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Original Contribution

Denver ED Trauma Organ Failure Score outperforms traditional methods of risk stratification in trauma☆,☆☆,★

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ABSTRACT

Background: Early identification of trauma patients at risk for inhospital mortality may facilitate goal-directed resuscitation and secondary triage to improve outcomes. The objective of this study was to compare prognostic accuracies of the Denver Emergency Department (ED) Trauma Organ Failure (TOF) Score, ED Sequential Organ Failure Assessment (SOFA) score, and ED base deficit and ED lactate for inhospital mortality in adult trauma patients.

Methods: Consecutive adult trauma patients from 2005 to 2008 from the Denver Health Trauma Registry were included. Prognostic accuracies of the Denver ED TOF Score, ED SOFA score, ED base deficit, and ED lactate for inhospital mortality were evaluated with receiver operating characteristic curves.

Results: Of the 4355 patients, the median age was 37 years (interquartile range [IQR], 26-51 years), median Injury Severity Score was 9 (IQR, 4-16), and 81% had blunt mechanisms. In addition, 38% (1670 patients) were admitted to the intensive care unit with a median intensive care unit length of stay of 2.5 days (IQR, 1-8 days), and 3% (138 patients) died. The areas under the receiver operating characteristic curves for the Denver ED TOF, ED lactate, ED base deficit, and ED SOFA were 0.94 (95% confidence interval [CI], 0.94-0.96), 0.88 (95% CI, 0.85-0.91), 0.82 (95% CI, 0.78-0.86), and 0.78 (95% CI, 0.73-0.82), respectively.

Conclusions: The Denver ED TOF Score more accurately predicts inhospital mortality in adult trauma patients compared to the ED SOFA score, ED base deficit, or ED lactate. The Denver ED TOF Score may help identify patients early who are at risk for mortality, allowing for targeted resuscitation and secondary triage to improve outcomes

1. Background

Trauma is the leading cause of death in the United States in people 1 to 44 years old and accounts for 41 million emergency department (ED) visits per year [1-3]. Almost 2 million individuals are hospitalized each year due to trauma, and of these, approximately 45 000 patients die before hospital discharge [4,5].

A multitude of tools have been developed in an attempt to accurately predict mortality outcomes in trauma. Commonly used scores to predict mortality outcomes include the Injury Severity Score (ISS), the new ISS, the *International Classification of Diseases*, *Ninth Revision* (*ICD-9*)–based ISS, and the Trauma Mortality Prediction Model [5-9,4,10,11]. Although these scores have demonstrated good predictive abilities for inhospital mortality in adult trauma patients [5-9,4,10-13], in many instances, the scores are not readily available early in the postinjury course due to the calculations necessary to determine the scores [14].

The ability to predict early in the injury course the likelihood of mortality after trauma is important to facilitate secondary triage, focus resuscitative efforts, and guide resource allocation. Several clinical indicators available early in the postinjury course have been determined to be associated with mortality after trauma including the Sequential Organ Failure Assessment (SOFA) score [15-17], base deficit [18-24], and lactate [22,23,19,1,25-31]. However, the predictive ability for these clinical indices for mortality when assessed shortly after injury has been variable [15,26,28,31].

The Denver ED Trauma Organ Failure (TOF) Score, which uses data within 4 hours of injury, has been demonstrated to predict multiple-organ failure in adult trauma patients (Fig. 1) [32]. No data are available on the ability of the Denver ED TOF Score to predict inhospital mortality.

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Predictor	Score
Age ≥ 65 years	1
Emergent intubation§	3
Hematocrit < 20%	2
Hematocrit ≥ 20% and < 35%	1
ED systolic blood pressure < 90 mmHg	1
Blood Urea Nitrogen ≥ 30 mg/dL	1
White Blood Cell count ≥ 20,000 /μL	1

§Emergent intubation defined as intubation in the prehospital setting or in the emergency department.

Fig. 1. Denver ED TOF Score [31].

The objective of this study was to compare the prognostic accuracies of the Denver ED TOF Score, SOFA score, ED base deficit, and ED lactate for inhospital mortality in a heterogeneous adult trauma population.

2. Methods

2.1. Study design and setting

This was a retrospective cohort study from Denver Health Medical Center in Denver, Colorado. Denver Health Medical Center is a 477-bed, urban safety net hospital that houses the Rocky Mountain Regional Level 1 Trauma Center, the only academic level 1 trauma center in Colorado [33]. The ED is the primary receiving facility for all trauma patients and has an approximate annual adult census of 60 000 visits, of which approximately 2000 are included in the trauma registry and approximately 500 of which are classified as major trauma (defined by an ISS >15).

The study was approved by the Colorado Multiple Institutional Review Board.

