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Permalink
https://escholarship.org/uc/item/9922n53h

Journal
Western Journal of Emergency Medicine: Integrating Emergency Care with Population Health, 10(2)

ISSN
1936-900X

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Publication Date
2009

Peer reviewed

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

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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 $\geq$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 $\geq$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 $\geq$ 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)

Decision Rule	Adverse Outcome	
	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.

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