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Comparison of pediatric motor vehicle collision injury outcomes at Level I trauma centers☆,☆☆,★

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ABSTRACT

Objective: Examine the association of American College of Surgeons Level I pediatric trauma center designation with outcomes of pediatric motor vehicle collision-related injuries.
Methods: Observational study of the 2009–2012 National Trauma Data Bank, including $n = 28{,}145$ patients <18 years directly transported to a Level I trauma center. Generalized estimating equations estimated odds ratios (ORs) for injury outcomes, comparing freestanding pediatric trauma centers (PTCs) with adult centers having added Level I pediatric qualifications (ATC + PTC) and general adult trauma centers (ATC). Models were stratified by age following PTC designation guidelines, and adjusted for demographic and clinical risk factors.
Results: Analyses included $n = 16{,}643$ children <15 and $n = 11{,}502$ adolescents 15–17 years. Among children, odds of laparotomy (OR = 1.88, 95% CI 1.28–2.74) and pneumonia (OR = 2.13, 95% CI 1.32–3.46) were greater at ATCs vs. freestanding PTCs. Adolescents treated at ATC + PTCs or ATCs experienced greater odds of death (OR = 2.18, 95% CI 1.30–3.67; OR = 1.98, 95% CI 1.37–2.85, respectively) and laparotomy (OR = 4.33, 95% CI 1.56–12.02; OR = 5.11, 95% CI 1.92–13.61, respectively).
Conclusions: Compared with freestanding PTCs, children treated at general ATCs experienced more complications; adolescents treated at ATC + PTCs or general ATCs had greater odds of death. Identification and sharing of best practices among Level I trauma centers may reduce variation in care and improve outcomes for children.

1. Background

Motor vehicle collisions (MVCs) are a leading cause of traumatic injuries and death among children aged 5–17 years [1–3]. Recent reports have emphasized the need to better understand outcomes and characteristics of injured children treated at various types of trauma centers to help guide prevention efforts and best practices in emergency departments [4,5]. However, comparison of outcomes and management for pediatric patients with MVC-related injuries treated at different types of trauma centers on a national level is lacking.

Pediatric trauma centers (PTCs) were created out of recognition that specialized equipment and trained personnel may provide more optimal care for injured children [6]. Still, access to high-level pediatric trauma care remains limited in some areas of the United States and the vast majority of injured children are not treated at trauma centers with pediatric verification [7–10]. In the United States, an estimated 17.4 million children <15 years of age, or approximately 28% of the pediatric population, do not have access to a pediatric designated (Level I or II) center within 60 min by ground or helicopter ambulance [7].

Although research supports that trauma centers provide optimal care for patients with traumatic injuries [7,11], within this designation studies disagree if outcomes are differential for pediatric patients at freestanding PTCs, adult trauma centers with added qualifications for children (ATC-AQ), or general adult verified trauma centers (ATC) [6,9,10,12–18]. One review article noted better outcomes for injured children treated at freestanding PTCs or ATC-AQs [6], while another found insufficient evidence to determine where pediatric trauma patients have the best outcomes [8,19]. The picture is even more unclear for older adolescent patients since freestanding PTCs or ATC-AQs are typically designated for pediatric patients <15 years of age, and outcomes may vary depending on whether centers treat adolescents as small adults or large children [20]. Furthermore, many studies have not considered the verification level (Level I-IV) of trauma centers in comparisons, and so it is unclear if differences in outcomes in some studies are because of the pediatric qualifications, or to the level of trauma center verification for adults and/or children.

Given that MVCs are an important public health problem for the pediatric population and access to and/or utilization of PTCs is limited, it is

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important to understand where patients have optimal outcomes. Thus in this study, we sought to describe the demographic and clinical characteristics of pediatric MVC-related trauma and compare select outcomes and management experienced by these patients across Level I trauma centers.

2. Material and methods

2.1. Data source

We used data from the National Trauma Data Bank (NTDB), years 2009–2012, which is managed by the American College of Surgeons (ACS). More than 700 U.S. trauma centers and hospitals voluntarily reported de-identified information about trauma patients to the NTDB [21]. Included among these centers were approximately 95% of all ACS-verified Level I and Level II trauma centers, which are required to report data to the NTDB as part of their ACS verification requirements [22]. The current analysis included data from 146 Level I trauma centers that reported data to the NTDB during at least one year of the study period. Data collection, reporting, and cleaning are standardized across all participating NTDB trauma centers, and details of these procedures are published elsewhere [23]. The Institutional Review Board at Children's Hospitals and Clinics of Minnesota reviewed the protocol for this study and approved it for exempt status.

2.2. Patient population

Analyses included patients <18 years of age treated at ACS-verified Level I trauma centers for MVC-related injuries, defined as International Classification of Diseases-9th Revision (ICD-9) e-codes 810–819. In an effort to create more homogenous groups for comparison, we excluded patients transferred from another facility because these patients received care at different centers during a variable time frame [24]. We also excluded patients missing gender information, injury severity score (ISS), or who presented to the emergency department (ED) "dead on arrival" or "died after attempted resuscitation" in the ED because they may have expired prior to care received in the trauma center. Based on age guidelines for PTCs, we stratified the population by children <15 years of age and adolescents aged 15–17 years.

