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The incidence of delayed splenic bleeding in pediatric blunt trauma☆,☆☆

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ABSTRACT

Background: One of the concerns associated with nonoperative management of splenic injury in children has been delayed splenic bleed (DSB) after a period of hemostasis. This study evaluates the incidence of DSB from a multicenter 3-year prospective study of blunt splenic injuries (BSI).
Methods: A 3-year prospective study was done to evaluate nonoperative management of pediatric (≤18 years) BSI presenting to one of 10 pediatric trauma centers. Patients were tracked at 14 and 60 days. Descriptive statistics were used to summarize patient and injury characteristics.
Results: During the study period, 508 children presented with BSI. Median age was 11.6 [IQR: 7.0, 14.8]; median splenic injury grade was 3 [IQR: 2, 4]. Nonoperative management was successful in 466 (92%) with 18 (3.5%) patients undergoing splenectomy at the index admission, all within 3 h of injury. No patient developed a delayed splenic bleed. At least one follow-up visit was available for 372 (73%) patients.
Conclusion: A prior single institution study suggested that the incidence of DSB was 0.33%. Based on our results, we believe that the rate may be less than 0.2%.
Level of evidence: Level II, Prognosis.

Delayed splenic bleeding (DSB) is described as a rare event historically associated with high mortality [1–3]. First described by Baudet in 1907, the reported incidence in adults ranges from 0.3% to 2%, with a best estimate in adults of approximately 0.27% [4,5]. DSB presentation in adults typically occurs between 4 and 8 days postinjury [6,7] but has been reported more than 5 years later [8,9]. In children, the definitive incidence of DSB is not known [10]. A recent study of splenic pseudoaneurysm suggests that 9% of children develop pseudoaneurysm after injury, but it appears unlikely that the incidence of DSB is anywhere near this frequent [10,11]. One study estimates it to be as low as 0.33% with delayed presentations reportedly occurring from 2 to 30 days postinjury. [1,6,12–17] Cases of DSB have been linked to subcapsular hematomas, clot disruption, rupture of a pseudoaneurysm, or splenic pseudocyst causing severe internal bleeding [7,17–19]. Fourteen pediatric cases reported in the literature since 1980 were collected in a case report and literature review by Davies et al. The mean age was 14 years (±4 years). The mean time to DSB was 10 (±7) days, although as many as half may not meet true criteria [1,20]. Their one case report adds to the count of pediatric DSB reported in the literature since 1980 [1], as does a recent potential case from Eastern Europe [21]. Research has not found common elements in mechanism, imaging characteristics or the presence of pseudoaneurysm among reported cases, despite widespread assumptions of a correlation [7,10].

The frequency of DSB after nonoperative management of traumatic splenic injury is still subject to some controversy and debate. Prior research has found it difficult to differentiate between true delayed

Abbreviation: BLSI, blunt liver and/or spleen injury.

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ruptures and delayed presentation of acute injuries [16,21,22]. Both the lack of a consistent empirical definition of DSB and variation in detection have undermined reliable measurement of the frequency of DSB. Many of the cases reported in the literature appear to have been continued bleeding or delayed detection, rather than delayed bleeds [1,15,20,21]. True delayed bleeds do not appear to occur commonly during the typical period of hospitalization but develop after a significant period of latency [1,5,12]. Case reports have not consistently defined the latency period [21], and the true incidence of DSB in children is still unknown.

With increasing numbers of children with successful nonoperative management after BSI, the opportunity to calculate accurate rates of delayed splenic bleed has also improved. One institution with a longstanding history of NOM suggested a DSB rate of 1 per 303 children with splenic injury (0.33%) [1]. The index case was observed 23 days after injury, resulting in death. This is the only known fatal case of a pediatric true delayed splenic bleed in the era of modern imaging. The purpose of this study is to estimate the frequency of DSB in children age 0–18 years who experience splenic injuries using prospective multi-institutional data.

