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The impact of transfer on pediatric trauma outcomes☆,☆☆,★

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ABSTRACT

Background: Recently, concerns have been raised over delays that result from transferring patients to designated trauma centers. This study aimed to assess whether transfer status had an impact on pediatric trauma outcomes.
Methods: Using a local 1996–2014 pediatric trauma database containing 1541 patients, the following outcomes were tested: death, major complication, time to definitive treatment (TDT), hospital length of stay (LOS), and ICU length of stay (ICU LOS). Logistic, generalized linear, and Poisson regression models were used.
Results: Mortality and complication rates did not differ significantly between direct (mortality = 52/1000, complications = 54/1000) and transferred (mortality = 59/1000; complications = 67/1000) patients (mortality aRR: 1.17, 95% CI: 0.76–1.80, p = 0.48; complication aRR: 1.13, 95% CI: 0.75–1.70, p = 0.57). Transfer status was not a significant predictor of ICU LOS (p = 0.72). Transfer status was a significant predictor of time to definitive treatment (transfer x= 17.4 h vs. direct x= 2.6 h, p = 0.0035) and of LOS for severely injured patients (p = 0.005). The significant predictors of pediatric trauma mortality were: ISS, transport mode, age, and TDT, and of major complication were ISS and TDT.
Conclusions: Although transferred patients had longer time to specialized care, there were no significant differences in the mortality or complication rates between transferred and direct patients after adjusting for injury severity.

There is significant evidence in the literature to suggest that organized trauma systems significantly improve trauma-related mortality [1–7]. The goal of these systems is to provide the appropriate level of care in a timely manner and to centralize trauma resources [8]. The function of trauma centers (Level 1 centers) in these systems is to treat the most severely injured, using up-to-date technology and highly trained specialists [9]. Significantly improved trauma-related mortality rates have been demonstrated at these centers compared to non-trauma centers [2,4,6,9].

Critically injured trauma patients are often triaged to outlying hospitals for stabilization prior to transfer to specialized care. Stabilization of patients at a peripheral hospital (level 3 or 4 trauma centre) has been associated with improved patient outcomes in some studies [10,11]. However, in some circumstances, this delay to definitive care at a trauma centre may have a significant negative impact on patient outcomes [12]. There are also concerning reports from medical critical care populations that transfer patients have a higher rate of mortality and longer lengths of stay than direct admissions [13,14].

Traumatic injuries are a significant issue in pediatrics since trauma is the leading cause of death in all children ages 1–19 in Canada [15]. Trauma systems also exist in pediatrics and several pediatric specific guidelines for transport teams have been created [16,17,18]. Similar to adult trauma care, numerous studies have shown that pediatric outcomes are better when patients are treated at level 1 trauma centers compared to non-trauma centers [1,2,19,20,21]. Furthermore, several studies have demonstrated that trauma mortality rates are significantly higher for children receiving definitive care at adult trauma centers and at rural centers, compared to pediatric trauma centers or adult centers with specialized pediatric training [19,22,23,24]. There are also studies that have investigated transfer times and causes of transfer delay including: mobilization, hand-over, and accepting constraints at the trauma centre [25,26]. However it is still unknown whether these delays in transfer of pediatric patients impact their outcomes.

Abbreviations: ICU, Intensive Care Unit; LOS, Length of Stay; TDT, Time to Definitive Treatment; ISS, Injury Severity Score; ARDS, Acute Respiratory Distress Syndrome; PE, Pulmonary Embolism; ATV, All-Terrain Vehicle; GLM, Generalized Linear Model; CHEO, Children's Hospital of Eastern Ontario.

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A recently published systematic review of the effect of secondary transfer to a Trauma Centre on outcomes for adult trauma patients showed no difference in mortality between transfer and direct admissions [27]. However the authors concluded that further prospective and database driven studies are necessary. As well, there are much fewer pediatric trauma centers than adult centers, located only in major urban centers in Canada, meaning that distances may be much further for transferred pediatric patients. Stabilization also occurs at adult facilities that do not have specialization in pediatric care [19]. Therefore, it is essential to investigate the effects of transfer on pediatric trauma patients in our population.

For the purposes of this study, patients who were transported directly from the field to the level 1 trauma centre will be referred to as "direct" patients and those that were transported to a peripheral hospital prior to being transferred to the trauma centre will be referred to as "transfer" patients. Transfer status will therefore indicate whether a patient was "direct" or "transfer."

Currently there are no clear guidelines for paramedics on transfer decisions and evidence is needed for the development of new pediatric guidelines. Given that nearly half of the trauma patients at our level 1 pediatric trauma centre are transported to peripheral hospitals prior to transfer, and that there is a lack of evidence on the impact of transfer on morbidity and mortality rates, we aimed to investigate the impact of transfer status in our trauma population. The objectives of this study were to determine whether transfer status has an impact on mortality, major complication rates, time to definitive treatment, length of hospital stay, and length of ICU stay, and to examine the factors that are associated with these outcomes in our pediatric trauma population. Based on the adult trauma literature [27], we hypothesized that there would be no significant difference in the mortality rates or complication rates between the two groups. However, we anticipated that the length of stay, and time to definitive treatment would be higher in patients transferred from a peripheral hospital, as a result of the delay in time to treatment.

