



Hypotension and the need for transfusion in pediatric blunt spleen and liver injury: An ATOMAC + prospective study^{☆,☆☆}



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ABSTRACT

Purpose: Children with blunt liver or spleen injury (BLSI) requiring early transfusion may present without hypotension despite significant hypovolemia. This study sought to determine the relationship between early transfusion in pediatric BLSI and hypotension.

Methods: Secondary analysis of a 10-institution prospective observational study was performed of patients 18 years and younger presenting with BLSI. Patients with central nervous system (CNS) injury were excluded. Children receiving blood transfusion within 4 h of injury were evaluated. Time to first transfusion, vital signs, and physical exams were analyzed. Patients with hypotension were compared to those without hypotension.

Results: Of 1008 patients with BLSI, 47 patients met inclusion criteria. 22 (47%) had documented hypotension. There was no statistical difference in median time to first transfusion for those with or without hypotension (2 h vs. 2.5 h, $p = 0.107$). The hypotensive group was older (median 15.0 versus 9.5 years; $p = 0.007$). Median transfusion volume in the first 24 h was 18.2 mL/kg (IQR: 9.6, 25.7) for those with hypotension and 13.9 mL/kg (IQR: 8.3, 21.0) for those without ($p = 0.220$). Mortality was 14% (3/22) in children with hypotension and 0% (0/25) in children without hypotension.

Conclusion: Hypotension occurred in less than half of patients requiring early transfusion following pediatric BLSI suggesting that hypotension does not consistently predict the need for early transfusion.

Type of study: Secondary analysis of a prospective observational study.

Level of evidence: Level IV cohort study.

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Abbreviations: AIS, abbreviated injury score; BLSI, blood liver and/or spleen injury; CNS, central nervous system; ISS, injury severity score; NOM, nonoperative management; PTC, pediatric trauma center; REDCap, Research Electronic Data Capture.

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Hypotension is a significant marker of hemorrhagic shock in adults, but appears to be infrequent in children following blunt torso trauma, even in children with significant injury. Approximately 5% of pediatric patients who sustain significant torso trauma develop a liver or spleen injury (BLSI) [1]. In typical pediatric trauma center series, approximately a quarter of the patients are transfused, but frequency of hypotension is not commonly reported, or seen only in studies of failure of nonoperative management (NOM) [2,3]. Other studies have suggested that hypotension in injured children is more frequently associated with traumatic brain injury than bleeding and is a poor marker for hemorrhagic shock in children [4]. Although clinically difficult, the identification of children

with recent or ongoing bleeding is imperative for optimal management [5–7].

Children with BLSI requiring early transfusion may present in shock without hypotension despite significant bleeding [8–10]. When recognized late, resuscitation from higher percentages of blood loss may be more difficult, and hypotension caused by hemorrhage in pediatric patients has been considered a preterminal event by some authors [8–11].

Very few descriptive data on children with BLSI who are hypotensive are available, and even less on children with shock who do not experience a hypotensive event. In this population of children with BLSI who received early transfusion, the frequency of early tachypnea, pallor, and hypotension is not known. The purpose of this study is to describe the population of children who sustain a BLSI with and without hypotension who required early blood transfusion.

1. Methods

1.1. Study population

We conducted a secondary analysis of a prospective observational study. Patients were included in the study if they were 18 years or younger and presented to one of ten level I pediatric trauma centers (PTC) after BLSI between April 2013 and January 2016. Patients were excluded if their first transfusion was >4 h postinjury. Four hours from injury was chosen as the time frame to identify the majority of children with significant ongoing hemorrhage. Patients with a severe head injury, as defined by a head AIS score > 2, were excluded to prevent confounding by an associated injury. Patients without a documented time of injury (i.e., nonaccidental traumas) were also excluded (Fig. 1). Participating centers were members of the Arizona–Texas–Oklahoma–Memphis–Arkansas + Consortium (ATOMAC+) and included: Phoenix Children's Hospital (Phoenix, AZ), Dell Children's Medical Center (Austin, TX), Children's Medical Center Dallas, part of Children's HealthSM (Dallas, TX), Arkansas Children's Hospital (Little Rock, AR), The Children's Hospital at OU Medical Center (Oklahoma

City, OK), LeBonheur Children's Hospital (Memphis, TN), American Family Children's Hospital (Madison, WI), Akron Children's Hospital (Akron, OH), Children's Mercy Hospital (Kansas City, MO), and Children's Healthcare of Atlanta (Atlanta, GA). Each institution received institutional review board approval.

