INTRODUCTION

It has been shown that elderly patients suffering severe trauma have worse outcomes than their younger counterparts [1-3]. As the proportion of elderly patients in the population continues to increase, the management and prognosis of these patients becomes increasingly important to trauma services [4,5]. Studies assessing trauma in elderly patients have demonstrated mortality rates of 3 - 32% [2,6-9]. Factors associated with mortality in this population include higher injury severity score (ISS), greater number of pre-injury comorbidities, older age, development of complications, pre-injury anticoagulation, and greater requirement for transfusion [2,3,6-10]. Amongst those surviving, many report a return to baseline or high functional levels in the majority of patients [10-12].

Most studies addressing issues surrounding elderly trauma patients have looked at the overall population of patients admitted to hospital after trauma. Between 14 - 42 % of elderly trauma patients, will require admission to an intensive care unit [2,9]. These patients represent the most severely injured subset, and therefore the results of previous studies must be applied with caution. We undertook this study to determine the mortality in elderly trauma patients admitted to the intensive care unit, and factors associated with mortality. Particular attention was paid to the relationship between therapeutic anticoagulation and mortality. We hypothesize that the mortality rate amongst elderly trauma patients admitted to the intensive care unit will be much higher than previously reported, and that patients on therapeutic anticoagulation prior to presentation will be at increased risk of mortality. Further, we hypothesize that the majority of patients who survive to hospital discharge will not be transferred to an independent home setting, and as such, the discharge disposition amongst patients who survived was also explored.

METHODS

London Health Sciences Centre (LHSC) is a Canadian level I trauma hospital located in London, Ontario, with a catchment area of approximately 1.5 million people. The LHSC prospectively collected trauma database is maintained for all patients who have sustained trauma with an ISS greater than 12, or that resulted in activation of the trauma team. Data from the LHSC trauma database were extracted for all patients aged ≥ 65 years admitted to the LHSC trauma intensive care unit (ICU) between 1997 and 2009. Individual chart review was completed to determine implementation and timing of compassionate care in addition to cause of death for non-survivors. Compassionate care was defined as action taken on the part of the clinical team at the discretion of the patient’s substitute decision maker to either withdraw life-sustaining therapies, or to prevent further escalation of care. The primary outcome of interest was in-hospital mortality. Further data were extracted on patient factors (age, gender, comorbidities), injury factors (etiology of trauma, ISS), operative intervention required, pre-injury anticoagulation and length of stay.

All comorbidities identified in the trauma database were extracted, and used to calculate a Charlson Comorbidity Index (CCI) score for each patient. The CCI is an age-adapted weighted index calculated from 19 common comorbidities, and is based on 1-year mortality data for patients admitted to hospital [13,14]. Scores range from 0 to 37, with higher scores associated with worse prognosis [13,14]. Pre-injury therapeutic anticoagulation was determined on the basis of patients’ initial value for international normalized ratio (INR), drawn routinely as part of the initial trauma laboratory investigations at LHSC since 1999. Pre-injury anticoagulation was considered to be present for any patient with an initial laboratory INR value of greater than 2.0, to avoid confounding related to trauma-induced coagulopathy. For analysis of anticoagulation, patients for the years 1999 - 2008 only were considered, as values obtained prior to the time of surgery are not representative of pre-injury anticoagulation.
routine assessment (beginning in 1999) may be considered to represent a source of bias related to the reason for obtaining this value.

Data were analyzed using SPSS Version 17 (Chicago). Univariate comparisons were completed for continuous normally distributed data using Student’s t-Test, non-normally distributed data using the Mann-Whitney U test, and for categorical data using the Pearson chi-square test. Multivariable logistic regression was performed for the outcome of in-hospital mortality. All predictors considered in univariate analysis were included in the model, to identify factors significantly associated with mortality. A p-value of < 0.05 was considered significant. The Research Ethics Board at the University of Western Ontario approved this study.

RESULTS

Of the 1209 patients aged ≥ 65 admitted after trauma during the study period, 355 (29%) were admitted directly to the ICU. Characteristics of the study cohort can be found in Table 1. Patients were severely injured, with a mean ISS of 27, and suffered primarily blunt trauma (n = 332, 94%). INR was measured on admission in 297 patients.

Overall, 161 (45%) patients died in hospital. The median time to death was 2 days (IQR 1 – 9 days), suggesting that the majority of these patients survived the initial resuscitation phase. The most common cause of death, not surprisingly, was traumatic brain injury (Figure 1). Of the 17 fatalities listed as “not classified”, the exact cause could not be determined in 11. The cause of death in the remaining 6 included ischemic stroke, embolic stroke, renal failure, suffocation, cervical spine dislocation, and fat embolism.

Of the 161 deaths, compassionate care was implemented in 68% of cases. The median length of time from hospital admission to decision to implement compassionate care was 2 days.

Table 2 demonstrates the results of the univariate analyses comparing patients who died to those who survived. Univariate analyses revealed that patients who died were older (mean age 77 vs. 74 years, p<0.01), had a higher ISS (mean 29 vs. 24, p<0.01), and were more likely to have INR values consisted with pre-injury anticoagulation (28% vs 9%, p<0.01).

