, modifiers like "close proximity," "summarize briefly," "very deep," "overcrowded," and "very precarious" add nothing to their parent terms. It is rarely necessary to use the same word twice in a sentence. For example, "Simpler sentences are preferred over more complex sentences," should be shortened to "Simpler sentences are preferred over more complex ones," or, better, "Simpler sentences are preferred." For most brevity, just use active voice: "Use simple sentences." (59 characters vs. 20).

CLARITY OF WRITING REFLECTS CLARITY OF THOUGHT

It is critical to outline a paper before beginning to write, using, for example, the template included here to include all vital elements (Appendix, online at www.westjem.org). Vary your sentence length to improve readability, alternating between short and long ones. If your concept is highly technical and requires a long explanation of a complicated process, with parenthetical phrases and multiple qualifiers, follow this with a short sentence. Your reader will appreciate it. The previous two sentences are an example of this concept. Conversely, avoid run-on sentences, or using more than one parenthetical phrase, (separated by commas) per sentence. Instead, simply divide the sentence into two.

A paragraph should have at least three sentences and rarely more than six. These include at least a topic sentence, an explanation of the topic, and a concluding sentence. If there are only two sentences, incorporate these into the previous or following paragraph.

When you have finished your draft, have someone not in your field, or not even in medicine, review the paper before submission. A college graduate should be able to understand much of medical writing. If they are lost, the paper needs more work. Write in plain English, rather than a foreign language called "medicine."

Avoid politicizing a research paper. If you consider a concept politically or socially provocative, it probably does not belong in a research paper. There is little room for opinion in scientific writing as the facts speak for themselves. Only the "Discussion" section should contain opinion, clearly prefaced by "we believe," and limited to a few sentences or conjectures. Most authors inherently overstate the importance of their findings, as they are invested in the project after years of work. It is almost always appropriate to tone down conclusions, as the definitive paper which settles an issue is exceedingly rare.

To gain experience with academic writing, consider volunteering as a reviewer. This flips perspective from author to consumer, and provides insight into common problems in academic writing. This process is time-consuming and intellectually demanding. A good review easily takes 2-3 hours, but will pay off in spades with a smooth road to the promised land of accepted publications.

What is wrong with the previous sentence? It includes three colloquialisms that do not belong in academic writing: "pay off in spades," "smoother road," and, "promised land." It is also passive voice. The sentence would read better as: "You will need to spend 2-3 hours on a good review, but this will enhance your papers' chances for acceptance. (129 vs. 108 characters, or 16% shorter)

SITTING DOWN TO WRITE THE PAPER

You may choose to use the template from the University of California, San Diego Emergency Medicine Residency, included as an appendix on-line at http://repositories.cdlib.org/uciem/westjem/.

The **title** should answer the question posed by the paper. It should include the study design: retrospective vs. prospective, randomized controlled trial, cohort study, before and after study, case series or report. Truncate the title as needed, as some journals have an 80-character limit, striking the best balance between brevity and accuracy. Spell out all abbreviations.

A structured **abstract** is next, and must include all major findings. The "introduction" should be two sentences

maximum, framing the background of the investigation. The "objective" sentence follows, and then the "methods" can be listed in 2-3 sentences, including the setting. Results should begin with the most important finding, and then, at most 1-2 secondary outcomes. The "conclusion" should be one sentence, qualified to clarify the subject population you studied. Readers may read and act upon the abstract alone, and even more distressing, only the "conclusion" sentence. These therefore must be able to stand alone with complete and honest reporting of both positive and negative results. Adhere to word count limits for abstracts, which vary by journal from 250-400 words.

The abstract should parallel the body of the paper in content and order. It is common to write the abstract first as an outline, then the paper itself. However, some results and conclusions may change in the arduous and lengthy writing process. Therefore, it is critical to return to the abstract and assure consistency in methods, results and conclusions. Nothing brands a paper as sloppy more than this common problem. The reviewer and editor think, "If the authors don't care enough to make the numbers match, then what confidence can I have in attention to detail in their research?" Such blatant inconsistency casts a pall on the entire peer-review.

The **introduction** is typically four paragraphs, and should not be a literature review. Rather, it should frame the problem or hypothesis, drawing from a few key papers whose conclusions lead to the question at hand. All other citations belong in the discussion (save "methods" published previously). The last sentence should be "we hypothesized," or "our objective was…" or similar.

