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Comparison of outcomes in severe pediatric trauma at adult trauma centers with different trauma case volumes

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ABSTRACT

Background: In addition to trauma center levels and types, trauma volume may be an important factor impacting outcomes in severe pediatric trauma.
Methods: All severely injured pediatric patients treated at adult trauma centers were identified from the National Trauma Data Bank. All qualifying centers were stratified into four groups based on the cumulative pediatric trauma case volumes with ISS >15: lowest (group 1), lower (group 2), higher (group 3), and highest (group 4) volume centers. Mortality rates among the groups were compared.
Results: A total of 3747 patients were stratified into group 1 (n = 2122, median annual pediatric trauma volume 3 cases/year), group 2 (n = 842, 15 cases/year), group 3 (n = 494, 24 cases/year), and group 4 (n = 289, 43 cases/year). In the hierarchical logistic regression analysis, the highest volume centers (group 4) were shown to have improved mortality (odds ratio 0.474, 95% confidence interval [CI] 0.301–0.747) compared to the lowest volume centers (group 1). Odds ratios of group 4 against group 1 for subgroups were 0.634 (age < 10, 95% CI 0.335–1.198), 0.491 (blunt injury, 95% CI 0.310–0.777), and 0.495 (level 1 center, 95% CI 0.312–0.785).
Conclusions: In severe pediatric trauma treated at adult trauma centers, higher volume centers were associated with improved mortality in comparison to the lower volume centers.
Level of evidence: Level III, therapeutic/care management, retrospective comparative study without negative criteria.

Pediatric trauma is the leading cause of morbidity and mortality among children in the United States. Timely resuscitation and definitive care are known to improve patient outcomes. Officially, pediatric trauma patients can receive medical treatment at adult, pediatric and mixed trauma centers with different levels of American College of Surgeon's Committee of Trauma (ACSCOT) verification or state designation. However, pediatric patients pose a unique challenge, given the need for age and size-appropriate resources, equipment, and care, which are not ubiquitously available. Pediatric hospitals that do boast specialized pediatric trauma expertise are scarce nationwide.

Studies have demonstrated that larger case volume centers, in general, are associated with improved outcome. In 1979, Luft et al., first reported associations between high hospital volumes with lower mortality rates particularly in cases involving complex surgical procedures [1]. Recent studies reiterate similar conclusions, associating higher trauma volume with improved patient outcomes [2–6]. Examining another vulnerable subpopulation of geriatric trauma patients, Matsushima et al. found improved geriatric outcomes at high geriatric-trauma volume centers [7]. While a number of studies have investigated in the relationship between pediatric trauma outcomes and trauma center types and levels [8–23], the correlation between the pediatric trauma volume and outcomes has not fully been explored [19,20,24]. Many pediatric trauma patients are treated at stand-alone adult trauma centers where pediatric surgeons may not be immediately available. However, little is known about what characteristics among those stand-alone adult trauma centers are associated with better pediatric outcomes.

The purpose of this study is to investigate whether an inverse correlation exists between the pediatric trauma volume at stand-alone adult trauma centers and mortality. We hypothesized that, for severe pediatric blunt and penetrating injuries, higher volume trauma centers would have lower in-hospital mortality as compared to lower volume centers.

1. Materials and methods

This study was approved by the Institutional Review Board at Children's Hospital Los Angeles. We conducted a retrospective, observational study utilizing data from the National Trauma Data Bank (NTDB)

Abbreviations: ISS, Injury Severity Score; NTDB, National Trauma Data Bank; CI, Confidence Interval; ACSCOT, American College of Surgeons Committee of Trauma; GCS, Glasgow Coma Scale; PICU, Pediatric Intensive Care Unit.