Table 1: Demographic, injury and management characteristics of the study cohort.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trauma patients admitted to ICU, n (%)</td>
<td>355 (29)</td>
</tr>
<tr>
<td>Age in years, mean (SD)</td>
<td>75 (7.0)</td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>215 (61)</td>
</tr>
</tbody>
</table>

Etiology of trauma, n (%)

| Motor vehicle collision | 178 (50.1) |
| Fall | 118 (33.2) |
| Self-inflicted | 51 (14.4) |
| Penetrating trauma | 8 (2.3) |

ISS, mean (SD) | 27 (11.5) |
CCI score, median (IQR) | 2 (1-2) |
Anticoagulation at presentation, n (%) | 51 (17) |
Required operative intervention, n (%) | 159 (45) |
Mortality, n (%) | 161 (45) |
Length of special care unit stay in days, median (IQR)* | 7 (3 – 21) |
Length of hospital stay in days, median (IQR)* | 15 (7 – 35) |
Discharged home, n (%)* | 44 (22.7) |

The denominator for all percentages calculated was 355, except for Anticoagulation at Presentation. In this case the denominator was 297.

Abbreviations: ICU: Intensive Care Unit; n: Number; IQR: Interquartile Range; SD: Standard Deviation; ISS: Injury severity score; CCI: Charlson Comorbidity Index
*amongst survivors only.

Table 2: Univariate comparisons between elderly trauma patients admitted to the ICU.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Died</th>
<th>Lived</th>
<th>Univariate p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in years, mean (SD)</td>
<td>77 (6.6)</td>
<td>74 (7.1)</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>97 (60.2)</td>
<td>118 (60.8)</td>
<td>0.91</td>
</tr>
<tr>
<td>ISS, mean (SD)</td>
<td>29 (12.1)</td>
<td>24 (10.5)</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>CCI score, median (IQR)</td>
<td>2 (1 – 2)</td>
<td>2 (1 – 2)</td>
<td>0.74</td>
</tr>
<tr>
<td>Anticoagulation, n (%)**</td>
<td>40 (28)</td>
<td>14 (9)</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

**For patients admitted after 1999 when routine testing of INR on admission was started

Abbreviations: SD: Standard Deviation; n: Number; ISS: Injury Severity Score; CCI: Charlson Comorbidity Index; IQR: Interquartile Range

All variables assessed using univariate comparisons were then assessed using multivariable logistic regression, with the outcome variable of discharge status (dead or alive). The results of these analyses can be found in Table 3. After adjusting for all other variables in the model, therapeutic anticoagulation at the time of presentation was associated with a significant increase in the odds of dying after trauma requiring admission to the ICU (OR 3.55, 95% CI 1.74, 7.24). Similarly, every 10-year increase in age was found to be associated with a 97% increase in the odds of dying (OR for 10 year increase in age 1.97, 95% CI 1.33, 2.92), and every 10 point increase in ISS was found to be associated with a 67% increase in the odds of dying (OR 1.67, 95% CI 1.29, 2.15).
Of the 194 patients who survived to hospital discharge, only 44 (23%) were discharged home. The remaining patients were discharged to either another acute care facility (n = 92, 47%) or a chronic care facility (n = 59, 30%).

**DISCUSSION**

This study assessed the outcomes of elderly patients sustaining trauma who required admission to the intensive care unit. Overall mortality was found to be higher than previously reported in the literature examining the outcomes after elderly trauma in general. Advanced age, increasing injury severity, and elevated INR were all found to be independent predictors of mortality. Finally, amongst survivors, less than one quarter of patients was discharged home, with the majority of patients discharged to another health care facility. The results of this study have important implications as the elderly trauma population grows.

The majority of studies on elderly trauma patients have included all elderly trauma patients, and we propose that relying on estimates from studies assessing all elderly trauma patients may be misleading. Gowing and Jain [2] reviewed 125 elderly trauma patients with an ISS > 12 assessed at a Canadian institution, only 14 of whom required ICU admission. The in-hospital mortality rate for this population was 26%, and 33% of patients were discharged home. Similarly, Richmond et al described outcomes of over 38,000 elderly trauma patients requiring ICU admission, surgical intervention or who had a length of stay after trauma of greater than 72 hours using data from the Pennsylvania state trauma registry [6]. They described a 10% mortality, and amongst survivors, a greater than 50% rate of discharge home. Finally, Ferreira and colleagues prospectively assessed 239 trauma patients, and found 81% returned to a functional level or back to baseline [10]. Studies such as these have been used to argue for aggressive treatment in elderly trauma patients. However, our results suggest that this may not be the case. Miller and colleagues assessed 115 trauma patients requiring prolonged ICU stay to determine functional outcomes at 3 months post-discharge [15]. In line with our results, amongst the 24 patients over the age of 75, 14 survived to hospital discharge, and of these, only 2 were discharged home. Our results showed that less than one-quarter of patients were discharged home. It is important to convey to decision makers not only prognosis with respect to mortality, but also data such as these, which highlight the potentially significant morbidity and loss of prior independence.