The **methods** section should describe the setting, the inclusiveness of the sample, specific inclusion/exclusion criteria and the intervention, if any. How were subjects identified? How did you gather, record and analyze the data? What safeguards were in place to protect data integrity and accuracy? What statistical tests and programs did you use? It is important to have a statistician or senior researcher write or review this portion of the methods section. If equipment or computer programs were used, list the manufacturer, model or version number, which would enable a reader to replicate the study. If the study is a retrospective chart review, describe compliance with the 7-12 elements outlined in one of two methodology papers by Gilbert and Lowenstein[3] or Worster and Bledsoe.[4]

Within the **results** section, present the primary outcome measure first, followed by secondary ones. If there are more than four or five related results, report them in a graph or table. Text in the results section should not repeat graphic or tabular results, but rather provide a synopsis of results. Design graphs in black and white, with different patterns, as most print journals are not color and the resultant shades of gray are difficult to discriminate.

Describe results in absolute, not relative, terms. For example, "The absolute risk reduction in mortality was 2% (4% to 2%)" rather than, "The relative risk reduction was 50%." This is intellectually honest, and avoids artificially inflating the relative benefit of an intervention. To compare groups, use p values with 95% confidence intervals, and report the number-needed-to-treat and to harm from the absolute difference in outcomes. This gives information to gauge clinical import of the intervention.

For diagnostic tests, use likelihood ratios in addition to sensitivity, specificity, and positive/negative predictive values. This allows the reader to change the pre-test probability of a condition to a post-test one after the diagnostic test, using the Fagan nomogram.[5]

Even if key findings in a picture or figure seem obvious, annotate them with arrows to provide greater clarity. Pictures must be high resolution, as low resolution images show pixels in print. Because tables and figures may be removed from the body of the paper and must therefore stand alone, define abbreviations, even if done elsewhere. The legends for both tables and figures are usually submitted on separate pages.

In the **discussion,** highlight the most important findings first, following the order of the methods and results sections. Discussion of secondary outcomes should follow. Limit and clearly label opinion, and identify how, and if, the study could or should change practice. Limit this section to 5-6 items, each with 1-2 paragraphs. Avoid submitting a comprehensive literature review, rather confining it to the outcomes of the paper.

Authors commonly overstate their **conclusions**, and offer them despite not having studied the issue. These should be quite narrow, and focused only on the sample studied. The definitive study is near impossible, so qualifiers such as "it appears," or "from these data" are appropriately included. Further investigation is always warranted. Remember that retrospective studies cannot, by definition, show causation, only association, so use this word when indicated. Make the conclusion specific enough to stand alone. Include for example, "in adults," or "in emergency department patients with a chief complaint of chest pain..." For case reports the conclusion should state the learning objective. Avoid statements such as, "The emergency physician must know about this rare condition…" and instead use phrases such as, "We present this case to increase awareness among emergency physicians of this condition…"

The **limitations** section should be 1-2 paragraphs and acknowledge major flaws, such as small sample size/ underpowered study, incomplete patient enrollment, patients lost to follow up, obvious sources of bias, retrospective design, lack of blinding, controls, or generalizability. It is better to be honest up front about shortcomings, rather than be guaranteed additional criticism in the peer-review process.

The **references** of course must be complete and correct, and conform to a journal's required format. The placement of

citations within the body of the paper must also conform to a journal's convention. It is important to do another literature review before submission, as new publications may have bearing on the paper, and failure to do so risks embarrassment if the reviewer finds pertinent references not included.

RESPONDING TO THE FIRST CRITIQUE

A very small minority of papers are accepted without revision, so expect a harsh critique. Whether resubmitting to the same journal, or to another, follow the reviewer's suggestions assiduously. If the review asks for information you did not collect, or cannot produce, acknowledge this in the limitations section. With repeated submissions, this section tends to grow sometimes longer than the discussion section itself.

Take a critical look at the clarity of the paper. If the first reviewers did not understand the paper, neither will subsequent ones. Show the paper to a colleague unfamiliar with the project, and respond to their confusion by clarifying seemingly obvious points.

If resubmitting to the same journal, avoid defensiveness in your response. Outline the changes you make in a point-by-point cover letter, so the reviewer can easily see compliance with suggested changes, and complete this within one month. Swift resubmission will increase chances of acceptance, as the reviewer will retain familiarity with the paper.

CONCLUSION

Academic writing is at worst maddening and at best painstaking. Attention to detail in reporting should parallel the same in execution of the project. With adherence to this advice, the severity of the critique will be manageable, and desire to replicate the research process will remain unscathed. The Editors of *WestJEM* wish you the best of luck in your academic writing.

Acknowledgements

To my partner Shahram Lotfipour, MD, MPH, without whose tireless efforts and ingenuity as Managing Associate Editor, the *Western Journal of Emergency Medicin*e would not succeed.

