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# Massive transfusion in pediatric trauma: analysis of the National Trauma Databank

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## ABSTRACT

**Background:** Massive transfusion (MT) in pediatric trauma has been described in combat populations and other single institutions studies. We aim to define the incidence of MT in a large US civilian pediatric trauma population, identify predictive parameters of MT, and the mortality associated with MT.

**Methods:** Data from the National Trauma Databank (2010-2012), a trauma registry maintained by the American College of Surgeons, were analyzed. We included pediatric trauma patients  $\leq 14$  y that underwent MT, as defined by 40 mL/kg of blood products within the first 24 h after admission. We compared the MT group with children receiving any transfusion within the same time frame. Univariate and multivariate analysis were performed.

**Results:** Of 356,583 pediatric trauma patients, 13,523 (4%) received any transfusion in the first 24 h and 173 (0.04%) had a MT. On multivariate analysis, factors predicting MT were: older patients (5-12: OR 2.71,  $P = 0.006$ , and  $\geq 12$ : OR 5.14,  $P < 0.001$ ), hypothermic patients (temperature  $< 35$ : OR 2.48,  $P < 0.025$ ), low Glasgow Coma Scale (Glasgow Coma Scale  $< 8$ : OR 2.82,  $P = 0.009$ ), and Injury Severity Scores  $\geq 25$  (OR 2.01,  $P = 0.03$ ). Overall mortality for the entire group, any transfusion group, and MT group were 2.5%, 13.6%, and 50.6%, respectively ( $P < 0.001$ ).

**Conclusions:** MT in pediatric trauma is an uncommon event associated with a significant mortality. Patients undergoing MT are older, more likely to be hypothermic and have sustained more severe injuries as measured by traditional trauma scoring systems than transfused trauma patients.

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## Background

In the pediatric population, trauma is the leading cause of death.<sup>1</sup> Hemorrhage remains one of the leading causes of preventable traumatic death for all patients, accounting for 20%-40% of all early trauma mortality.<sup>2,3</sup> Significant focus has

been directed toward incorporation of massive transfusion (MT) into damage control resuscitation and identifying appropriate resuscitation ratios to improve outcomes in adult trauma. In the recent PROPPR trial examining appropriate MT ratios in an adult civilian population, MT was deemed necessary in 4.7% of patients and was associated with a

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mortality nearing 25%.<sup>4</sup> There have been prior studies examining MT in pediatric trauma. However, these are limited to MT of children in combat situations and MT of pediatric trauma patients at single institutions. The published experience with MT and developed protocols is limited due to the smaller single-institution studies with limited number of pediatric patients experiencing severe hemorrhagic shock.<sup>5-7</sup> The objective of this study was to use a National Trauma Database (NTDB) to estimate the incidence of transfusion and MT in the pediatric trauma population within the first 24 h of admission. We would also examine specific parameters that predicted MT in this pediatric trauma population, but we cannot extrapolate to ensure that each of these patients had appropriate indications for MT. We hypothesized that this incidence of pediatric MT would be significantly less than in adult trauma, yet the significant mortality associated with MT would still persist.

## Methods

### Data source and study population

The NTDB represents a national database containing more than three million injured patients from more than 900 hospitals in the United States.<sup>8</sup> Demographics, hospital characteristics, injury severity, admission vital signs, *International Classification of Diseases, Ninth Revision* diagnosis codes (ICD-9), intensive care unit admission, transfusion of blood products, mechanical ventilation, emergency department, and hospital disposition were collected for each subject. We also evaluated hospital characteristics and region of the country for the facilities taking care of these children.

The study population consisted of pediatric trauma patients, defined by  $\leq 14$  y of age, from the combined NTDB from 2010 to 2012. After identifying this entire population, we identified our exposure group: those patients receiving  $\geq 40$  mL/kg of any blood product—this group was defined as the MT group. The comparison group consisted of those patients who received transfusion of any blood product within the first 24 h. Within the NTDB, there are procedure codes for patients  $\leq 14$  y of age that are specific for MT, characterized as  $\geq 40$  mL/kg of any blood product, and any transfusion of any blood product within 24 h after arrival. Those patients  $>14$  y of age were categorized as receiving a MT by adult criteria ( $>10$  units of blood products within the first 24 h after admission), thus these older patients were excluded in order to limit our evaluation to pediatric trauma patients with a similar MT definition. To further characterize these patients, we identified particular interventions (by ICD-9 codes) that these children underwent which may identify them at risk for hemorrhage—angiography, exploratory laparotomy (including other abdominal procedures: splenectomy/splenorrhaphy, hepatectomy/hepatorrhaphy, bowel resection, and so forth), and thoracotomy. Patients at particular risk for severe traumatic brain injury were categorized as those undergoing ventriculostomy, craniotomy, and/or craniectomy (TBI group). Finally, an additional group of procedures termed as “other” were tabulated—the majority of these consisted of orthopedic fracture management. As mentioned prior, this database only

allows us to identify which patients endured these procedures, but no decision can be rendered on the appropriate nature of these procedures.

### Statistical analysis

We compared age, presenting vital signs (temperature, pulse, and systolic blood pressure), Glasgow Coma Scale (GCS) scores, and Injury Severity Scores (ISS) between those who received any transfusion and a MT using the nonparametric, independent sample test of medians. We analyzed ICU length of stay (LOS) and hospital LOS between those who never received a transfusion, received any transfusion, and received a MT using the nonparametric, independent sample test of medians. Mortality among the no transfusion, any transfusion, and MT group was analyzed using the Pearson's chi-square test. All *P* values are two-tailed and considered statistically significant if the *P* value is  $<0.05$ . To better characterize the MT population, general descriptive characteristics of the mechanism of injury for patients receiving MT, the region of country for the MT, and the hospital type were analyzed.

We then analyzed the patients' demographics, presenting vital signs (temperature, pulse, and systolic blood pressure), GCS scores, and ISS by univariate and multivariate analysis. All factors were analyzed separately in a univariate model and together in a multivariate model using stepwise logistic regression. Factors with *P* values that were  $>0.05$  were individually removed from the multivariate model to create the adjusted model. All analysis was performed using IBM SPSS Statistics for Windows Version 22 (IBM Corp, Armonk, NY) and SAS 9.4 (Statistical Analytics Software Institute, Cary, NC).

## Results

We identified a total of 356,583 children ( $\leq 14$  y of age) who were included in the merged NTDB from 2010 to 2012. The overall demographics of entire population showed a slight male predominance (53%), 68% of the children were less than 12 y of age, and 71% were Caucasian. A majority of these patients were not critically injured as evidenced by their admission GCS scores and ISS scores—92.2% had a GCS score from 12 to 15 and 3.9% had an ISS  $\geq 25$ . This population of pediatric trauma patients was divided into those patients requiring MT, less than MT (referred to as any transfusion), and no transfusion (Figure). A vast majority, 96%, of children experiencing trauma did not require any blood product transfusion within 24 h of admission. Four percent of the pediatric population did require transfusion of any blood product within the first 24 h of admission. Of the 13,696 children requiring any transfusion—there were 173 MTs required in 170 patients, or 0.04% of the entire population, required MT during the first 24 h of care. The types of blood products and adjunct agents given to this entire pediatric trauma cohort are listed in Table 1. The total number of transfusions is 14,069 demonstrating that many patients received more than one type of blood product.

As expected, the comparison of demographics, presenting vital signs, and ISS are quite different between those that

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