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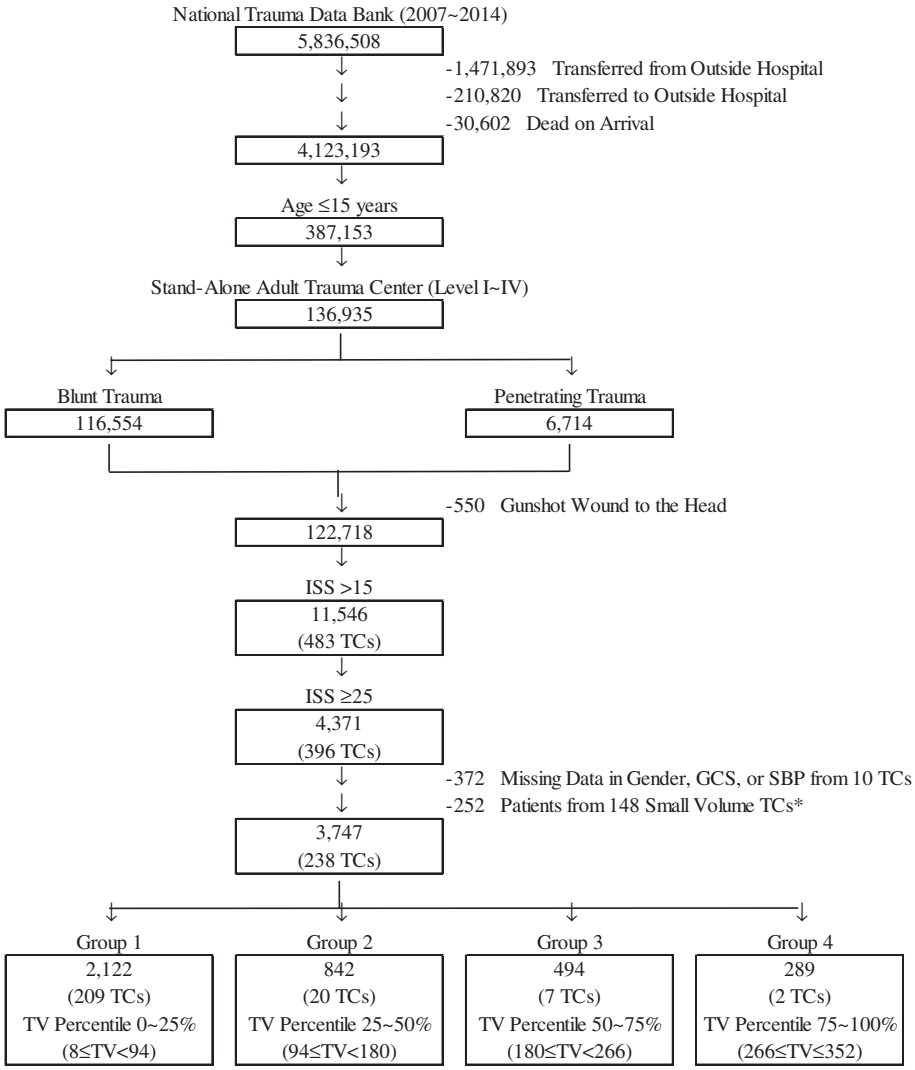

Fig. 1. Patient selection. Inclusion and exclusion criteria.

from 2007 to 2014. All blunt or penetrating injuries among pediatric patients age 15 years or younger with Injury Severity Score (ISS) >25, treated at stand-alone adult trauma centers were identified. *Stand-alone adult trauma center* was defined as any trauma center having adult ACSCOT verification or adult state designation and no pediatric qualifications. We extracted demographics, descriptive variables and outcomes. Patients transferred between hospitals, gunshot wounds to the head, and patients who were dead on arrival were excluded. All stand-alone adult trauma centers were evaluated for the cumulative case volumes of ISS >15, blunt or penetrating pediatric injuries during 2007–2014, and were stratified into four groups according to percent quartiles based on volume: lowest (group 1), lower (group 2), higher (group 3), and highest (group 4) volume centers. In order to recruit severely injured patients and adequate number of patients for trauma center stratification, we selected patients with ISS > 25 while selecting trauma centers with ISS > 15. Patients treated at trauma centers with extremely low trauma volume (less than 8 cases during 8-year study period) were excluded from the study. Inclusion and exclusion criteria are shown in Fig. 1.

The primary outcome was inpatient mortality, which was compared among different trauma volume centers. After univariate analysis, the mortality rate was controlled by hierarchical logistic regression analysis for the following patient characteristics variables: age, gender, mechanism of injury, Emergency Department Glasgow Coma Scale (GCS), presence of hypotension, and Injury Severity Scale (ISS), as well as trauma center characteristics variables: volume group (1–4), trauma center level (1–4), and the presence of pediatric intensive care unit (PICU). Hypotension was defined based on the following definitions: Systolic blood pressure of less than $70 + 2 \times$ age in years for age < 10, or less than 90 for age > 10. Additionally, subgroup analyses were performed for the following subgroups: a) age < 10 years old, b) blunt injury, and c) level 1 trauma center. All analyses were performed using IBM SPSS Statistics for Windows version 22.0 (IBM Corp., Armonk, NY, USA).

2. Results

A total of 3747 patients met the inclusion and exclusion criteria (Fig. 1). These patients were stratified into four groups according to percent quartiles based on center volume (group 1–4). Patient and trauma center characteristics are shown in Table 1. A majority of the study population were between the ages of 10 to 15 years (2396, 63.9%) with approximately two thirds being male (2420, Table 1). Blunt injury was the most common mechanism of injury (92.7%). Overall mortality rate in our study population was 23.9% (895). Overall, an upward trend was seen between the number of patients age < 10 years old and increasing trauma volume ($p < 0.001$). Similar positive trends were seen with the number of blunt injuries with higher volume trauma centers ($p < 0.001$). Conversely, penetrating injuries and hypotension were more common in lower volume centers ($p < 0.001$ and $p = 0.001$, respectively). With regard to the anatomical regions involved,