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

REFERENCES

1. Strunk, William. *Elements of Style.* Ithaca, NY: Priv. print. Geneva, NY: Press of W.P. Humphrey; 1918; Bartleby.com; 1999.
2. Watson JD, Crick FHC, A structure for deoxyribose nucleic acid. *Nature*. 1953; 171:737-738.
3. Gilbert E, Lowenstein S, Koziol-McLain J, Barta D, and Steiner J. Chart reviews in emergency medicine research: Where are the methods? *Ann Emerg Med*. 1996; 27:305-308.
4. Worster A, Bledsoe RD, Cleve P, Fernandes CM, Upadhye S, Eva K. Reassessing the methods of medical record review studies in emergency medicine research. *Ann Emerg Med*. 2005; 45:448-451.
5. Fagan TJ. Letter: Nomogram for Bayes theorem. *N Engl J Med*. 1975; 293:257.

Challenging the Cost Effectiveness of Medi-Cal Managed Care

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Supervising Section Editor: Mark I. Langdorf, MD, MHPE
Submission history: Submitted July 07, 2008; Revision Received January 12, 2009; Accepted January 14, 2009.
Reprints available through open access at www.westjem.org
[*West*JEM. 2009;10:124-129.]

INTRODUCTION

Researchers and consultants have promoted expansion of Medi-Cal managed-care (MCMC) to additional Medi-Cal beneficiaries currently covered under the Medi-Cal Fee-for-Service (FFS) program to achieve greater cost efficiency and quality of care. Proponents have also promoted MCMC as a cost-effective way to expand state-subsidized health insurance for many of the State's 6.5 million uninsured,[1] even though claims of this cost effectiveness have been disputed.[2] This paper presents data that challenge the cost effectiveness of MCMC, and suggests that cost savings may actually represent cost shifting to the Medi-Cal FFS system. This in turn places an unfair burden on emergency physicians and other fee-for-service Medi-Cal providers. This cost shifting appears to have been facilitated by the unique manner in which MCMC has been implemented, allowing health plans to not enroll or dis-enroll the most costly beneficiaries without a concomitant adjustment in the state's per-member-per-month capitation payments. Because of the highly skewed distribution of the cost of care, shifting even a small number of high-cost patients from a MCMC health plan into the Fee-for-Service program allows these plans to falsely promote the reduced monthly cost of care per enrollee as the result of cost-effective care management.

Of the 6.62 million Medi-Cal enrollees in the fiscal year 2007-08, 3.33 million were enrolled in MCMC, which receives $6.06 billion of the $33.98 billion total Medi-Cal budget. Even a small overestimate in the monthly cost per member used to calculate capitation rates has a large aggregate financial impact, easily reaching hundreds of millions of dollars annually. Ever since the Medi-Cal program began shifting its beneficiaries into MCMC in 1994, numerous claims have been made regarding the beneficial fiscal impact of the managed-care model on program expenditures.[3] Organizations such as the California Legislative Analyst's Office[4] and the Little Hoover Commission have touted the ability of MCMC to contain costs. Based on these assertions, MCMC proponents have recently introduced state legislation (SB 1332) to expand MCMC enrollment for aged, blind and disabled (ABD) populations, many of whom are prime candidates for dis-enrollment and carve-out cost shifting once per member per month (PMPM) capitation payments are set. However, there is little evidence that substantiates anticipated savings in the Medi-Cal program. In **Appendix A** (all appendixes are available online as a related file at http://repositories.cdlib.org/uciem/westjem/vol10/iss2/art17/), the author assesses the validity of the claims in support of, and challenging, managed-care cost effectiveness in California and elsewhere in the country.

The Skewing of Cost Distribution in Medi-Cal

Selection bias in managed-care is a systematic assignment of beneficiaries to a health plan based on health needs. The Medi-Cal program employs a methodology for setting capitation rates based on the **average per capita cost** of the eligibility cohort or population to which each beneficiary belongs. If, however, the population actually enrolled is healthier and therefore less expensive than the estimates for the eligible population as a whole (risk-averse selection), the plan benefits. Economists have studied the distribution of healthcare costs within populations and consistently found, both over time and across patient groups, that medical spending tends to be highly concentrated among a small percentage of patients, rather than spread evenly through the population.[5,6] This skewed cost distribution means that the departure of even a small number of high-cost patients can have a large impact on the average cost of care for the remaining population. This perverse disincentive also potentially discourages health plans from including the most qualified specialists in their provider networks, lest this attract potential enrollees with more complicated health problems. **Appendix B** reviews the relevant literature on the distribution of costs in healthcare populations.

Focusing on the Medi-Cal population, Thomas MaCurdy et al.[7] found that, "Medi-Cal spending is extremely concentrated

among a small segment of the enrollee population. An enormous share of all expenditures goes to a small number of cases; 60 percent of all Medi-Cal expenditures went to benefits for only five percent of the enrollees." The same study noted a near absence of expenditures for services associated with the least expensive 25% of the Medi-Cal population.

