Impact of Trauma Center Designation on Outcomes: Is There a Difference Between Level I and Level II Trauma Centers?

Laurent G Glance, MD, Turner M Osler, MD, FACS, Dana B Mukamel, PhD, Andrew W Dick, PhD

BACKGROUND: Within organized trauma systems, both Level I and Level II trauma centers are expected to have the resources to treat patients with major multisystem trauma. The evidence supporting separate designations for Level I and Level II trauma centers is inconclusive. The objective of this study was to compare mortality and complications for injured patients admitted to Level I and Level II trauma centers.

STUDY DESIGN: Using data from the Pennsylvania Trauma Outcomes Study registry, we performed a retrospective observational study of 208,866 patients admitted to 28 Level I and Level II trauma centers between 2000 and 2009. Regression modeling was used to estimate the association between patient outcomes and trauma center designation, after controlling for injury severity, mechanism of injury, transfer status, and physiology.

RESULTS: Patients admitted to Level I trauma centers had a 15% lower odds of mortality (adjusted odds ratio [adj OR] 0.85; 95% CI 0.72 to 0.99) and a 35% increased odds of complications (adj OR 1.37; 95% CI 1.04 to 1.79). The survival benefit associated with admission to Level I centers was strongest in patients with very severe injuries (Injury Severity Score [ISS] $\geq$ 25; adj OR 0.78; 95% CI 0.64 to 0.95). Less severely injured patients with an ISS $<$ 9 (adj OR 0.91; 95% CI 0.64 to 1.30) and with an ISS between 9 and 15 (adj OR 0.98; 95% CI 0.81 to 1.18) had similar risks of mortality in Level I and Level II trauma centers.

CONCLUSIONS: Severely injured patients admitted to Level I trauma centers have a lower risk of mortality compared with patients admitted to Level II centers. These findings support the continuation of a 2-tiered designation system for trauma. (J Am Coll Surg 2012;215:372–378. © 2012 by the American College of Surgeons)

There is strong evidence that regionalization of trauma care leads to improved survival in patients with severe injuries.[1-3] Within organized trauma systems, both Level I and Level II trauma centers are expected to have the resources to treat patients with major multisystem trauma. However, in addition, Level I trauma centers are also required to staff a surgically directed critical care service, participate in residency training, conduct trauma research, and meet minimum trauma case volume criteria.[4] These verification standards are expert-based and have not been extensively validated. Although most previous studies have shown that patients treated in Level I trauma centers are more likely to survive compared with patients treated in Level II trauma centers,[5-8] many of these studies have significant methodologic limitations.

One of the goals of the Healthy People 2020 initiative is to increase access to high-quality trauma care.[9] Between 1990 and 2005, more than 25% of trauma centers in the United States closed.[10] Reduced access disproportionately affects disadvantaged populations such as poor, uninsured, and black patients.[10] These closures have been attributed to the high cost of trauma care coupled with the underfunding of hospitals caring for trauma patients.[10] In light of these findings, it is especially important to determine

Disclosure Information: Nothing to disclose.

Supported by a grant from the Agency for Healthcare and Quality Research (RO1 HS 16737).

The views presented in this manuscript are those of the authors and may not reflect those of the Agency for Healthcare and Quality Research. These data were provided by the Pennsylvania Trauma Systems Foundation. The Foundation specifically disclaims responsibility for any analyses, interpretations or conclusions.

Received February 22, 2012; Revised March 22, 2012; Accepted March 27, 2012.

From the Department of Anesthesiology, University of Rochester School of Medicine, Rochester, NY (Glance); the Department of Surgery, University of Vermont Medical College, Burlington, VT (Osler); the Center for Health Policy Research, Department of Medicine, University of California, Irvine, CA (Mukamel); and RAND, RAND Health, Santa Monica, CA (Dick).

Correspondence address: Laurent G Glance, MD, Department of Anesthesiology, University of Rochester Medical Center, 601 Elmwood Ave, Box 604, Rochester, NY 14642.Email: Laurent_Glance@urmc.rochester.edu

ISSN 1072-7515/12/$36.00
http://dx.doi.org/10.1016/j.jamcollsurg.2012.03.018

Abbreviations and Acronyms
adj OR = adjusted odds ratio
ISS = Injury Severity Score
PTOS = Pennsylvania Trauma Outcomes Study

whether the additional resources available to treat patients in Level I trauma centers compared with Level II trauma centers are justified by improved patient outcomes.