1.2. Definitions

Within in the ATOMAC algorithm, the criteria for blood transfusions were hemoglobin less than 7 g/dL or a symptomatic patient [5]. Symptomatic patients included those that manifested clinical signs of shock such as pallor, tachycardia, or cold extremities. Hypotension was defined as systolic blood pressure (mm Hg) $< 55 + (2 \times \text{age (years)})$ [e.g., a 5-year-old patient with a systolic blood pressure < 65 mm Hg would be considered hypotensive] [12]. Patients found to be hypotensive in the field, at the outside hospital, or after arrival to the PTC were classified as “hypotensive”. Anemia was defined as hemoglobin < 7.0 g/dL within 48 h of injury. For patients with both liver and spleen injury, the higher grade of injury was utilized for summary analysis. Patients who required surgery for splenectomy, splenorrhaphy, hepatectomy, hepatorrhaphy, or packing were considered failures of NOM caused by bleeding.

1.3. Data collection

Study data were collected and managed using REDCap (Research Electronic Data Capture) hosted at Phoenix Children's Hospital [13]. REDCap is a secure, Web-based application designed to support data capture for research studies, providing 1) an intuitive interface for validated data entry; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for importing data from external sources [13].

1.4. Data analysis

Descriptive statistics were used to report the frequency of hypotension, anemia caused by blood loss, demographics, and clinical data regarding patients and their treatment. Comparisons were made between hypotensive and normotensive patients, using chi-squared or Fisher's exact and Mann–Whitney for categorical and continuous data, respectively. Data were not normally distributed and therefore presented as median and interquartile range (IQR).

To report ability of clinical indicators to predict transfusion, parent-population of 1008 patients (excluding head injured patients and those with unknown time of injury) was used to run a sensitivity and specificity analysis; results are reported with 95% confidence intervals (95% CI). Data were analyzed using Stata13.1 (College Station, TX). All tests were two-tailed and statistical significance was assessed at the 0.05 level.

2. Results

During the 34-month study period, 1008 subjects were enrolled. Patients were excluded if they were not transfused within 4 h of injury ($n = 917$), had a head abbreviated injury score (AIS) greater than 2 ($n = 36$), had an unknown head AIS ($n = 3$) or had an unknown time of injury ($n = 5$), resulting in sample size of 47 patients (Fig. 1).

Overall, 25 (53%) patients were male; median age was 12.0 years [IQR: 8.2, 15.3]. Mechanism of injury was most commonly motor vehicle collision ($n = 23$; 49%) or being struck by a car as a pedestrian or cyclist ($n = 5$; 11%). Most patients in this cohort sustained a spleen injury ($n = 18$; 38%); 16 (34%) had a liver injury and an additional 13 (28%) had both a liver and spleen injury. Median Injury Severity Score (ISS) was 27 [IQR: 18, 38]. By design, all patients in this study required blood transfusion; median time from injury to transfusion was 2 h

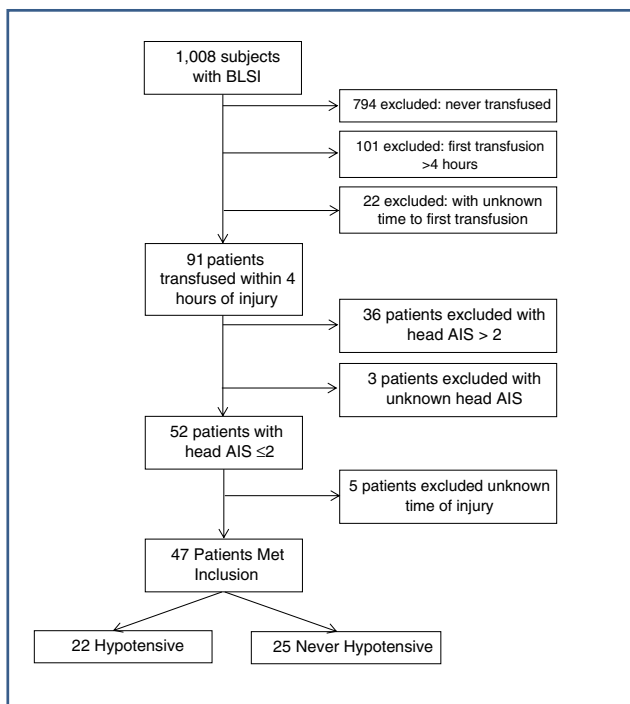


Fig. 1. Consort diagram depicting patient sorting for study inclusion and exclusion criteria and distribution to final hypotensive versus nonhypotensive cohort.

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