The per capita cost method of calculating capitation rates used by Medi-Cal is similar to the methodology employed, and then abandoned, by the Medicare program during the 1990s. Then, actuaries discovered that the introduction of managed-care into the Medicare program led to the "favorable selection" of healthier and less expensive beneficiaries into health plans, and subsequent overpayments to these plans.[8] Since the same conditions appear to exist in MCMC as did in Medicare, this should cause concern over the possibility that MCMC plans might be receiving an inappropriately higher allocation of limited Medi-Cal program funds. **Appendix C** reviews the Medicare experience with risk adjustment of Medicare managed-care capitation rates.

To understand the impact of the skewing of costs in the Medi-Cal population, it may help to consider a hypothetical TANF (Temporary Aid to Needy Families) population of 200,000 Medi-Cal patients in a medium-sized California county. Assume an average cost of $125 PMPM, with eight months of average enrollment during the year, and total annual expenditures of $200 million. Next, assume that the patients are randomly assigned to two groups of 100,000 each, one enrolled in MCMC, and the other in the FFS program. Applying the distribution found by Berk and Monheit in 1996, and assuming a $125 average PMPM cost, the distribution of expenses for this hypothetical TANF patient population would appear as in the table in Exhibit 1. (Additional supporting tables for this illustration are in **Appendix D**).

The shift of the most expensive 1% of patients (for example, those with chronic illnesses) out of MCMC and into FFS causes the average PMPM cost of the remaining population to decline 26% or $32, from $125 to $92 (Figure 1). Shifting the most expensive 10% reduces the PMPM

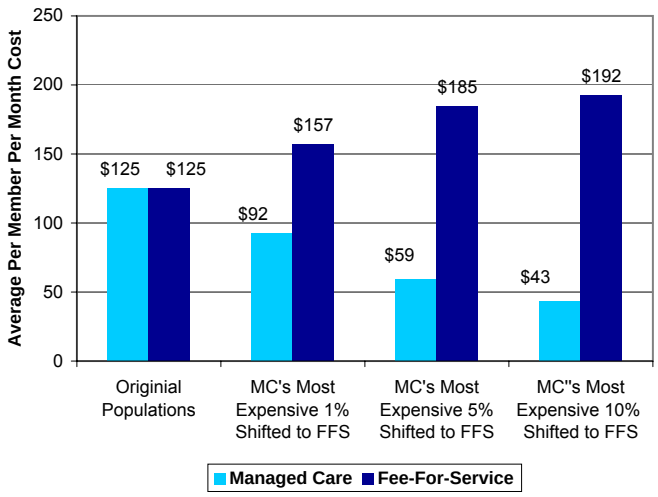


Figure 1. Changes to average per member per month costs resulting from movement of most expensive beneficiaries from managed care (MC) to fee-for-service (FFS)

cost of the remaining population to $43. The shifting of the most expensive 1% of patients to FFS causes the average PMPM cost of the expanded FFS population to increase by $32, from $125 to $157. Shifting the most expensive 10% increases the PMPM cost under FFS to $192. As this illustration demonstrates, the shifting of a very small number of high-cost beneficiaries from managed-care to FFS can drastically alter the average cost of both populations. To an observer unfamiliar with this phenomenon, it would be easy to mistakenly conclude that managed-care does hold down costs.

Aggregate payments to the managed-care program reflect the loss of member months as the most expensive patients are dis-enrolled. The PMPM rates, however, are not recalculated to reflect the reduced average cost of the population, and this significantly improves plan profitability, even though capitation rates paid to MCMC plans are reduced by 5% to build in some of the anticipated cost savings. For example,

Table. Beginning cost distribution of each group of beneficiaries in hypothetical California county

Total number of beneficiaries	100,000				
Member months	800,000				
Total annual expenditures	$100,000,000.00				
Percent of unduplicated beneficiaries	Top 1%	Top 5%	Top 10%	Top 50%	Bottom 50%
Number of unduplicated beneficiaries	1,000	5,000	10,000	50,000	50,000
Amount of expenditures	$27,000,000	$55,000,000	$69,000,000	$97,000,000	$3,000,000
Percent of expenditures	27.0%	55.0%	69.0%	97.0%	3.0%
Member months	8,000	40,000	80,000	400,000	400,000
Per member per month	$3,375.00	$1,375.00	$862.50	$242.50	$7.50

Applied to Temporary Assistance for Needy Families beneficiaries in hypothetical county. Assumes $125 per beneficiary per month average cost.

using a capitation rate set at $118.75, which is predicated on 95% of the original average PMPM cost of the population, the shifting of even the most expensive 1% of 100,000 beneficiaries originally enrolled in managed-care to FFS would result in an overpayment of $2.6 million a month, or $31.6 million a year. Unfortunately, these plans bank these unearned profits while the burden for the care of these patients is shifted to FFS providers at rates that are among the lowest in the country.[9]

