Patterns of Injury, Outcomes, and Predictors of In-Hospital and 1-Year Mortality in Nonagenarian and Centenarian Trauma Patients

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**IMPORTANCE** With the dramatic growth in the very old population and their concomitant heightened exposure to traumatic injury, the trauma burden among this patient population is estimated to be exponentially increasing.

**OBJECTIVE** To determine the clinical outcomes and predictors of in-hospital and 1-year mortality in nonagenarian and centenarian trauma patients (NCTPs).

**DESIGN, SETTING, AND PARTICIPANTS** All patients 90 years or older admitted to a level 1 academic trauma center between January 1, 2006, and December 31, 2010, with a primary diagnosis of trauma were included. Standard trauma registry data variables were supplemented by systematic medical record review. Cumulative mortality rates at 1, 3, 6, and 12 months after discharge were investigated using the Social Security Death Index. Univariate and multivariable analyses were performed to identify the predictors of in-hospital and 1-year postdischarge cumulative mortalities.

**MAIN OUTCOMES AND MEASURES** Length of hospital stay, in-hospital mortality, and cumulative mortalities at 1, 3, 6, and 12 months after discharge.

**RESULTS** Four hundred seventy-four NCTPs were included; 71.7% were female, and a fall was the predominant mechanism of injury (96.4%). The mean patient age was 93 years, the mean Injury Severity Score was 12, and the mean number of comorbidities per patient was 4.4. The in-hospital mortality was 9.5% but cumulatively escalated at 1, 3, 6, and 12 months after discharge to 18.5%, 26.4%, 31.3%, and 40.5%, respectively. Independent predictors of in-hospital mortality were the Injury Severity Score (odds ratio [OR], 1.09; 95% CI, 1.02-1.16; \(P = .01\)), mechanical ventilation (OR, 6.23; 95% CI, 1.42-27.27; \(P = .02\)), and cervical spine injury (OR, 4.37; 95% CI, 1.41-13.50; \(P = .01\)). Independent predictors of cumulative 1-year mortality were head injury (OR, 2.65; 95% CI, 1.24-5.67; \(P = .03\)) and length of hospital stay (OR, 1.06; 95% CI, 1.02-1.11; \(P = .005\)). Cumulative 1-year mortality in NCTPs with a head injury was 51.1% and increased to 73.2% if the Injury Severity Score was 25 or higher and to 78.7% if mechanical ventilation was required. Most NCTPs required rehabilitation; only 8.9% were discharged to home.

**CONCLUSIONS AND RELEVANCE** Despite low in-hospital mortality, the cumulative mortality rate among NCTPs at 1 year after discharge is significant, particularly in the presence of head injury, spine injury, mechanical ventilation, high injury severity, or prolonged length of hospital stay. These considerations can help guide clinical decisions and family discussions.

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he Department of Health and Human Services’ Administration on Aging estimates that the number of individuals 85 years or older will increase from 5.8 million in 2010 to 8.7 million in 2030, with this number expected by 2050 to reach 19 million.1 According to the 2010 US Census Bureau data, more than 1.87 million adults are 90 years or older, representing a 29% increase from 2000, when the number was 1.45 million.2 The incidence of nonfatal injuries increased from 14 549 per 100 000 in 2001 to 17 485 per 100 000 in 2010 among this patient population.3 With the dramatic growth in the very old population and their concomitant heightened exposure to traumatic injury, the trauma burden among this patient population is estimated to be exponentially increasing.

In the overall geriatric trauma population, the reported in-hospital mortality ranges from 10%4 to as high as 33%,3 depending on several factors. Such predictors of mortality include preexisting conditions or comorbidities,6 mechanism and severity of injury,5 Glasgow Coma Scale score,7 and postinjury complications.8,9 The Eastern Association for the Surgery of Trauma,10,11 after an extensive review of studies on geriatric trauma published between 1966 and 2008, suggested the following: (1) advanced age by itself is not an absolute indicator of poor outcomes after trauma and should not be the only criterion for limiting or denying care; (2) in the very old trauma patient, the presence of multiple comorbidities is not necessarily an indicator of poor outcome; and (3) with the exception of the moribund geriatric trauma patients, the initial treatment approach should be aggressive because most of these patients will eventually return home.

While few studies (and resultant guidelines) examine mortality and outcomes in the trauma patient older than 65 years, as discussed above, scant data evaluate the patterns, mechanisms, and outcomes of injury specifically in nonagenarian and centenarian trauma patients (NCTPs).12-13 Furthermore, few investigations have examined postdischarge mortality among trauma patients in general, particularly for elderly trauma patients. Evaluating postdischarge mortality will reflect more accurately the effectiveness of trauma care in this patient population.

In this study, we sought to determine the patterns, mechanisms, and predictors of clinical outcomes of traumatic injury in NCTPs. A particular focus was on the in-hospital mortality and cumulative mortality at 1 year after discharge.