It is impossible to analyze these results without acknowledging that over two-thirds of our cohort died after transition from life-sustaining therapy to a focus on compassionate care. Though an understanding of the exact circumstances surrounding the decision to transition to compassionate care is beyond the scope of this retrospective study, it is important to acknowledge that there is some subjectivity in many of these decisions. It is a widely-held philosophy in our institution to engage substitute decision makers early in the hospital course of critically ill and injured patients, and to facilitate discussion surrounding the patient’s known prior wishes and best interests. To help inform this discussion, information is provided from a multidisciplinary team, with respect to prognosis, as early as possible. This strategy is designed to empower the patient through the substitute decision makers, and likely has some impact on the outcomes of our elderly trauma patients admitted to the ICU.

As a secondary objective, the importance of pre-injury coagulopathy in elderly patients was confirmed in this study. Oral anticoagulant therapy is used in many comorbid conditions affecting elderly trauma patients. The literature surrounding pre-injury anticoagulation use in trauma patients has so far demonstrated mixed results. Wojcik and colleagues retrospectively reviewed 2942 trauma patients, of which 1916 patients had pre-injury condition of anticoagulant therapy [16]. Their results demonstrated no difference in mortality between patients who did and did not receive anticoagulant therapy. Similarly, Fortuna and colleagues retrospectively assessed 416 patients with hemorrhagic brain injury and found no increased mortality amongst the 40% of patients in their cohort receiving pre-injury warfarin, clopidogrel, or aspirin [17]. In contrast, Franko and colleagues retrospectively reviewed adult 1493 patients with traumatic brain injury, of which 159 were anticoagulated with warfarin at the time of trauma [18]. The mortality amongst warfarin-anticoagulated patients was 6 times higher than that of non-anticoagulated patients (23.9% vs 4.9%). The therapeutic effect of warfarin, as measured by an elevation in the INR, is likely the mechanism of effect of any observed mortality increase. It is estimated that up to 40% of patients taking warfarin have sub-therapeutic anticoagulation, as measured by INR [19], and therefore we would argue that therapeutic INR should be assessed instead of just warfarin use. Pieracci and colleagues assessed this in 225 elderly trauma patients admitted to a Level I trauma centre [20]. Of the 40 warfarin users identified, only 22 (55%) had therapeutic INR (INR ≥ 2) at the time of their trauma, and an odds ratio for mortality of 4.48 was found for those with therapeutic INR. Similarly, Williams and colleagues retrospectively assessed 3242 trauma patients over 50 years of age, of which an INR on admission was obtained in 1251 patients, and was found to be elevated (> 1.5) in 102 patients [21]. Regression analysis demonstrated an age and ISS adjusted odds ratio of death of 2.5 for patients with an elevated INR, and the authors argue that INR should therefore be assessed early in all elderly patients presenting after trauma. In the current study, we used INR as a marker, and found anticoagulation to be an independent risk factor for mortality. These results highlight the need to address this early in trauma management, and suggest a potential avenue for mortality reduction worthy of further investigation.

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**Table 3:** Results of multivariable logistic regression for the 297 patients admitted from 1999 - 2008.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds ratio</th>
<th>95% CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in years</td>
<td>1.07</td>
<td>1.03, 1.11</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Male gender</td>
<td>1.04</td>
<td>0.61, 1.77</td>
<td>0.88</td>
</tr>
<tr>
<td>ISS</td>
<td>1.05</td>
<td>1.03, 1.08</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>CCI Score</td>
<td>0.98</td>
<td>0.86, 1.10</td>
<td>0.71</td>
</tr>
<tr>
<td>Anticoagulation</td>
<td>3.55</td>
<td>1.74, 7.24</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

**Abbreviations:** ISS: Injury Severity Score; CCI: Charleson Comorbidity Index
This study is limited by its retrospective nature. In assessing for pre-injury anticoagulation, we relied on the surrogate marker of elevated INR, which may not be accurate in all cases. Further, we were unable to identify the contribution of additional medications the patients were prescribed or taking at the time of trauma, which may have an additional impact on outcome. We attempted to control for the baseline health status of the patient using the previously validated CCI, however this relies on only the comorbidities that are coded in the trauma database. While regular audits of the validity of our trauma database are preformed, and our coding is accurate, the data are limited to what is recorded. Finally, we are unable to provide insight into what happened to patients once they were discharged from LHSC, and it is possible that some patients discharged to another hospital eventually returned home indepently.

We believe the results of this study have important implications as the elderly trauma population grows and as we are increasingly relied upon to assist families in decision making for their previously high-functioning elders. This study demonstrates that the mortality rate amongst the most severely injured elderly trauma patients admitted to the ICU is higher than previously reported in the literature, and even amongst those surviving trauma, discharge home is rare. Further research may focus on strategies to reduce mortality, such as early and aggressive management of therapeutic anticoagulation. The importance of informed discussions conveying the relatively poor prognosis for elderly trauma patients admitted to the ICU must not be overlooked.

REFERENCES