Causes of Non-Enrollment in Mandatory Managed-care Enrollment Populations

During calendar year 2005, 1,120,964 Medi-Cal beneficiaries assigned to aid codes for which enrollment into a MCMC plan is mandatory were initially enrolled under the FFS model (47%), or subsequently moved from MCMC into FFS (53%). These are disturbing figures that may not have been appropriately considered in the determination of PMPM costs or capitation rates. Certainly, the previous illustration suggests that the cost-shifting impact of selection bias that eliminates one-fourth of all potential MCMC enrollees is likely to be huge. The reasons a mandatory beneficiary may not be enrolled, or may have dis-enrolled from a health plan, are described in **Appendix E**, and include logistical problems such as the patient changing counties or being homeless, pregnancy, chronic diseases such as HIV/AIDS or cardiomyopathy, current cancer therapy, consideration for organ transplant, or pending major surgical procedures. All of these would be expected to drive up the cost of care for these prospective MCMC beneficiaries.

There appear to be policy loopholes and incentives allowing or encouraging pregnant women to never enroll into MCMC plans, or to dis-enroll when they become pregnant or near delivery. (In 2005, 71% of deliveries were under FFS.) As a consequence, some MCMC plans had higher rates of deliveries relative to the rates of initial enrollment of pregnant women in MCMC than other plans, even though the administrative and demographic characteristics of the enrollees were equivalent. Having identified this discrepancy, Mercer and Associates,[10] the actuarial consultant for the Department of Health Care Services, recommended that the Medi-Cal program implement a maternity supplemental payment to the plans to cover the cost of all deliveries to level the playing field. The department recently followed this recommendation, providing approximately $7000 in supplemental payments to MCMC plans for each delivery (which, perversely, may reverse the incentive and encourage MCMC providers to provide prenatal care under FFS and enroll these pregnant women into MCMC as they near term).

Low Rates of Managed-care Enrollment in Voluntary Populations

The rules determining enrollment of Medi-Cal beneficiaries into MCMC plans are based on the "Plan Model Type" of their county of eligibility. There are three major types of MCMC plans: 1) County Organized Health System (COHS), where there is one health plan run by a public agency and governed by an independent board. Nearly all Medi–Cal enrollees residing in the COHS are required to receive care from this system; 2) the Geographic Managed Care (GMC) system allows Medi–Cal beneficiaries to choose to enroll in one of many commercial health maintenance organizations (HMOs) operating in a county; and 3) the Two–Plan Model, which consists of counties where the department contracts with only two managed-care plans, one locally developed and operated, the other a commercial HMO, selected through a competitive bidding process. In the 12 "Two-plan" model counties and the two GMC counties, certain aid codes are considered "voluntary" for managed-care enrollment. Typically, beneficiaries in aid codes for the aged, blind and disabled are considered voluntary. Additionally, newborn babies with birth complications receiving care from the California Children's Services (CCS), are often enrolled in aged, blind and disabled aid codes; and in that way, are not enrolled into MCMC. A disabled or presumptively disabled premature newborn is assigned to a disabled aid code. The premature beneficiary is then considered enrolled in FFS, not into MCMC. These enrollment rules enable many MCMC plans to manipulate enrollment and selectively limit their exposure to high-cost patients.

According to the Department of Health Care Services, enrollment data for beneficiaries assigned to voluntary aid codes reveal that a large proportion of the population is not enrolled into managed-care. To further complicate matters, only a small proportion of the mandatory population has enrolled into a MCMC delivery system. For example, while foster-care aid codes are considered mandatory, only 10 to 12 percent of this population enrolls into managed-care plans. Foster care children are much more likely to be afflicted with psychological disorders or behavioral problems and display PMPM costs that are as much as twice that of other children of similar age, gender, and ethnicity (source: DHCS Medical Care Statistics Section).

Capitation rates based on the average cost of a given population are effective when all members of the population enroll in a plan, but become less accurate and appropriate as increasing numbers dis-enroll. In the voluntary aid code population, where 85% of the potentially eligible beneficiaries may never enroll, the difference between the cost of the potentially eligible population and the population that actually enrolls is likely very great. This is especially true if the sickest members of the population never enroll, but remain in the FFS model. The recent decision to require quarterly re-enrollment of beneficiaries in California offers MCMC plans yet another avenue to selectively manipulate enrollment.