Methods

Patient Population

The Partners Human Research Committee at the Massachusetts General Hospital approved this study. A waiver of informed consent was granted. The Trauma Registry of the Massachusetts General Hospital, a level I American College of Surgeons-verified academic trauma center, was queried for all trauma patients 90 years or older for any primary International Classification of Diseases, Ninth Revision, diagnosis of trauma between January 1, 2006, and December 31, 2010.

Data Variables

The Trauma Registry data were supplemented by a retrospective medical record review. Collected variables included patient-related data (age, sex, race/ethnicity, baseline comorbidities, and insurance type), injury-related data (cause and mechanism of injury, Injury Severity Score [ISS], and primary diagnosis by anatomic distribution), and process-related or outcome-related data (length of hospital stay, requirement of intensive care unit [ICU] admission, need for mechanical ventilation, in-hospital complications, and in-hospital mortality). Our main outcome was in-hospital and postdischarge mortality.

Mortality After Discharge

Mortality data at 1, 3, 6, and 12 months after the index hospitalization were abstracted from a hospital-based Research Patient Data Registry. The Research Patient Data Registry derives mortality data from hospital records and from the Social Security Death Index and reports vital status as deceased, deferred, living, or not recorded. The Social Security Death Index is a robust database containing death records of persons who have been issued a Social Security number by the US Social Security Administration. We defined cumulative mortality as the in-hospital mortality plus postdischarge mortality at the specific time point in question (ie, 1, 3, 6, or 12 months). Postdischarge mortality refers to mortality after discharge, not including the in-hospital mortality, and applies only to those who survived the index hospitalization.

Data Analysis

Survivors and nonsurvivors at 1 year after discharge were compared. Categorical variables were described using proportions, while continuous variables were expressed as summary statistics. The t test or the Mann-Whitney test was used, as appropriate, to compare continuous variables, whereas the χ2 test and the Fisher exact test were used to compare proportions. Univariate and multivariable analyses were performed to identify the predictors of in-hospital and cumulative 1-year mortality. All statistical analyses were performed with a software program (SPSS Statistics 20; IBM).

Results

In total, 474 NCTPs were included in the study, with a mean (SD) age of 93 (3) years. Table 1 summarizes the demographics, comorbidities, insurance type, mechanism of injury, ISS, length of hospital stay, and discharge disposition of all patients. Among them, 71.7% were female, 94.9% were of white race/ethnicity, and 85.7% were covered by Medicare. The mean (SD) number of comorbidities per patient was 4.4 (2.7), with the most common being heart disease (50.2%), hypertension (34.8%), and neurologic disease (28.3%). Almost all patients had experienced blunt trauma rather than penetrating trauma (99.4% vs 0.6%), and the most common mechanism of injury was a fall (96.4%). Lower limb injuries (44.3%), head injuries (29.3%), and cervical spine injuries (7.2%) were the most common primary diagnoses.
The mean (SD) ISS for the study population was 12 (8); 46.8% had an ISS of 25 or higher. Sixteen percent of patients were admitted to the ICU, but only 7.4% required mechanical ventilation. The mean (SD) length of hospital stay was 7 (5) days.

### In-Hospital and Cumulative 1-Year Mortality

The in-hospital mortality was 9.5%. Cumulative mortality rates at 1, 3, 6, and 12 months after discharge were 18.5%, 26.4%, 31.3%, and 40.5%, respectively (Figure). Survivors and nonsurvivors at 1 year after discharge were similar in age, sex, race/ethnicity, insurance type, admission source, and mechanism of injury (Table 2). However, nonsurvivors had a higher ISS, a longer ICU stay, and a prolonged period of mechanical ventilation.

### Predictors of In-Hospital Mortality

No association was found between any of the comorbidities and in-hospital mortality. Independent predictors of in-hospital mortality were ISS, mechanical ventilation, and cervical spine injury (Table 3). For patients with cervical spine injury, in-hospital mortality was 26.6%. For those with an ISS of less than 15, in-hospital mortality was 5.5% but increased to 34.5% for patients with an ISS of 25 or higher.

### Predictors of 1-Year Mortality

No association was observed between any of the comorbidities and cumulative 1-year mortality. Independent predictors...
of cumulative 1-year mortality were head injury and length of hospital stay (Table 3). The NCTPs having head injuries were almost 3 times as likely to die by 1 year compared with the NCTPs not having head injuries. Forevery additional day in the hospital, cumulative 1-year mortality increased by 6.0%. Cumulative 1-year mortality in all patients with a head injury was 51.1% but increased to 73.2% if the ISS was 25 or higher and to 78.7% if mechanical ventilation was required.

Table 4 summarizes cumulative 1-year mortality with different combinations of injury, ISS, ICU admission, and mechanical ventilation.

