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

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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 >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.

[WestJEM. 2009;10:79-84.]

INTRODUCTION

Increasing age has been found to be an independent risk factor for a poor outcome after traumatic injury. 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. 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 \(\geq 65\) with AIS of 1-5 in the thoracic region between January 1998 and December 2002. Patients with serious injury to other body areas (AIS \(\geq 3\)) 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 \(\geq 85\) 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...
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>
<thead>
<tr>
<th>Characteristics</th>
<th>Percentage*</th>
<th>Characteristics</th>
<th>Percentage*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (Standard Deviation)</td>
<td>74.9 (7.4)</td>
<td>Hemotherax</td>
<td>13</td>
</tr>
<tr>
<td>Male</td>
<td>59</td>
<td>Pneumothorax, unilateral</td>
<td>26</td>
</tr>
<tr>
<td>Weight, mean (lbs)</td>
<td>166.9</td>
<td>Pneumothorax, bilateral</td>
<td>3</td>
</tr>
<tr>
<td>Height, mean (inches)</td>
<td>66.4</td>
<td>Clavical fx</td>
<td>11</td>
</tr>
<tr>
<td>Auto vs. Pedestrian</td>
<td>8</td>
<td>Scapula fx</td>
<td>3</td>
</tr>
<tr>
<td>Motor vehicle accident</td>
<td>75</td>
<td>Multiple rib fx</td>
<td>48</td>
</tr>
<tr>
<td>Fall</td>
<td>14</td>
<td>Bilateral rib fx</td>
<td>10</td>
</tr>
<tr>
<td>Other mechanism of injury</td>
<td>3</td>
<td>Left sided rib fx</td>
<td>38</td>
</tr>
<tr>
<td>Seatbelt sign</td>
<td>12</td>
<td>Right sided rib fx</td>
<td>27</td>
</tr>
<tr>
<td>Systolic blood pressure in the field, mean</td>
<td>151</td>
<td>Sternum fx</td>
<td>6</td>
</tr>
<tr>
<td>GCS on admission, mean</td>
<td>14.6</td>
<td>Cervical spine fx</td>
<td>3</td>
</tr>
<tr>
<td>GCS less than 12</td>
<td>3</td>
<td>Thoracic spine fx</td>
<td>7</td>
</tr>
<tr>
<td>Systolic blood pressure in the ED, mean</td>
<td>143.4</td>
<td>Lumbar spine fx</td>
<td>9</td>
</tr>
<tr>
<td>Heart rate in the ED, mean</td>
<td>89.3</td>
<td>Spinal cord injury</td>
<td>1</td>
</tr>
<tr>
<td>Respiratory rate in the ED, mean</td>
<td>21.9</td>
<td>Pulmonary contusion, unilateral</td>
<td>15</td>
</tr>
<tr>
<td>Alcohol leve, mean</td>
<td>8.0</td>
<td>Pulmonary contusion, bilateral</td>
<td>3</td>
</tr>
<tr>
<td>Negative toxidology screen</td>
<td>90</td>
<td>Flail chest</td>
<td>7</td>
</tr>
<tr>
<td>Toxicology positive for opiates</td>
<td>6</td>
<td>Long bone fx</td>
<td>14</td>
</tr>
<tr>
<td>Toxicology positive for benzodiazepines</td>
<td>2</td>
<td>Abnormal mediastinum</td>
<td>37</td>
</tr>
<tr>
<td>Toxicology positive for barbituates</td>
<td>1</td>
<td>Pelvic fx</td>
<td>11</td>
</tr>
<tr>
<td>Toxicology positive for multiple drugs</td>
<td>1</td>
<td>Thoracostomy</td>
<td>26</td>
</tr>
<tr>
<td>Base deficit, mean</td>
<td>3.4</td>
<td>PRBC transfusion in the first 24 hours</td>
<td>22</td>
</tr>
<tr>
<td>Anion gap, mean</td>
<td>8.0</td>
<td>Exploratory laparotomy</td>
<td>2</td>
</tr>
<tr>
<td>Lactate level, mean</td>
<td>2.5</td>
<td>Thoracotomy</td>
<td>1</td>
</tr>
<tr>
<td>Oxygen saturation on arrival to ED, mean</td>
<td>97</td>
<td>ISS, mean</td>
<td>10.6</td>
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<tr>
<td>History of CAD</td>
<td>25</td>
<td>Unanticipated Intubation</td>
<td>4</td>
</tr>
<tr>
<td>History of CHF</td>
<td>3</td>
<td>Transfer to ICU for hypoxemia</td>
<td>3</td>
</tr>
<tr>
<td>History of CABG</td>
<td>4</td>
<td>Pneumonia</td>
<td>12</td>
</tr>
<tr>
<td>History of Asthma</td>
<td>5</td>
<td>ARDS</td>
<td>1</td>
</tr>
<tr>
<td>History of COPD</td>
<td>5</td>
<td>Death secondary to pulmonary sequelae</td>
<td>0</td>
</tr>
<tr>
<td>History of diabetes</td>
<td>5</td>
<td>Ventilator days, mean</td>
<td>1.4</td>
</tr>
<tr>
<td>Present use of aspirin</td>
<td>16</td>
<td>ICU length of stay</td>
<td>4.3</td>
</tr>
<tr>
<td>Present use of coumadin</td>
<td>9</td>
<td>Hospital length of stay</td>
<td>7.4</td>
</tr>
<tr>
<td>Present use of plavix</td>
<td>1</td>
<td>Death</td>
<td>2</td>
</tr>
<tr>
<td>Presence of any of the adverse outcomes</td>
<td>16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*All values are the percentage unless otherwise noted.

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.
Table 2. Candidate predictor variables: univariate analysis.

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

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.

The elderly population has the highest hospitalization rate after injury.\(^8,15\) 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
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 ≥ 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.

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

<table>
<thead>
<tr>
<th>Decision Rule</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>16</td>
<td>49</td>
</tr>
<tr>
<td>No</td>
<td>0</td>
<td>34</td>
</tr>
</tbody>
</table>

Table 4. Sensitivity and specificity of this decision rule.

<table>
<thead>
<tr>
<th>Sensitivity:</th>
<th>100%</th>
<th>79.4%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specificity:</td>
<td>34.9%</td>
<td>24.8%</td>
<td>46.2%</td>
</tr>
<tr>
<td>Likelihood ratio (+):</td>
<td>1.54</td>
<td>1.31</td>
<td>1.8</td>
</tr>
<tr>
<td>Likelihood ratio (-):</td>
<td>0</td>
<td>0</td>
<td>0.33</td>
</tr>
<tr>
<td>Positive predictive value:</td>
<td>22.9%</td>
<td>13.7%</td>
<td>34.4%</td>
</tr>
<tr>
<td>Negative predictive value:</td>
<td>100%</td>
<td>88.1%</td>
<td>100%</td>
</tr>
</tbody>
</table>

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 ≥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 ≥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

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