Number of rib fractures thresholds independently predict worse outcomes in older patients with blunt trauma

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Background. *There have been conflicting reports regarding whether the number of rib fractures sustained in blunt trauma is associated independently with worse patient outcomes. We sought to investigate this risk-adjusted relationship among the lesser-studied population of older adults.*
Methods. *A retrospective review of the National Trauma Data Bank was performed for patients with blunt trauma who were ≥65 years old and had rib fractures between 2009 and 2012 (*N = *67,695). Control data were collected for age, sex, injury severity score, injury mechanism, 24 comorbidities, and number of rib fractures. Outcome data included hospital mortality, hospital and intensive care unit durations of stay, duration of mechanical ventilation, and the occurrence of pneumonia. Multiple logistic and linear regression analyses were performed.*
Results. *Sustaining ≥5 rib fractures was associated with increased intensive care unit admission (odds ratio: 1.14,* P < *.001) and hospital duration of stay (relative duration: 105%,* P < *.001). Sustaining ≥7 rib fractures was associated with an increased incidence of pneumonia (odds ratio: 1.32,* P < *.001) and intensive care unit duration of stay (relative duration: 122%,* P < *.001). Sustaining ≥8 rib fractures was associated with increased mortality (odds ratio: 1.51,* P < *.001) and duration of mechanical ventilation (relative duration: 117%,* P < *.001).*
Conclusion. *In older patients with trauma, sustaining at least 5 rib fractures is a significant predictor of worse outcomes independent of patient characteristics, comorbidities, and trauma burden. (Surgery 2016;■:■-■.)*

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Blunt thoracic injuries comprise 10–15% of all trauma admission and >25% of all trauma-related fatalities.[1] More than 20% of patients with blunt trauma are diagnosed with rib fractures and subsequently are at increased risk for substantial morbidity, mortality, and decreased long-term quality of life.[2] In the care of these patients, the identification of those at high risk for poor outcomes is of critical importance for appropriate early intervention and supportive measures. For more than a decade, it has been debated in the literature whether the number of rib fractures sustained could serve as a useful prognostic tool in the management of blunt trauma patients.[3] Nevertheless, a consistent conclusion on the impact of the number of rib fractures on patient outcomes has yet been reached. For example, a 2005 article by Flagel et al[4] reported an increase in mortality of 5.8–10% for each additional rib fracture in adult trauma patients. In contrast, a 2002–2006 retrospective review by Whitson et al[5] concluded that the number of rib fractures sustained was not an independent predictor of mortality in all blunt trauma patients.

Furthermore, the majority of research regarding the number of rib fractures on patient

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outcomes has been focused primarily on all-ages adult populations with only a few investigations focused on patients >64 years of age. A landmark report in 2000 by Bulger et al[6] reviewed 277 elderly patients and found a 19% increase in mortality with each additional rib fracture when compared with younger controls. In 2003, Bergeron et al[7] examined 113 elderly patients and reported significant increases in mortality when sustaining ≥3 rib fractures. To date, studies assessing the number of rib fractures among older patients have been lacking in quantity, sample size, and contemporaneity. Moreover, there has been a paucity of studies controlling for the multitude of patient characteristics and comorbidities known to have significant and considerable effects on this venerable population's hospital outcomes.

To address these gaps in the literature, we designed a comprehensive study using a large national sample of patients in order to characterize the influence of the number of rib fractures on hospital outcomes. The principal aim of this study was to determine whether the number of rib fractures sustained by blunt trauma patients >64 years old was independently associated with worse hospital outcomes when rigorously controlling for other patient factors, comorbidities, and trauma burden.

METHODS

Data collection. After exemption by our institutional review board, patient data were obtained from the National Trauma Data Bank (NTDB)[8] with permission from the American College of Surgeons' Committee on Trauma. The NTDB is the largest aggregation of prospectively collected trauma registry data available in the United States and contains information on >6 million trauma cases from >740 facilities.

The NTDB was queried for all patients ≥65 years old with a diagnosis of rib fracture between 2009 and 2012. The presence and number of ribs fractured was determined by *International Classification of Diseases, Ninth Revision* (ICD-9) codes 807.00 through 807.19. Patients with rib fracture codes which did not include information regarding the exact number of ribs fractured (ICD-9: 807.00, 807.09, 807.10, and 807.19) were excluded. Additionally, those who had concomitant sternal fractures (ICD-9: 807.2 and 807.3), those who were not admitted to the hospital, and those who had nonblunt causes of injury (ie, burn or penetrating) were excluded from analysis.

Additional data collected on patient characteristics included age, sex, 24 different comorbidities, Injury Severity Score (ISS), mechanism of injury (MOI), the presence of at least 1 open rib fracture (ICD-9: 807.1X), and the presence of flail chest (ICD-9: 807.4). Given the fact that comorbidities assessed by the NTDB vary from year to year, only those with data available for all 4 years of the study were included. MOIs were characterized by ICD-9 E-codes and categorized into groups consisting of the 6 largest MOI modes: accidental falls (E880–E888), motor vehicle collisions (E810–E825, post-dot 0 or 1), motorcycle collisions (E810–E825, post-dot 2 or 3), pedestrian injuries (E810–E825, post-dot 6 or 7), mechanical or striking accidents (E916–E919), assaults (E960, E965–968), and a group consisting of all other MOI E-codes.

Primary and secondary outcome measures. Primary outcome data consisted of in-hospital mortality. Secondary outcome data consisted of hospital length of stay (LOS), intensive care unit (ICU) admission and LOS, the need for and duration of mechanical ventilation, and the occurrence of a pneumonia complication.

Statistical analysis. The number of rib fractures sustained was modeled as an ordinal variable with groups of 1, 2, 3, 4, 5, 6, 7, or ≥8 rib fractures. To avoid misinterpretations secondary to continuous modeling,[9] ISS was categorized as an ordinal variable with score groupings of 1–9, 10–16, and 17–75. MOI was modeled as a nominal variable. All other patient factors and comorbidities aside from age were modeled as binary values. All outcomes were considered dichotomous, except for hospital LOS, ICU LOS, and duration of mechanical ventilation, which were modeled as continuous and log-transformed for analysis.

Descriptive statistics were reported for continuous variables, and proportions were reported for categorical variables. Logistic regression analysis was utilized for dichotomous outcomes, and log-transformed linear regression analysis was utilized for continuous outcomes. Univariate analyses were performed with all patient characteristic and outcome pairs in order to identify significant factors ($\alpha < .1$) for inclusion in each respective multiple regression model. Bivariate correlations were calculated between all patient characteristics and identified no meaningful interactions ($P < .05$ and $R^2 > 0.4$) which would have interfered with multiple regression model interpretation. Multiple regression analysis was performed for each outcome including its respective significant patient factors. Statistical significance was defined as $P < .05$. Due to the low prevalence of a few predictor-outcome combinations, some patient