1. Material and Methods

1.1. Setting, participants

This study used data on patients admitted between April 2000 and March 2013 from a prospectively collected pediatric trauma database, filled using Digital Innovations incorporated software (Collector Ontario 2012) at our academic tertiary care Children's Hospital in Ontario, Canada, from April 2000 to March 2013. A total of 1541 pediatric trauma patients were included. The inclusion criteria were as follows: age ≤18 years (based on the admission criteria at our center), patients for whom the trauma team was activated, admission for injury due to ATV, and patients who did not have trauma team activation but on retrospective review met the guidelines. The exclusion criteria included: patients who did not meet trauma team activation guidelines, patients with unspecified injuries, and non-traumatic mechanisms. Patients who were dead-on-arrival were also excluded. Patients were followed from the time of injury to the time of discharge from hospital. Any complications or deaths occurring after discharge were not captured. Research ethics approval was obtained from the hospital research ethics board and patient consent was not required as the data were routinely collected. Patient information was de-identified and patients were assigned a unique identifier.

1.2. Data analysis

Patients transported directly to our pediatric trauma centre were compared with patients transferred from another facility. Primary outcomes included: death, major complications, length of hospital stay (LOS), length of stay in the intensive care unit (ICU LOS), and time to definitive treatment (TDT). Major complications included: pneumonia, pulmonary embolism (PE), acute respiratory distress syndrome (ARDS), sepsis, post-operative complication, post-operative hemorrhage, convulsion, CNS (Central Nervous System) infection, and wound dehiscence. Time to definitive treatment was defined as the total time from injury to arrival at the pediatric trauma centre (in hours). Predictor variables included in the multivariate analyses were: age, sex (male vs. female), injury severity score (ISS) (severe vs. *minor*), and transport mode (air vs. land). For injury severity score, a score ≥12 was classified as a severe injury and a score <12 as a minor injury. Injury Severity Score (ISS) was calculated using AIS 90 (Abbreviated Injury Scale), as AIS 2005 was only available from 2008 onward. We hypothesized that transferred patients would have a longer time to definitive treatment; therefore TDT was also assessed as a predictor variable in the death and complication models in order to examine the clinical impact of a longer time to definitive treatment.

Statistical analyses for this study were performed using SAS version 9.4 and Microsoft Excel. All statistical tests were 2-tailed, with a P value <0.05 considered statistically significant. Descriptive statistics were calculated in order to assess the population characteristics, and diagnostic testing was done to assess all of the variables pre-specified for inclusion in the analyses.

Mortality and complication rates were compared between the transferred and direct patients using Log Linear Poisson Regression Models. We attempted to control for transfer bias (higher injury severity in transferred patients as a results of transferring only the more severely injured patients), by adjusting for ISS in the rate comparison model. Continuous outcomes (LOS, ICU LOS, and TDT) were compared between the two groups using the Satterthwaite *t*-test after testing the equality of variances. Univariate analyses were used to assess the association between transfer status and the outcome variables. Multivariate analyses were then built based on the univariate analyses using the predictor variables described above. Logistic regression models were used for dichotomous outcomes (death and complication), using stepwise selection for the multivariate models. Generalized linear models (GLM) were used for the continuous outcome variables. A p-value ≤0.2 was considered for inclusion in the multivariate models and a p-value <0.05 was considered statistically significant in final multivariate models.

1.3. Data Completeness

The database was reviewed by the research coordinator to ensure data was complete, and missing data was extracted from patient charts whenever possible. Some information remained missing as a result of non-modifiable reporting issues, such as incomplete ambulance transfer forms. No data was missing for the primary outcomes of death, any major complication and ICU length of stay, or the predictor variables transfer status, ISS, age, and sex. Data was missing for 15% of patients (n = 244) for length of hospital stay, 34% (n = 522) for time to definitive treatment, and 53.8% (n = 829) for mode of transportation. Data were believed to be missing at random, and given that separate models were run and that the sample sizes were still sufficient, available data was used to handle missing data. All of the patients that met the inclusion from the database were included in the analyses, for a total sample size of 1451 patients. Patients were only excluded from the analyses when data was missing for the primary outcomes or predictor variables.

2. Results

2.1. Participants

A total of 1451 pediatric trauma cases were included in the analyses. 713 patients were directly transported to the trauma centre and 828 were transferred from other facilities (Table 1). Patients were followed from time of injury to discharge from hospital therefore the length of follow up was the duration of care. The approximate mean and median