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Nonoperative management of penetrating abdominal solid organ injuries in children

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ABSTRACT

Background: Nonoperative management (NOM) of penetrating solid organ injuries (SOI) has not been well described in the pediatric population. The objective of this study was to characterize the epidemiology, injury patterns, and factors associated with trial and failure of NOM.

Methods: This is a retrospective cohort analysis of the National Trauma Data Bank for the period of 2007-2014. The study population included patients ≤18 y with penetrating injury to the liver, spleen, or kidney. NOM was defined as no operative intervention (exploratory laparotomy or operation involving the liver, spleen, or kidney) < 4 h of emergency department arrival. Failed NOM was defined as operative intervention ≥4 h after emergency department arrival. Multivariate logistic regression explored clinical factors potentially associated with trial and failure of NOM.

Results: Of 943,000 pediatric trauma patients included in the National Trauma Data Bank, 3005 (0.32%) met our inclusion criteria. Median age was 17.0 y; 88.8% were male. Gunshot wounds (GSW) accounted for 71.7% of injury mechanisms and stab wounds accounted for the remaining 28.3%. Median injury severity score was 9 (interquartile range: 5-13). Two thousand one hundred and twenty-one (70.6%) patients sustained kidney injury, 1210 (40.3%) liver injury, and 159 (5.3%) splenic injury. NOM was pursued in 615 (20.5%) patients. Factors significantly associated with immediate operative intervention included GSW, hypotension, and associated hollow viscus injury. Failed NOM was identified in 175 patients (28.5%). Factors significantly associated with failed NOM included GSW, high-grade SOI, and associated hollow viscus injury. Overall mortality was 26 (0.9%).

Conclusions: NOM can be safe in a carefully selected group of pediatric patients with penetrating SOI. Future prospective studies are warranted to validate its feasibility.

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Over the past few decades, the selective nonoperative management (NOM) of solid organ injuries (SOI) has become a widely accepted practice in pediatric patients following blunt abdominal trauma.[1,2] Selective NOM in blunt SOI has led to a decrease in nontherapeutic laparotomies, associated complications, hospital length of stay (LOS), and costs.[1,3,4] As a result, a significant decrease in operative intervention for pediatric blunt SOI has been observed in the United States.[4]

Historically, mandatory exploration of penetrating injuries was considered standard of care for the adult population. However, a high incidence of negative laparotomy was reported following abdominal penetrating injury.[5] Further, contemporary data have led to a major paradigm shift such that selective NOM is now considered the appropriate management for adult patients sustaining penetrating abdominal trauma, who are hemodynamically stable without signs of peritonitis.[6-10] To date, little data have examined whether the use of selective NOM in pediatric patients with SOI following penetrating abdominal trauma is an appropriate management strategy. In contrast to adult patients, selection principles for NOM for penetrating SOI are not well defined in children, and there are conflicting reports on the need for mandatory exploration.[9,11,12] Furthermore, no previous studies have assessed for clinical factors associated with failure of NOM for penetrating SOI in pediatric population.[6]

The aims of this study were to characterize the epidemiology, injury patterns, and patient-level factors associated with trial and failure of NOM for penetrating abdominal SOI in the pediatric population and to characterize outcomes in this specific group of trauma patients. We hypothesized that selective NOM would be safe in carefully selected pediatric patients who sustain penetrating abdominal SOI.

Methods

Study design and patient selection

We performed an 8-y (2007-2014) retrospective analysis of the National Trauma Data Bank (NTDB). The NTDB is a nationwide trauma database maintained by the American College of Surgeons and contains data on more than 5 million patients, with contributions from more than 900 trauma centers across the United States. Our study was approved as exempt by the institutional review board of the University of Southern California.

Patients ≤18 y of age were included. Penetrating solid organ (liver, kidney, spleen) injuries were identified using the International Classification of Disease (ICD)-9 diagnosis and external cause of injury codes. Patients were excluded if they were pronounced dead on arrival or if they were lost to follow-up following the index hospitalization (hospital disposition: left against medical advice) or if they had associated severe injuries defined as abbreviated injury scale ≥3 to the head, neck, chest, spine, or extremity. The primary outcome included initial trial of NOM and NOM failure. The definition of NOM was time dependent and consisted of no emergent operative intervention for abdominal injuries <4 h after arrival to emergency department (ED) based on previous data in adult patients.[10] NOM failure included any major abdominal operations ≥4 h of ED arrival, including diagnostic laparoscopy. Major abdominal operations were defined by ICD-9 procedure codes and included exploratory laparotomy (54.11) as well as operations on the spleen (41.00-41.99), esophagus (41.20-42.19, 42.30-42.80, 42.84-42.92), hollow viscus (43.00-43.99, 44.00-44.09, 44.30-44.61, 44.63-44.99, 45.00-47.99, 48.60-48.99), liver (50.00-50.09, 50.20-50.89, 50.99), hepatobiliary (51.00-51.09, 51.20-51.99), pancreas (52.00-52.09, 52.20-52.99), kidney (55.00-55.19, 55.30-55.99), urinary system (56.00-56.29, 56.40-56.99), and vascular (38.04, 38.06, 38.07, 38.14, 38.16, 38.34, 38.36, 38.37, 38.44, 38.46, 38.47, 38.84, 38.86, 38.87, 39.10, 39.24, 39.26, 39.30-39.35, 39.79, 39.93, 39.98, 39.99). Angiography and angioembolization (39.79, 88.40, 88.45, 88.47, and 88.49) were considered separately and did not constitute NOM failure.

We abstracted the following variables: patient demographics, ED vital signs and Glasgow coma scale, mechanism of injury, injury severity using injury severity score and abbreviated injury scale, mechanical ventilation support, intensive care unit (ICU) admission, hospital LOS, ICU LOS, and in-hospital mortality. Tachycardia was defined as a pulse rate >120. Hypotension was defined according to age as follows: systolic blood pressure (SBP) < 90 mmHg if age ≥10 otherwise SBP < (70 + 2 × age) if age <10.[13] We also calculated shock index, pediatric age-adjusted (SIPA: heart rate/SBP).[14] Cutoffs used to define increased SIPA were following: 1.2 (age 1-6), 1.0 (age 7-12), and 0.9 (age 13-18) as defined by Acker *et al*.[14]

Statistical analysis

Descriptive statistical analysis was performed for the study population. Values were reported as mean with standard deviation for continuous variables with normal distributions, median with interquartile range (IQR) for continuous variables with nonnormal distributions, and as frequencies for categorical variables. Bivariate analysis was performed using chi-square to test differences in proportions and unpaired Student's *t*-test or Wilcoxon test to compare differences between means and medians, respectively. Mantel–Haenszel chi-square was used to test for the significance of a linear relationship between ordinal variables. Univariate logistic regression was performed to assess for the association between clinically relevant variables and trial and failure of NOM. Variables that were significantly associated with the outcome of interest were then included in a multivariable model with results reported as raw and adjusted odds ratios (OR) and 95% confidence intervals (CIs). A two-sided *P* value of 0.05 was considered statistically significant, and no adjustments were made for multiple comparisons. Statistics were performed using SAS software (Version 9.4; SAS Institute, CARY, NC).

Results

A total of 63,716 pediatric patients with SOI were identified in the NTDB during our study period. Of these, 7330 (11.5%) were due to a penetrating mechanism of injury. After excluding 3936 patients that had severe concomitant injuries and 389