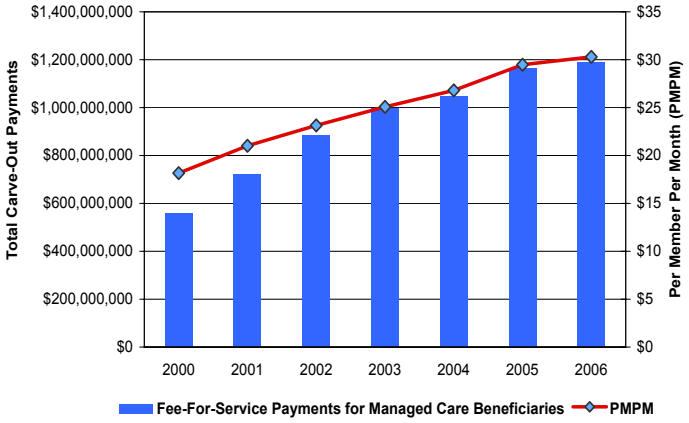
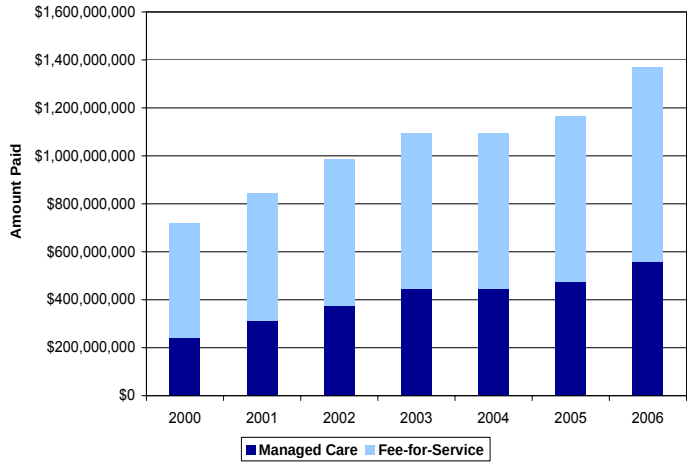


Figure 2. Fee-for-service carve-out payments for Medi-Cal managed care enrollees.



Source: EDS Paid 35-File with 6- Month Lag

Figure 3. Change in California Children's Services payments under fee-for-service and Medi-Cal Managed Care

The Impact of "Carve-Out" or Excluded Services

Another argument for the greater cost efficiency of MCMC is the slower rate of increases in Medi-Cal capitation rates compared to other indicators of health cost inflation. Data show, for example, that Medi-Cal capitation rates have risen more slowly than the medical care component of the Consumer Price Index, or employer health-insurance premiums. Alluding to the implied cost effectiveness of MCMC, Mark Smith,[11] president of the California Health Care Foundation, told a 2007 conference audience, "The growth of Medi-Cal Capitation Rates has been substantially less than commercial premiums." While the figures may be accurate, the comparison itself is misleading. Not only does this comparison ignore the underlying age and health status differences of the populations being compared; it also ignores the difference in scope of services associated with these reported cost increases.

The Medi-Cal program places a wide range of services, known as "carve-outs," outside the scope of its capitation payments to the managed-care plans for the purposes of rate setting and contractual service obligations. Medi-Cal patients who need these services must obtain them under traditional FFS arrangements and not through their plans. Carve-outs may include: CCS (California Children's Services) payments; Rural Health Clinics/FQHC's (Federally Qualified Health Clinic) wrap-around payments; Long-Term Care in Skilled Facilities; Nursing, drugs and services to patients receiving treatment for mental illness; treatment for HIV; and surgeries for organ transplantation. This process limits the exposure of the MCMC program to higher cost services, more expensive specialty care, and less predictable overhead.

While capitation payments made to MCMC plans may not have increased as much as employer-based insurance premiums, the cost of the carved-out services that are excluded from capitation agreements with MCMC plans certainly have. Between 2000 and 2006, FFS payments for MCMC patients rose by 113%. Some of this increase reflects the 27% expansion of MCMC enrollment during this period. However, the PMPM cost of carved-out services also rose by 67%, indicating that on a per-person basis, carve-out costs rose by an average of 9.5% annually. In calendar year 2006, Fee-for-Service carve-out payments made by the Medi-Cal program on behalf of MCMC enrollees totaled slightly less than 1.2 billion dollars[12] (Figure 2). Of these, $616 million, or 52%, were related to the CCS and the Genetically Handicapped Persons Program (GHPP). (See below).

CCS is a statewide program that treats children with certain physical limitations and chronic health conditions or diseases. GHPP provides health coverage for Californians 21 and older who have specific genetic diseases, including cystic fibrosis, hemophilia, sickle cell disease, and certain neurological and metabolic diseases. GHPP also serves children under 21 with GHPP-eligible medical conditions who are not financially eligible for CCS. While it may have been assumed that services paid for by California Children's Services (CCS) would remain static or fall in counties where managed-care has been introduced, MCMC plans have aggressively utilized CCS to provide care for premature and compromised infants, driving fee-for-service CCS payments for Managed Care beneficiaries from $230.2 million in the fiscal year 1999-2000 to $517.8 million in the fiscal year 2004-2005 (Figure 3).