2.2. Study population

Consecutive trauma patients (≥ 18 years old) who presented to Denver Health Medical Center from January 1, 2005, to December 31, 2008, and who were entered in the trauma registry were included in this study. The trauma registry contains trauma patients who are admitted to the ED observation unit for at least 12 hours, admitted to the hospital, die in the ED, or are transferred from outside hospitals for further trauma care. Patients were excluded from this study if they (1) were younger than 18 years, (2) died in the ED, or (3) were transferred from another hospital.

2.3. Data collection

Patients included in the trauma registry are identified daily from the ED log by a team of personnel specifically trained in the oversight of the trauma registry and in the acquisition of data. Data are systematically abstracted from the patients' medical records and entered into an electronic database. To maintain quality assurance, an internal review of approximately 20% of the trauma registry records is conducted on a regular basis using a standardized institutional protocol. Each review is completed by registry staff members who did not perform the initial abstraction for the patient. Any discrepancies identified in this quality assurance review are presented to the trauma registry committee, and corrections are made through a consensus process.

Clinical data for each patient entered into the trauma registry are abstracted from the medical record. Structured trauma nursing records from the ED are used to obtain the clinical data from the initial evaluation and treatment of the patient. Diagnoses and procedures are entered into the registry database according to *ICD-9* codes.

Data recorded in the trauma registry and obtained for purposes of this study included demographics (age, race, ethnicity, and sex), prehospital care characteristics (paramedic response time, scene time, and transport time), date and time of presentation to the ED, prehospital and ED vital signs within 4 hours of arrival (heart rate, respiratory rate, and systolic blood pressure), prehospital and ED Glasgow Coma Scale (GCS) score within 4 hours of arrival, prehospital and ED intubation or cricothyroidotomy, the Abbreviated Injury Scale for each body region (head, face, neck, chest, abdomen/pelvis, extremities, and skin), ISS, *ICD-9* external cause of injury code, hospitalization characteristics (whether the patient was admitted; admitted to the intensive care unit [ICU] and, if so, the number of ICU days; and survival to hospital discharge), and final diagnoses (*ICD-9* codes).

Laboratory data obtained within 4 hours of arrival were obtained from the hospital's computerized laboratory reporting system (MiSYS Healthcare Systems, Raleigh, NC) and linked to all patients obtained from the trauma registry. If more than 1 laboratory value was available within 4 hours of hospital arrival for calculation of the SOFA score or the Denver ED TOF Score, the most extreme value was used; the highest value of the blood urea nitrogen, creatinine, lactate, total bilirubin, and white blood cell count were used, and the lowest value of the base deficit, hematocrit, and platelet count was used for purposes of this study.

2.4. Outcome measures

The primary outcome, inhospital mortality, was determined using mortality data recorded in the Denver Health Medical Center trauma registry.

The medical records of all study patients admitted to the ICU from the ED were systematically reviewed in a blinded fashion by trained physician abstractors to determine the SOFA score on admission [34]. The SOFA score consists of measures of function across 6 organ systems [35]. The lowest values of the Pao_2/fraction of inspired oxygen ratio, platelet count, GCS score, mean arterial pressure, and urine output and the highest values of total bilirubin, adrenergic agent use, and creatinine were recorded and used in the score calculation. In instances in which an ICU patient did not have a platelet count, total bilirubin, or creatinine obtained in a 24-hour period, the value for these absent laboratory test results was assumed to be normal in the calculation of the SOFA score. The data for the SOFA score were recorded in an electronic closed-response data collection instrument (Microsoft Access; Microsoft Corporation, Redmond, WA). The abstractors were trained to use the data collection instrument to systematically abstract each end point using standardized medical record abstraction methodology [34].

Ten percent of the charts were reabstracted to verify reliability of the abstraction process. Interrater reliability was assessed to determine the overall agreement and the median κ was 0.92 (interquartile range [IQR], 0.81-0.98).

2.5. Data management and statistical analyses

Data were transferred electronically from the trauma registry and MiSYS into separate electronic spreadsheets (Microsoft Excel; Microsoft Corporation), and all outcome data were manually entered into an electronic database (Microsoft Access). Each electronic file was then transferred into native SAS format using translational software (dfPower DBMS copy; DataFlux Corporation, Cary, NC) and concatenated. All analyses were performed using SAS version 9.3 (SAS Institute, Inc, Cary, NC) or Stata version 10.1 (Stata Corporation, College Station, TX).

Continuous data are reported as medians with IQRs, and categorical data are reported as percentages with 95% confidence intervals (CIs). Multiple imputation was performed with SAS-callable IVEware (Survey Methodology Program; Survey Research Center, Institute for Social Research, University of Michigan, Ann Arbor, MI). Multiple imputation has been shown to be a valid and effective way of handling missing data and minimizes the bias that may result from excluding such patients from the analyses and has been shown to be a valid strategy when the proportion of the missing data is large [36-38]. In this study, 10 replications of imputation were performed.

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