

Original Research Article

A retrospective examination of the management of pediatric blunt spleen and liver injuries

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Abstract

Introduction: The American Pediatric Surgical Association (APSA) has published validated guidelines regarding non-operative management of pediatric blunt spleen and liver injuries (BSLI) based on injury grade. Although these guidelines exist, few studies have examined guideline implementation and adherence in a clinical setting. This study sought to examine current clinical treatment of BSLI and assess practitioner adherence to guidelines at a single pediatric tertiary care center.

Methods: A retrospective review was performed of all pediatric patients (<18 years) in the local Trauma Registry who received non-operative management of BSLI between January 1st, 2004 and November 31st, 2014. Collected data included demographic information, guideline compliance and radiology grade reporting. Statistical analyses with chi square tests were conducted to assess differences between spleen/liver injuries and organ injury grades.

Results: Sixty-five (92%) abstracted cases were analyzed. Guideline compliance for intensive care unit (ICU) admission, length of hospitalization, pre-/post-discharge imaging, and physical activity restriction were 29%, 21%, 75%, 75%, and 40%, respectively. Radiologists reported injury grades in 22% of spleen cases and 15% of liver cases (p=0.46). Additionally, 8% of spleen and 33% of liver injuries (p=0.01) did not have a reported grade of organ injury.

Discussion: At this center, a substantial number of BSLI cases had no reported grade, and APSA guideline adherence was low for ICU admission, activity restriction, and length of hospitalization. In order to emphasize the importance of guideline compliance, future directions include the creation of clinician and patient educational handouts to increase adherence rates.

Keywords: Non-operative injury; guidelines; pediatric; blunt; spleen; liver

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Introduction

Traumatic injuries account for an estimated 500,000 hospitalizations and 20,000 paediatric deaths annually (1). Within this category, abdominal injuries are frequently cited as the second most common cause of trauma-related death and are reportedly found in 10-15% of pediatric trauma patients (2,3). More specifically, amongst all cases of traumatic paediatric abdominal injuries, approximately 30% involve blunt spleen and liver injuries (4). Within the pediatric population, non-operative management of blunt spleen and liver injuries (BSLI) is the standard method of treatment for hemodynamically stable patients. This method has been associated with reduced hospital costs, earlier discharge, and improved mortality rates (5,6). Non-operative management is dictated by various protocols, such as the American Pediatric Surgical Association (APSA) evidence-based guidelines, the abbreviated APSA protocol, and the Arizona Texas Oklahoma Memphis Arkansas Consortium (ATOMAC) Protocol (7-9).

Currently, the majority of paediatric centers utilize the APSA protocol, which was published by Dr. Stylianos and the APSA Trauma Committee in 2000 based on evidence from a retrospective review of 856 children (8). These guidelines recommend the appropriate length of hospital stay, intensive care unit (ICU) admission, pre-discharge imaging, post-discharge imaging, and interval of physical activity restriction based on the computerized tomography (CT) determined grade of the injury (7). Adherence to these guidelines is integral to treatment success, as they have been shown to improve resource utilization, increase conformity of treatment, and safely and effectively treat patients (7,8,10,11). This protocol was prospectively validated by Stylianos and the APSA Liver/Spleen Trauma study group in 2002 and again in 2004 by Leinwand et al. (10,11). In comparison to historical controls, these prospective studies reported a significant reduction in ICU stay, length of hospital stay, follow up imaging, and interval of activity restriction. In both studies, no patients required operation for BSLI, providing further evidence of the effectiveness of these guidelines (10,11). Despite the demonstrated safety and efficacy of the APSA guidelines for non-operative management of BSLI, few studies have sought to examine compliance and clinician adherence to these guidelines (7,8,10,11). Furthermore, the implementation of such guidelines, as well as their documentation, can prove to be challenging, as many sites do not adequately report such data. Additionally, certain components lack standardization, such as the restriction of activity, which requires patient self-reporting (12). Lastly, it is not always possible to adhere to strict criteria on the basis of clinical judgement (13). The aim of this study was to examine current clinical practice at a single tertiary healthcare center in the treatment of BSLI, and to assess local compliance and practitioner adherence to the standardized APSA guidelines over the last ten years.

