A chest trauma scoring system to predict outcomes

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Background. *Rib fractures (RIBFX) are a common injury and are associated with substantial morbidity and mortality. Using a previously published RIBFX scoring system, we sought to validate the system by applying it to a larger patient population. We hypothesized that the RIBFX scoring system reliably predicts morbidity and mortality in patients with chest wall injury at the time of initial evaluation.*
Methods. *A 3-year, registry-based, retrospective study involving 1,361 trauma patients was performed. Patients were divided into two groups with a Chest Trauma Score (CTS) < 5 and ≥5 (n = 724 and 637, respectively). Each cohort was analyzed for specific outcomes (mortality, pneumonia, acute respiratory failure). CTS was defined by age, severity of pulmonary contusion, number of RIBFX, and the presence of bilateral RIBFX with a maximum score of 12. Receiver operating characteristics were used to determine the use of CTS ≥5 cut point.*
Results. *Patients with a CTS of 5 or more were (P ≤ .05) older (61 vs 50 years), had greater Injury Severity Scores (21.6 vs 16.2), and had a greater prevalence of pneumonia (10.1 vs 3.5%), tracheostomy (7.4 vs 2.9%), and mortality (9.0 vs 2.2%). Patients with CTS ≥ 5 had nearly 4-fold increased odds of mortality (odds ratio 3.99, 95% confidence interval 1.92–8.31, P = .001) compared with those who had CTS < 5.*
Conclusion. *A CTS of at least 5 is associated with worse patient outcomes. Increased vigilance is needed with trauma patients who present with RIBFX and a CTS ≥ 5 at initial presentation. This simple RIBFX scoring system may improve early identification of vulnerable patients and expedite therapeutic interventions. (Surgery 2014;156:988-94.)*

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RIB FRACTURES (RIBFX) are a common problem in blunt trauma, with 10% of injured patients sustaining RIBFX.[1] Factors associated with increased morbidity and mortality from RIBFX are varied and include age, number of RIBFX, and the development of pneumonia. Pre-existing conditions such as congestive heart failure and renal and liver dysfunction have also been found to be associated with poorer outcomes.[2,3] Interventions to implement protocols for elderly trauma victims with RIBFX reported improved outcomes and decreased hospital length of stay.[4] Several chest trauma scoring systems have been published to identify at risk patients, but these systems have been evaluated in small volume patient cohorts.[5] The rationale for this study is to develop and eventually to use a chest trauma scoring system that is easy to calculate by a medical provider so medical decisions and or interventions can be made in an expedited fashion.

This work uses a RIBFX scoring system that was previously published by Pressley et al,[6] and we sought to validate that chest trauma scoring system in a larger dataset. The Chest Trauma Score (CTS) was derived from several factors identified previously to be associated with worse outcomes, including age, number of RIBFX, pulmonary contusions, and bilaterality of injury.[6] We hypothesized that a CTS system may be used to predict outcomes in blunt trauma patients with RIBFX.

METHODS

With institutional review board approval, we used trauma registry data to identify 1,361 patients with blunt torso trauma from a single busy Level 1 Trauma Center during a 3-year period (2009–2011). A CTS

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was calculated for each of the individual cohorts. The CTS is composed of four different components with a point system assigned: age (<45 years = 1, 45–65 = 2, >65 = 3); pulmonary contusion (none = 0, unilateral minor = 1, bilateral minor = 2, unilateral major = 3, bilateral major = 4); number of RIBFX (<3 = 1, 3–5 = 2, >5 = 3); and the presence of bilateral RIBFX = 2. The CTS ranges from 2 to 12 (Table I).

Computed tomography (CT) images were reviewed by the authors (W.F. and J.C.) to assign pulmonary contusion scores and create the individual CTS for each patient in the cohort. Our cohort was then divided into two groups defined by having a CTS ≥ 5, which was similar to the previous study by Pressley et al[6]; however, we further delineated the patient cohort by using different cut points identified with sensitivity and specificity for the CTS with the outcomes being evaluated (mortality, acute pneumonia and respiratory failure). Table II demonstrates the different cut points for the different outcome markers by CTS.

Retrospective trauma registry data were collected for each patient, including: demographics, Injury Severity Score (ISS), abbreviated injury scale for chest (AIS chest), duration of stay, and tracheostomy procedure. Hospital complications included deep-vein thrombosis and pulmonary embolism. Specific patient outcomes were examined for acute respiratory failure (ARF), development of pneumonia, and mortality. Definitions for PNX and ARF are given in the Pennsylvania Trauma Systems Foundation 2011 manual to standardize capture of these entities in the registry. The registry codes are assigned to the definitions to enter these complications into the registry. AIS 98 and 2005 were used to assess rib fractures and pulmonary contusions.

Specific pulmonary complications, such as pneumonia and respiratory failure, were chosen because of the nature of the study involving blunt chest trauma with RIBFX as these carry substantial morbidity.

Standard definitions, from the Pennsylvania Trauma Systems Foundation's 2011 Pennsylvania Trauma Outcomes Study Manual, for these complications were used as follows: Pneumonia required documentation by physical examination of chest pathology as well as presence of sputum, sepsis, or culture. Radiographic documentation of a pulmonary infiltrate or consolidation, and a positive sputum culture was also used to define the presence of pneumonia. ARF was defined as need for ventilator support after a period (>48 hours) of non-assisted breathing or requirement for reintubation.

Univariate analysis was conducted using 2 sample *t* test or Wilcoxon rank sum test for continuous

Table I. Chest scoring system

Age score	
<45 y	1
45–65 y	2
>65 y	3
Pulmonary contusion score	
None	0
Unilateral minor	1
Bilateral minor	2
Unilateral major	3
Bilateral major	4
Rib score	
<3 RIBFX	1
3–5 RIBFX	2
>5 RIBFX	3
Bilateral RIBFX	
No	0
Yes	2

RIBFX, Rib fracture.

variables based on the distribution and chi-square analysis was used for categorical variables. Kaplan-Meier survival analysis and multivariable logistic analysis were performed to determine the association of CTS with mortality, pneumonia, and ARF as separate outcomes. Receiver operating characteristics (ROCs) were used to compare the ISS and CTS for the different outcomes. All tests were two-sided. Stata SE 12 (College Station, TX) was used for analysis.

RESULTS

Overall mortality for the cohort of 1,361 patients was 5.4%. Table III illustrates the % mortality by CTS. Compared with patients who had a CTS < 5, patients with a CTS ≥ 5 were older (61.6 vs 50.1), had greater mortality (9.0 vs 2.2%), greater rate of hospital complications (ie, pneumonia, ARF), tracheostomy, and greater duration of stay (Table IV).

Figure 1 illustrates the Kaplan Meier survival curve for patients with CTS ≥ 5 and < 5 over the course of hospitalization. A CTS ≥ 5 was associated with greater mortality ($P < .001$, test for equality by log rank). ROC curves (Figs 2, 3, and 4) were calculated for the different outcomes separately (mortality, pneumonia, and ARF). Compared with ISS, the CTS appeared to have leas area under the curve for mortality and pneumonia but greater area under the curve for ARF. All three separate outcomes by ISS and CTS, however, were not different by ROC test of equality. When multivariable logistic regression was used, CTS ≥ 5 continued to be an important independent predictor for all three outcomes separately (mortality, pneumonia, and ARF). In contrast, ISS and AIS chest lacked significance for the three outcomes in some of the multivariable regression models (Tables V, VI, and VII).