1. Materials and methods

1.1. Study population

A planned secondary analysis was conducted as part of a prospective observational study of patients with blunt liver and/or spleen injury identified by computed tomography (CT). Patients 18 years of age or younger, presenting to any of the 10 level 1 pediatric trauma centers (PTC) between April 2013 and January 2016 were included. For purposes of this analysis, only patients with spleen injuries, both with and without other concurrent injuries were included. Participating centers were part of the Arizona-Texas-Oklahoma-Memphis-Arkansas + Consortium (ATOMAC+) and included: Phoenix Children's Hospital (Phoenix, AZ), The Children's Hospital at OU Medical Center (Oklahoma City, OK), Children's Medical Center, part of Children's Health℠ (Dallas, TX), Le Bonheur Children's Hospital (Memphis, TN), Dell Children's Medical Center (Austin, TX), Arkansas Children's Hospital (Little Rock, AR), Children's Healthcare of Atlanta (Atlanta, GA), Mercy Children's Hospital (Kansas City, MO), Akron Children's Hospital (Akron, OH), and American Family Children's Hospital (Madison, WI). All institutions had previously adopted the ATOMAC protocol for the nonoperative management of BLSI [23]. Institutional Review Board approval was obtained at each institution.

1.2. Data collection & definitions

Study data were collected and managed using REDCap electronic data capture tools hosted by Phoenix Children's Hospital. REDCap (Research Electronic Data Capture) 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 [24]. Data collected during the study included demographics, injury characteristics, vitals (from scene and transfer centers, where applicable, and PTC), labs, radiology, procedures, and short- (14 days postinjury) and long- (60 days postinjury) term outcomes.

To determine delayed splenic bleed (DSB), patients were assessed prior to discharge and followed up at 2 weeks postinjury and again at 60 days from the date of the injury. DSB was defined as development of new bleeding confirmed by surgery, ultrasound, or computed tomography (CT) by 14 or 60 days postinjury. All patients were on a protocol allowing for abbreviated periods of bed rest and early discharge as described in the ATOMAC guideline [23]. Activity restriction preventing sports and rough play was recommend per the APSA guideline for a period equal to the grade of injury +2 (in weeks) [25]. Raw counts of incidence were generated for all patients at 14 days and 60 days of follow-up.

1.3. Statistical analysis

Descriptive statistics were used to summarize patient, injury and clinical characteristics at injury and at follow-up. Data were summarized using counts for categorical variables or median and interquartile range (IQR) for ordinal variables. Patients with follow up were compared to patients without follow up to assess the risk of selection bias in the calculation of incidence. Comparisons between the patients with and without follow-up were made using the Wilcoxon Signed Ranks Test and the Chi-Square Test as appropriate. Statistical significance was set at $p \leq 0.05$ for a 2-tail test. An analysis was employed to determine the likelihood of observing at least one occurrence of DSB based on the sample size at follow-up with a 95% confidence interval, and an analysis was done to estimate a 50% likelihood with no events for the given population. Data from follow-up at 14 days and 60 days were combined in estimating the likelihood of observing incidence. Data were analyzed using SPSS version 20 [26].

2. Results

2.1. Patient characteristics

During the 34 month study period 508 patients presented with BSI. Two-thirds were male and 297 (58%) had a splenic injury grade of ≥3. A full description of the cohort demographics, splenic injury, and clinical characteristics is found in Tables 1, 2, and 3, respectively. Of the cohort, 372 (73%) had follow-up data: 194 had available follow-up data at both 2 weeks and 60 days; 129 had follow-up data at 2 weeks only and 39 had follow-up data at 60 days only (Fig. 1). DSB was defined as an event occurring after discharge and within the period of follow-up. No patient experienced a delayed splenic bleed (DSB). Surgeons initially assessed 180 (35%) of the 508 study patients as having recently bled or bleeding owing to solid organ injury at arrival to the pediatric trauma center. Another 29 patients were classified as bleeding from any source after admission but prior to discharge. Of the 180 bleeding patients, 132 (73%) had follow-up data (similar to the overall follow up).

The entire patient cohort was compared to the proportion of patients in the follow-up to assess the risk of selection bias in the calculation of incidence. There were no differences in patient characteristics (Table 1), injury grade (Table 2), or clinical characteristics (Table 3) suggesting that the follow-up cohort can be treated as equivalent to the

Table 1
Patient demographics.

Patient Demographics	n = 508 n (%) Median [IQR]
Gender	
Female	171 (33.7)
Male	337 (66.3)
Race/Ethnicity	
White	355 (69.9)
Hispanic/Latino	73 (14.4)
Black	64 (12.6)
American Indian	6 (1.2)
Other	15 (3.0)
Insurance	
Public	252 (49.6)
Commercial	225 (44.3)
None	28 (5.5)
Other/unknown	3 (0.6)
Weight (kg)	44.2 [25.7, 62.6]
BMI	20.4 [17.2, 25.3]
Age	11.6 [7.0, 14.8]

Definition of abbreviations: IQR = interquartile range.