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Sternal fracture—an analysis of the National Trauma Data Bank

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ABSTRACT

Background: The clinical significance of sternal fractures (SFs) after blunt trauma is heavily debated. We aimed to test the hypothesis that isolated SF is not associated with significant morbidity or mortality.

Materials and methods: The National Trauma Data Bank (NTDB) sets for 2007–2010 were retrospectively examined. Adult subjects with SF were identified by *International Classification of Diseases, Ninth Revision, Clinical Modification* diagnostic codes. Data collected included demographics, mechanisms of injury, clinical variables, and in-hospital mortality. The primary outcome measure was in-hospital mortality. Secondary outcome measures included hospital length of stay, intensive care unit days, and ventilator days.

Results: A total of 32,746 subjects with SF were included. Motor vehicle crash (MVC) was the most common mechanism (84%) in this group and SF was present in 3.7% of all patients admitted after MVC. The mean age was 51 y, 66% were males, and most were white (74%). Overall in-hospital mortality was 8.8% and mortality with isolated SF was 3.5%. Increasing thoracic fracture burden (rib fracture, clavicular fracture, and scapular fracture) was associated with increasing hospital length of stay, intensive care unit days, ventilator days, and mortality. On multivariate regression analysis, other significant predictors of mortality were cardiac arrest, acute respiratory distress syndrome, pulmonary embolism, blunt cardiac injury, pulmonary contusion, increasing age, and lack of insurance.

Conclusions: SFs occur in 3.7% of victims after MVC. With isolated SF, the mortality rate is low (3.5%); the tendency for poorer outcomes is most heavily influenced by associated injuries (pulmonary contusions, other thoracic fractures), complications (cardiac arrest, pulmonary embolism, acute respiratory distress syndrome), comorbidities (currently on or requiring dialysis, residual neurologic deficit from stroke), and lack of insurance.

1. Introduction

Sternal fracture (SF) has been reported to be present in up to 8% of admissions after blunt thoracic trauma and motor vehicle crashes (MVCs) [1,2]. Before widespread seat belt use, SF was considered to be a marker of high-energy trauma. In recent decades, mandatory seat belt laws have resulted in increased survival from MVC, with a concomitant sharp rise in

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the incidence of SF, so much so that it has been termed the typical "seat belt injury" [3].

The clinical significance of an isolated SF has been debated in the literature. Some contend that it should be respected as a marker of significant force transfer and that more serious occult injuries should be actively sought while the patient is admitted for close monitoring [1,4]. Others, however, believe that SF *ipso facto* has no influence on outcome and hospital admission for isolated SF is unnecessary [5,6]. Many believe that the morbidity is attributable to the presence of other associated injuries rather than the SF alone [6–11]. Previous studies have been mostly limited to single institutions and thus, the relatively small sample sizes preclude robust statistical analysis.

The National Trauma Data Bank (NTDB) is the largest aggregation of trauma registry data ever assembled, with over 5 million records from 744 facilities. The NTDB is sponsored and maintained by the American College of Surgeons Committee on Trauma and has been used extensively for academic research, education, and resource allocation [12].

We hypothesized that the morbidity associated with SF is due mostly to other accompanying injuries and that isolated SF is not associated with significant morbidity or mortality. Our aim was to use a large research database to evaluate the significance of SF as it relates to outcome and analyze factors that may contribute to adverse outcome.

2. Materials and methods

2.1. Patient selection and study design

The NTDB Research Data Sets for the years 20072010 were retrospectively examined. All subjects aged 18 y and above with an SF were identified using the *International Classification of Diseases, Ninth Revision, Clinical Modification* diagnostic codes 807.2 (closed SF) and 807.3 (open SF). Associated blunt cardiac injury (BCI) was identified with the *International Classification of Diseases, Ninth Revision, Clinical Modification* code 861.01, whereas pulmonary contusion was identified with the codes 861.21 and 861.31. Scapular, clavicular, and rib fractures were also determined using the appropriate codes. Data collected included demographics (age, gender, race, insurance type), mechanisms of injury, mode of transportation, clinical variables, (Glasgow Coma Scale scores, vital signs, Injury Severity Score [ISS], baseline comorbid conditions, in-hospital complications, associated injuries), and in-hospital mortality. For the purposes of our analysis, "isolated SF" was defined as SF being the only thoracic injury, including soft tissue injuries such as pulmonary contusions. "SF" was defined as sternal fracture being the only thoracic fracture, but soft tissue injuries were present.

2.2. Outcome measures

The primary outcome measure was in-hospital mortality. Secondary outcome measures included hospital length of stay (LOS), time spent in the intensive care unit (ICU) days, and the duration of mechanical ventilation (ventilation days).

2.3. Statistical analysis

Continuous variables were described with summary statistics, whereas categorical variables were described with proportions. The Student *t*-test or the Mann-Whitney *U*-test as appropriate was used to test for statistically significant differences between continuous variables, whereas the chi-square test or Fisher exact test was used for categorical variables. To determine predictors of mortality, univariate and multivariate analyses were performed. In the univariate analysis, correlation between mortality and the following variables were tested: age, gender, race, insurance type, ISS, hospital LOS, ICU LOS, ventilation days, systolic blood pressure <90 mm Hg, total Glasgow Coma Score <8, pulmonary contusion, cardiac contusion, rib fracture, clavicular fracture, scapular fracture, cardiac arrest, acute respiratory distress syndrome (ARDS), myocardial infarction, pulmonary embolization, unplanned intubation, and comorbidities, including but not limited to congestive heart failure, hypertension requiring medication, history of angina within the past 1 mo, history of myocardial infarction within the past 1 mo, and history of revascularization within the past 1 mo. Variables that were significantly correlated with mortality were then entered into the multivariate model. Statistical significance was defined as $P<0.05$. The SPSS statistics for windows, version 17.0 (SPSS Inc, Chicago, IL) was used to perform all analysis. The study was approved by our Institutional Review Board.

3. Results

A total of 32,746 subjects were included in the study. Table 1 shows the demographic and clinical characteristics of subjects. The mean age was 51 y, 66% were males, and most were white (74%). The most common insurance type was Private or Commercial (22%), followed by Medicare (13%), and Self-pay (13%). About 57% of patients were transported to the hospital by ground ambulance, with helicopter ambulance, the next most frequent mode of transport (21%). MVC (84%) was the most common mechanism of injury, followed by falls (8%) and assault (2%). Other mechanisms accounted for the remaining 6% of cases. Of all patients in the NTDB over the 4 y studied (20072010) with MVC as mechanism of injury ($n = 782,685$), SF was present in 3.7% (29,103/782,685). SF was evenly distributed among all severity groups of ISS.

The median ISS was 14. A total of 9659 subjects (29.5%) had associated pulmonary contusion and 1270 (3.9%) had BCI. The mean hospital LOS, ICU days, and ventilator days were 10 ± 13, 5 ± 9, and 4 ± 8, respectively. Overall, in-hospital mortality was 8.8% (2898/32,746). Isolated SF (i.e., no other injuries) was associated with a mortality rate of 3.5% (253/7265). Table 2 demonstrates that although increasing thoracic fracture burden was associated with increased incidence of pulmonary contusion, there was no significant association with the incidence of BCI.

As expected, a greater burden of thoracic injury was associated with a higher mortality, and certain injuries contributed disproportionately (Fig. 1). The presence of one or both of pulmonary contusion and BCI significantly increased