A FQHC is a community-based health organization that provides comprehensive primary care, dental and mental health/substance abuse services to underserved, underinsured and non-insured populations. FQHC carve-out payments represent 41% of the total cost of MCMC carve outs not related to CCS/GHPP. Under the federal Medicaid statute,

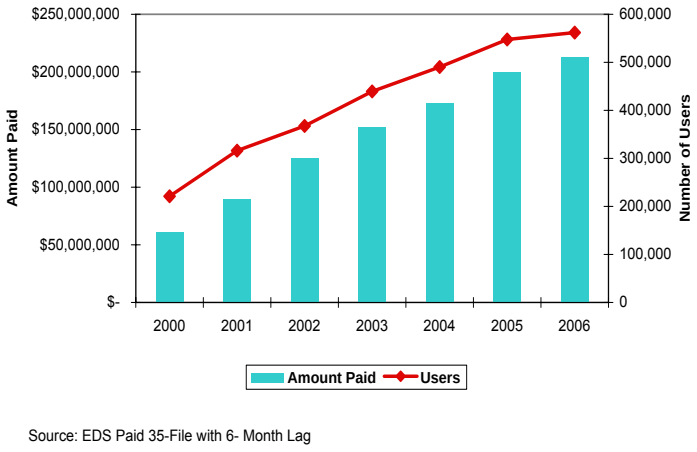


Figure 4. Medi-Cal Manged Care Federally Qualified Healthcare Center wrap around payments and users - calendar year 2000-2006

when a contract between a managed-care organization and a FQHC results in the FQHC receiving less than the amount of reimbursement due under the FQHC prospective payment system (PPS), the state must make a supplemental "wrap-around" payment to the FQHC to make up for the difference the FQHC is owed. Between 2000 and 2006 there has been a dramatic increase in the use of FQHC providers by MCMC patients. During this period MCMC wrap-around payments increased by 211%, while the number of managed-care beneficiaries utilizing FQHCs increased by 154% (Figure 4).

The rapid increase in FQHC utilization by MCMC beneficiaries, which greatly outpaces the growth in MCMC enrollment, is worrisome for three reasons:

1) It suggests that there are inadequate numbers of non-clinic affiliated physicians and physician groups to enable the plans to form a primary care network for Medi-Cal beneficiaries.
2) Visits by managed-care patients to FQHC providers create millions of dollars in additional FFS carve-out expenditures that would not exist if the health plans were able to contract with non-FQHC affiliated physicians and physician groups.
3) While Medi-Cal would still be required to pay the higher FQHC rate for services incurred at clinics under a FFS scenario, it would do so without, in addition, paying a portion of a capitation rate to a health plan for these subcontracted primary care services. For the care of these patients, MCMC is 'double dipping' into a limited funding pool.

CONCLUSION

In light of the indicators of cost shifting identified in this review, the assertion that the MCMC program is cost effective is highly suspect. A number of questions need to be answered before program administrators can claim with confidence that billions of dollars in Medi-Cal funds are being properly allocated, and that expansion of these programs to cover other beneficiaries is indicated. These questions include but are not limited to:

1) What is the distribution of costs for mandatory enrollment code beneficiaries that remain in, or are excluded or dis-enrolled from, MCMC?
2) What is the risk-adjusted distribution of costs for voluntary enrollment codes that elect to enroll in MCMC vs. FFS?
3) When adjusted for risk, how do costs compare between MCMC and FFS enrollees?
4) What is the actual medical loss ratio for MCMC plans, after full consideration of all contracting plan and subcontracting provider group tiers in the MCMC model?
5) What percentage of pregnant managed-care enrollees are dis-enrolled prior to delivery?
6) What are the true costs of carved-out services?
7) Do certain mandatory aid code categories with higher relative cost risk have a lower rate of enrollment in MCMC?
8) How do risk-adjusted capitation payments affect Medicaid enrollment patterns, carve-outs, and provider networks?

The data presented here indicate that the MCMC program is subject to perverse incentives that adversely impact the Medi-Cal safety net. It is widely acknowledged that the average expenditure per enrollee in the Medi-Cal Program (California's version of Medicaid) is one of the lowest in the nation. FFS providers, especially those obligated under Emergency Medical Treatment and Active Labor Act (EMTALA) to provide emergency care, believe they have had to bear the increasing burden of caring for those patients who are maneuvered out of MCMC enrollment, in return for FFS payments that inevitably fail to cover the provider's costs. The data presented suggest that expansive carve-outs, enrollment loopholes, and dis-enrollment incentives misdirect limited Medi-Cal program funds to plans and provider groups, rather than to the FFS providers that actually provide a disproportionate share of services to high-cost Medi-Cal beneficiaries. The magnitude of this shift easily approaches several hundred million dollars per year. This undermines the potential benefits of applying the managed-care concept to those that need management the most, and under-compensates providers that actually render services to these patients under fee-for-service.