Our study is designed to address the limitations of previous studies using comprehensive clinical data from the Pennsylvania Trauma Outcomes Study (PTOS) registry and robust risk adjustment based on the recently developed Trauma Mortality Prediction Model.[11] We compare survival and complications in Level I vs Level II trauma centers. We also determine whether patients with more severe injuries derive greater benefit compared with less severely injured patients when they are admitted to Level I trauma centers compared with Level II trauma centers. This study is part of the Agency for Healthcare Research and Quality (AHRQ)-funded Survival Measurement and Reporting Trial for Trauma designed to investigate the impact of nonpublic reporting on trauma outcomes, and to examine the link between structure, processes of care, and survival in injured patients.

METHODS

Data source

This study was based on data obtained from the Pennsylvania Trauma Systems Foundation (PTSF) on patients admitted to PTSF-accredited Level I and Level II trauma centers between 2000 and 2009. The Pennsylvania population includes rural and urban areas, and provides a representative casemix of trauma patients.[12] The Pennsylvania Trauma Outcomes Study (PTOS) database is a population-based statewide trauma registry that includes data on all trauma admissions at accredited trauma centers meeting any one of the PTOS inclusion criteria: admission to the ICU or step-down unit, hospital length-of-stay greater than 48 hours, hospital admissions transferred from another hospital, transfers out to an accredited trauma center, or trauma death.[13] The PTOS database includes deidentified data on patient demographics, Abbreviated Injury Score (AIS) codes and ICD-9-CM codes, mechanism of injury (based on ICD-9-CM Ecodes), comorbidities, physiology information, in-hospital mortality and complications, transfer status, processes of care, and encrypted hospital identifiers. Data quality is assured through the use of standard abstraction software with automatic data checks, a data definition manual, and internal and external data auditing.[14]

Patient population

The study population consisted of trauma patients with age greater than 16 years admitted to either Level I or Level II trauma centers in Pennsylvania, after excluding patients with burns, hypothermia, isolated hip fractures, superficial injuries, unspecified injuries, nontraumatic mechanism of injury, and patients transferred out to another hospital. From this initial cohort of 226,283 patient observations, we excluded patients with missing information on transfer status (n = 286), and demographics (n = 170); as well as patients with invalid Abbreviated Injury Score codes (n = 12,662), and patients transferred out (n = 4,299). The final study cohort consisted of 208,866 patients in 28 Level I and Level II trauma centers. This study was approved by the institutional review board at the University of Rochester School of Medicine.

Analysis

The aims of this study were to estimate the association between trauma center designation (Level I vs Level II) and in-hospital mortality and major complications. We defined the composite complication outcomes if one or more of the following complications occurred during the initial hospitalization: acute respiratory distress syndrome, acute myocardial infarction, acute respiratory failure requiring more than 48 hours of ventilatory support after a period of normal nonassisted breathing (minimum of 48 hours) or reintubation, aspiration pneumonia, pneumonia, pulmonary embolism, fat embolism syndrome, acute renal failure, central nervous system infection, progression of original neurologic insult, liver failure, sepsis, septicemia, empyema, dehiscence, gastrointestinal bleeding, small bowel obstruction, compartment syndrome, arterial occlusion, or postoperative hemorrhage.

We estimated the independent effect of trauma center designation on in-hospital death using multivariate logistic regression. In the baseline model, we controlled for injury severity using the previously validated Trauma Mortality Prediction Model (TMPM-AIS),[11] modified by the addition of age and sex, mechanism of injury, transfer status, and year of admission (model 1). We estimated additional sequential models, which also included the systolic blood pressure and the motor component of the Glasgow Coma Scale (model 2) and comorbidities (model 3). The selection of comorbidities was based on backward stepwise selection and clinical judgment. The optimal specification of age was determined using fractional polynomials.[15] Multiple imputation of missing values of the motor component of the Glasgow Coma Scale and the systolic blood pressure was performed using the STATA implementation of the MICE method of multiple imputation described by van Buuren and colleagues.[16] Rubin's rule was used to combine the