Discharge Disposition and Mortality
Of all admitted patients, only 8.9% were discharged to home, with 57.6% discharged to rehabilitation facilities, 22.6% to other post–acute-care skilled nursing facilities, and 1.3% to hospice. Postdischarge mortality at 1 year varied by discharge disposition (Table 5) and was 23.8% for patients discharged to home, 26.0% for patients discharged to a rehabilitation facility, 45.2% for patients discharged to a skilled nursing facility (SNF), and 100.0% for patients discharged to hospice. Table 6 lists the mortality rates of patients discharged to a rehabilita-

Discussion
In-Hospital and 1-Year Mortality Rates
The in-hospital mortality rate of the NCTP population was 9.5%, a significantly higher rate than the 2.5% and 6.8% rates previously reported by Sieling et al12 and Dangleben et al,13 re-
Discharge Disposition and Quality of Postdischarge Care

Our study also provides insight into the discharge dispositions and their correlation with cumulative mortality. Less than 10% of NCTPs were discharged to home, with the rest going to rehabilitation or post-acute-care skilled nursing facilities. Most important, the difference in cumulative 1-year mortality between rehabilitation patients (26.0%) and SNF patients (45.2%) is striking and a legitimate cause for concern. After stratifying for ISS, mortality was still markedly higher among SNF patients compared with rehabilitation patients. This raises the question of whether patients discharged to these 2 facilities received markedly different quality of care and whether this difference in post-acute-care quality can contribute to increased mortality in one group. Davidson et al15 found that trauma patients of all ages who were discharged to a SNF had a significantly higher cumulative postdischarge mortality compared with those who were discharged to a rehabilitation facility at 1 year (18.7% vs 5.5%) and at 3 years (34.0% vs 12.0%). In that study, mortality was also higher among trauma patients discharged to SNFs compared with those discharged to home at 1 year (18.7% vs 1.7%) and at 3 years (34.0% vs 4.0%). This study was criticized by others who claimed that discharge to an SNF rather than a rehabilitation facility or home may be due to factors such as old age, severe primary injury, or less severe injury but more complex medical management.16 Our data dispute these claims: even among the most elderly patients and after controlling for ISS, we showed that patients discharged to SNFs still had a much higher cumulative 1-year mortality. Further evaluation of the variation in quality of postdischarge care among trauma patients, including NCTPs, is warranted.

Limitations

Our findings are limited by the retrospective design of this single-institution study. The patient population was heterogeneous in terms of severity of injury. The causes of mortality and the reasons for choosing one discharge disposition vs another could not be deciphered retrospectively. Most important, we were unable to study postdischarge meaningful survival, quality of life, or the functional outcome of the discharged NCTPs.

Conclusions

Our study results suggest that NCTPs show a misleadingly low mortality rate in the hospital, which increases by more than 4-fold by the end of the year following discharge. Cervical spine injury, head injury, ICU admission, mechanical ventilation, high ISS, and prolonged length of hospital stay place NCTPs at high risk of in-hospital or postdischarge death within 1 year. Discharge to home is unlikely. One-year mortality is worse among NCTPs discharged to SNFs than among NCTPs discharged to rehabilitation facilities. These findings offer a realistic picture of the outcomes following injury in the extremes of age and help physicians set appropriate goals and engage in meaningful discussions with families about ultimate expectations.

### Table 6. One-Year Postdischarge Mortality for Rehabilitation Facility and Skilled Nursing Facility Patients, Stratified by Injury Severity Score

<table>
<thead>
<tr>
<th>Injury Severity Score</th>
<th>Rehabilitation Facility Mortality, No./Total No. (%)</th>
<th>Skilled Nursing Facility Mortality, No./Total No. (%)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;9</td>
<td>8/41 (19.5)</td>
<td>6/11 (54.5)</td>
<td>.001</td>
</tr>
<tr>
<td>9-14</td>
<td>47/176 (26.4)</td>
<td>21/50 (42.0)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>15-24</td>
<td>7/32 (21.9)</td>
<td>7/19 (36.8)</td>
<td>.001</td>
</tr>
<tr>
<td>≥25</td>
<td>8/18 (44.4)</td>
<td>8/13 (61.5)</td>
<td>.86</td>
</tr>
</tbody>
</table>

While ISS, mechanical ventilation, and cervical spine injury increased the odds of in-hospital mortality, the predictors of cumulative mortality at 1 year were head injury and length of hospital stay. Table 4 summarizes the chances of survival among NCTPs at 1 year after discharge. For example, an NCTP with a combination of a cervical spine injury and ICU admission or a cervical spine injury and mechanical ventilation would have a likelihood of 100.0% to die within the first year from injury. For those with a combination of a head injury and mechanical ventilation or a head injury and an ISS exceeding 25, cumulative 1-year mortality was 78.7% and 73.2%, respectively. While recognizing and appreciating the limitations of this retrospective study and the unique circumstances of each NCTP, the trauma surgeon or intensivist can use Table 4 as a summary guideline to set reasonable long-term expectations with the patient and the family.
ARTICLE INFORMATION

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Study concept and design: All authors.
Acquisition, analysis, or interpretation of data: Hwabejire, Kaafarani, King, de Moya, Velmahos.
Drafting of the manuscript: Hwabejire, Kaafarani, Velmahos.
Critical revision of the manuscript for important intellectual content: All authors.
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REFERENCES