Alternatively, aligning incentives through appropriate risk-adjustment of capitation rates by paying much higher cap rates 1) to cover services that are currently carved out, 2) for

patients that are currently exempted from managed care, and 3) for higher cost patients that are currently being selectively not enrolled or dis-enrolled, and then closing these loopholes, could provide sufficient incentive for plans and capitated provider groups to actually focus on the cost-effective and innovative case management of these patients. This approach might also encourage plans to enhance their network of qualified providers to accomplish this goal, and reduce the program's reliance on EMTALA-obligated FFS emergency care providers and expensive emergency department visits to meet these patients' needs.

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Conflicts of Interest: By the WestJEM article submission agreement, all authors are required to disclose all affiliations, funding sources, and financial or management relationships that could be perceived as potential sources of bias. Dr. R. Myles Riner is affiliated with CEP America as the Director of Provider Relations, and is responsible for managed-care contracting, problem payer management, and government regulatory agency relations. He is also a past president of the California Chapter of the American College of Emergency Physicians (CAL/ACEP), and a member of the ACEP Reimbursement Committee. There were no funding sources for the development of this article.

REFERENCES

1. The Little Hoover Commission. A Smarter way to care: Transforming Medi-Cal for the Future. May 2007.
2. Duggan M. Does Contracting Out Increase the Efficiency of Government Programs? Evidence from Medicaid HMOs. Journal of Public Economics. 2004; 88: 2549– 2572.
3. The Lewin Group. Medicaid Managed Care Cost Savings – A Synthesis of Fourteen Studies. July 2004.
4. Legislative Analyst's Office. Analysis of the 2004-05 Budget Bill. February 2004.
5. Berk ML, Monheit AC. The Concentration of Health Care Expenditures, Revisited. Health Affairs. 2001; 20:9-18.
6. Cohen SB, Yu W. The Persistence in the Level of Health Care Expenditures over Time: estimates for the US Population, 2002-2003. Agency for Healthcare Research and Quality. 2006; Medical Expenditure Panel Survey Statistical Brief #124.
7. MaCurdy T, Chan R, Chun R, Johnson H, O'Brien-Strain M. Medi-Cal Expenditures: Historical Growth and Long-Term Forecasts. Public Policy Institute of California. June 2005.
8. Thiede-Call K, Dowd B, Feldman R, Maciejewski M. Selection Experiences in Medicare HMOs: Pre-Enrollment Expenditures. Health Care Financing Review. 1999; Volume 20: 197-209.
9. Centers for Medicare & Medicaid Services, Center for Medicaid and State Operations. Fiscal Year 2004 National MSIS Tables. June 22, 2007.
10. California Department of health Services. Capitation Rate Development Process and Reimbursement Review. Mercer Government Human Services Consulting. September 2006; Page 3.
11. Smith M. Quality, Affordability and Transparency: A New Era for Medi-Cal? Lecture presented at: California Department of Health Services and Delmarva Foundation for Medical Care, Inc., Annual Quality Conference. March 19, 2007; Sacramento, CA.
12. California Department of Health Care Services. Medical Care Statistics Section: FFS Expenditures Summary Table, CY2006. State of California.

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5. Derlet RW, Richards JR. Ten Solutions for Emergency Department Crowding. 2008; 9:25-28. Available at: http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1054&context=uciem/westjem
6. Vaca FE, Winn D. The Basics of Alcohol Screening, Brief Intervention and Referral to Treatment in the Emergency Department. 2008; 8:88-92. Available at: http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1014&context=uciem/westjem
7. Scruggs W, Fox JC, Potts B, Zlidenny A, McDonough J, Anderson CL, Larson J, Barajas G, Langdorf MI. Accuracy of ED Bedside Ultrasound for Identification of Gallstones: Retrospective Analysis of 575 Studies. 2008; 9:1-5 Available at: http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1069&context=uciem/westjem
8. Arora S. Combining Ketamine and Propofol ("Ketofol") for Emergency Department Procedural Sedation and Analgesia: A Review. 2008; 9:20-24. Available at: http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1049&context=uciem/westjem
9. Brownfield J, Herbert M. ECG Criteria for Fibrinolysis: What's Up with the J Point? 2008; 9:40-42. Available at: http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1047&context=uciem/westjem
10. Garmel GM. Wide Complex Tachycardias: Understanding this Complex Condition Part 2 - Management, Miscellaneous Causes, and Pitfalls. 2008; 9:97-103. Availble at: http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1295&context=uciem/westjem

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