2.3. Variables

Outcomes included mortality, theoretically preventable complications, and procedures related to the management of MVC-related injuries. In-hospital mortality was defined as an ED discharge disposition of "death" or hospital discharge disposition of "expired". The following complications were defined according to the NTDB data dictionary and included because they were relevant for a pediatric population and have been used in at least one other study [25]: decubitus ulcer, pneumonia, deep surgical site infection, deep vein thrombosis [DVT], extremity compartment syndrome, acute respiratory distress syndrome [ARDS], and sepsis. We report the frequency of patients with at least one of these complications, and frequencies for the top three most common complications in the sample, which were pneumonia, ARDS, and DVT. Variations in splenectomy, splenic artery embolization, laparotomy, and CT scans defined differences in injury management across trauma centers because, in general, the goal is to avoid or minimize these procedures as much as possible in children. We used ICD-9 procedure codes to identify splenectomies (41.5) and splenic artery embolization (39.79, 38.86, 38.87, or 88.47, as in reference [26]) among patients with an ICD-9 code for a spleen injury (865.0–865.19). ICD-9 codes were used to define laparotomies (54.11–54.12, 54.19, 54.21), blood transfusions (99.01, 99.03–99.09), and CT scans of the head, neck, chest, abdomen, and thoracic spine (87.03, 87.04, 88.01, 88.02, 87.22–87.24, 87.41, 87.42, or 87.71) among the full cohort.

Our primary exposure variable was pediatric designation among Level I trauma centers. We classified trauma centers into freestanding PTCs (ACS pediatric trauma verification Level I, no adult beds), Level I adult trauma centers with added Level I pediatric qualifications (ATC + PTC) (ACS pediatric trauma verification Level I, with adult beds), or Level I general adult trauma centers (ATC) (no ACS pediatric trauma verification Level I, with adult beds).

2.4. Statistical analysis

We described patient demographic and clinical characteristics by trauma center type using means (SD) or median (IQR, range) for continuous variables and n (%) for categorical variables. ANOVA, Kruskal–Wallis tests, or chi-square tests compared patient characteristics between the three types of trauma centers.

Generalized estimating equation (GEE) models examined the association of type of trauma center with the mortality, complications, and management outcome variables. Addition of an interaction term for type of trauma center by age in the mortality model showed evidence for effect modification by age ($p < 0.01$, with stronger association among adolescents), further supporting age stratification of models. Models accounted for correlation within facility and estimated odds ratios (ORs) for the outcomes using freestanding PTCs as the reference group. We started with age- and NTDB-year adjusted models, and then added confounding variables that were associated with both center type and our outcomes of interest, including those suggested by Haider et al. [27]. Specifically, all models included patient age (continuous), sex, method of payment (government, commercial, self-pay, other/missing), mechanism of injury (occupant, pedestrian, bicycle, motorcycle, unspecified), head injury (yes/no), multiple injury locations (yes/no), EMS time (defined as time from EMS dispatch to hospital arrival and categorized as less than 45 min [the median time in the population], greater than or equal to 45 min, or unspecified); and injury severity as defined by ISS score (continuous) [28]. Inclusion of race/ethnicity in the models did not substantively change estimates so this variable was not included in our final models.

Glasgow Coma Scale (GCS) was missing for a large proportion of cases (18%). To preserve sample size and prevent bias from excluding a large number of patients from our sample, we did not include GCS in our main models. However, as a sensitivity analysis we additionally adjusted all models for GCS among the patients who had this variable available, and presented the results in a supplementary table (see Table 1S). There was a large difference in ISS scores for patients treated at the different types of trauma centers, with patients treated at freestanding PTCs having lower (less severe) median ISS compared with patients treated at ATC + PTC or general ATCs. Although we adjusted for ISS in our models, to help ensure that results were not driven by residual differences in injury severity between the types of trauma centers, we restricted analyses to those patients with severe injuries (defined as ISS 15+) as a second sensitivity analysis (Table 2S). As an additional sensitivity analysis, we included torso and spine/back injury variables as covariates in the laparotomy and pneumonia models to see if differences in the proportion of patients with these injuries at the different types of trauma centers were driving results for those specific outcomes. We made no adjustments for multiple comparisons because all of the outcomes were related to quality of care. Analyses were run using SPSS Statistics 20.0 (IBM, Inc., Somers, NY) and SAS version 9.4 (Cary, NC).

3. Results

The 2009–2012 NTDB included 286,678 trauma patients <19 years of age. After excluding transfers ($n = 141,850$), patients who were classified as "dead on arrival" or "died after attempted resuscitation" ($n = 5506$), non-MVC-related injuries ($n = 43,706$), trauma centers that were not Level I ACS-verified ($n = 59,255$), age greater than 17 years ($n = 6525$), cases missing ISS ($n = 1685$), and cases with