Validation of the Denver Emergency Department Trauma Organ Failure Score to Predict Post-Injury Multiple Organ Failure

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BACKGROUND: Early recognition of trauma patients at risk for multiple organ failure (MOF) is important to reduce the morbidity and mortality associated with MOF. The objective of the study was to externally validate the Denver Emergency Department (ED) Trauma Organ Failure (TOF) Score, a 6-item instrument that includes age, intubation, hematocrit, systolic blood pressure, blood urea nitrogen, and white blood cell count, which was designed to predict the development of MOF within 7 days of hospitalization.

STUDY DESIGN: We performed a prospective multicenter study of adult trauma patients between November, 2011 and March, 2013. The primary outcome was development of MOF within 7 days of hospitalization, assessed using the Sequential Organ Failure Assessment Score. Hierarchical logistic regression analysis was performed to determine associations between the Denver ED TOF Score and MOF. Discrimination was assessed and quantified using a receiver operating characteristics (ROC) curve. The predictive accuracy of the Denver ED TOF score was compared with attending emergency physician estimation of the likelihood of MOF.

RESULTS: We included 2,072 patients with a median age of 46 years (interquartile range [IQR] 30 to 61 years); 68% were male. The median Injury Severity Score was 9 (IQR 5 to 17), and 88% of patients had blunt mechanism injury. Among participants, 1,024 patients (49%) were admitted to the ICU, and 77 (4%) died. Multiple organ failure occurred in 120 (6%; 95% CI 5% to 7%) patients and of these, 37 (31%; 95% CI 23% to 40%) died. The area under the ROC curve for the Denver ED TOF Score prediction of MOF was 0.89 (95% CI 0.86 to 0.91) and for physician estimation of the likelihood of MOF was 0.78 (95% CI 0.73 to 0.83).

CONCLUSIONS: The Denver ED TOF Score predicts development of MOF within 7 days of hospitalization. Its predictive accuracy outperformed attending emergency physician estimation of the risk of MOF. (J Am Coll Surg 2016;222:73–82. © 2016 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)

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Abbreviations and Acronyms

Denver ED TOF Score	= Denver Emergency Department Trauma Organ Failure Score
DHMC	= Denver Health Medical Center
IQR	= interquartile range
LOS	= length of stay
MOF	= multiple organ failure
OHSU	= Oregon Health Science University
ROC	= receiver operating characteristics
SOFA	= Sequential Organ Failure Assessment
UCDMC	= University of California Davis Medical Center

Trauma is the leading cause of death in the United States in people 1 to 44 years of age and accounts for 41 million emergency department (ED) visits per year.[1-3] Post-injury multiple organ failure (MOF) is common among seriously injured trauma patients, and organ failure is identified in 1 or more systems in 29% of all trauma patients.[4] Despite recent improvements in trauma resuscitation strategies, MOF remains the leading cause of morbidity and mortality among those who survive the immediate post-injury period.[5-19] Given the morbidity, mortality, and health care costs associated with MOF after traumatic injury, early recognition of this syndrome, rather than delayed treatment, is important.[10,12]

Limited data are available to predict MOF in trauma in the early post-injury period. Previous models predicting MOF in trauma incorporate variables obtained 24 to 48 hours after injury, when opportunities for early intervention have passed. These predictive models were analyzed by Cryer and colleagues,[11] who noted that MOF was already present in a high proportion of trauma patients when these models were implemented to predict whether it would occur. Given this, investigators recommend that risk stratification for the development of MOF in trauma patients begin on the day of injury.[10,11]

Because the rate of morbidity and mortality associated with MOF is so high, early identification of MOF is still the best strategy to improve health care outcomes.[12] Early identification for patients at risk for MOF is especially important to provide appropriate hemodynamic monitoring and, importantly, to facilitate triage of these patients to a higher level of trauma care with a cadre of trauma specialists. Because there are limited resources in regionalized trauma care, a clinical prediction tool that successfully identifies patients at risk for MOF in need of specialized health care resources and transfer to a higher level of trauma care is especially important. This type of tool may facilitate goal-directed resuscitation and timely triage to successfully reduce the morbidity associated with MOF, thereby improving trauma outcomes and reducing health care costs.

We recently derived and internally validated a clinical prediction instrument at the Denver Health Medical Center, the Denver ED Trauma Organ Failure (TOF) Score,[20] which uses clinical and laboratory data within 4 hours of ED arrival in adult trauma patients to predict the development of MOF within 7 days of hospitalization (Table 1). The objective of this study was to externally validate the Denver ED TOF Score[20] and to assess its performance in a prospective multicenter cohort of trauma patients at 3 level 1 trauma centers. To determine the utility of the Denver ED TOF Score in clinical practice, we also compared the predictive accuracy of the Denver ED TOF Score to physician judgment. We hypothesized that the Denver ED TOF Score would accurately predict development of MOF within 7 days of hospitalization in a heterogeneous trauma population and would be more sensitive and specific than the clinical judgment of attending emergency physicians for predicting the development of MOF within 7 days of hospitalization.

METHODS

Study design and setting

This was a prospective multicenter cohort study performed at 3 urban, level 1 trauma centers: Denver Health Medical Center (DHMC) in Denver, CO; Oregon Health and Science University (OHSU) in Portland, OR; and University of California Davis Medical Center (UCDMC), in Sacramento, CA. The DHMC patients included in this external validation study were a different cohort than patients enrolled for the internal validation of the Denver ED TOF Score at DHMC. The study was approved by the institutional review boards at each site.

Table 1. The Denver Emergency Department Trauma Organ Failure Score for Prediction of Multiple Organ Failure in Adult Trauma Patients

Predictor	Score*
Age $\geq$ 65 y	1
Emergent intubation†	3
Hematocrit $<$ 20%	2
Hematocrit $\geq$ 20% and $<$ 35%	1
Emergency department systolic blood pressure $<$ 90 mmHg	1
Blood urea nitrogen $\geq$ 30 mg/dL	1
White blood cell count $\geq$ 20,000/μL	1

*Vogel JA, Liao MM, Hopkins E, et al. Prediction of post-injury multiple organ failure in the emergency department: Development of the Denver Emergency Department Trauma Organ Failure Score. J Trauma Acute Care Surg 2014;76:140–145.[20]

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

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