Methods

Following ethics approval by the local Research Ethics Board (REB Approval #14-890-C), a retrospective chart review was performed. De-identified medical records of patients at a single

paediatric tertiary healthcare center in Southern Ontario were obtained through the Institutional Trauma Registry. Patient records were included for analysis if the patient was <18 years of age, had been treated between January 1st, 2004 and November 31st, 2014, and had received non-operative management for a blunt spleen and/or liver injury. This timeframe was chosen as it was believed to be representative of the time at which the APSA guidelines were implemented locally. Records were excluded if patients had sustained a grade V injury, or were treated for penetrating, rather than blunt, spleen and/or liver injuries, as treatment of such injuries is outside the scope of the APSA guidelines. Hospital admissions data were collected from patient records and included patient demographics, Injury Severity Score (ISS), admission hemoglobin levels, mechanism of injury, grade of organ injury and by whom it was determined (e.g., physician, radiologist, other), method of diagnosis (e.g., operation, ultrasound, CT), transfusion status, additional injuries, and outcome (e.g., death, hospital readmission).

Guideline adherence was assessed using the guidelines established by the APSA Trauma Committee in 2000, which focus on the following primary outcomes: ICU admission, length of hospitalization, pre-discharge imaging, post-discharge imaging, and activity restrictions (Table 1). These guidelines are based on the CT-determined grade of organ injury and exclude recommendations for patients with grade V injuries, as they are rare and require treatment beyond the scope of the guidelines. The guidelines suggest that length of hospitalization (in days) should be determined by the grade of organ injury plus one, and only patients with a grade IV injury should be admitted to the ICU for one day of observation. The guidelines also propose that physical activity restriction (in weeks) is to be determined by the grade of injury plus two, and that pre-discharge, as well as post-discharge, imaging should not be routinely ordered for any grade of injury (7). Overall compliance to the guidelines was assessed by analyzing cases for ICU admission, length of hospitalization, pre-/post- discharge imaging and activity restrictions, and by comparing the values to those recommended by the APSA guidelines. Each medical record was examined by a single reviewer and assigned a categorical value of 1= adherent vs. 0=non-adherent for each domain outlined by the guidelines. In the event of uncertainty regarding adherence, a second independent reviewer was consulted. Based on the data and the retrospective nature of the study, blinding to the outcome of interest was not possible.

Data were collected and recorded using secure, encrypted Research Electronic Data Capture (REDCap) online data collection forms. Statistical analyses were performed using IBM SPSS V21.0 software. Descriptive statistics were calculated to estimate overall adherence to guidelines. Chi square tests were conducted to assess for subgroup differences in reporting and guideline compliance between grades (I-IV) and organ of injury (spleen vs. liver), with a cut-off of $p < 0.05$ considered significant.

Table 1. APSA evidence-based guidelines

	CT Grade*			
	I	II	III	IV
ICU Stay (days)	NR	NR	NR	I
Hospital Stay (days)	2	3	4	5
Pre-discharge imaging	NR	NR	NR	NR
Post-discharge imaging	NR	NR	NR	NR
Activity restriction (weeks)	3	4	5	6

*Grade of solid organ injury based on AAST organ injury scale; NR, not required

Results

Of the 71 patient records obtained from the Trauma Registry, 65 cases were included in the final analysis (Table 2). Six cases were excluded; two cases involved penetrating injuries, two cases were not treated for BSLI (wrongfully included), and two cases were unavailable for data abstraction.

Grade IV injuries (n=29) were found to be most prevalent, comprising 45% of all included cases. Organ injuries were diagnosed almost exclusively by CT scan (n=63); only two patients were diagnosed by ultrasound or operation. Ten (15%) patients developed complications (Table 3) during their initial treatment and eight (12%) patients were readmitted to the hospital following discharge, the majority of which were treated for grade IV injuries (n=5). Only one (1.5%) patient died while receiving treatment at this institution due to uncontrolled bleeding during exploratory surgery. No patients required surgery to treat BSLI injuries; therefore, no deviation from non-operative management occurred.

Although 52 (80%) cases were given a grade of I-IV, 13 (20%) cases had no reported organ injury grade. Of the cases that were given a grade, grading of injuries was reported by attending physicians, radiologists, or was indicated in the Trauma Registry and thus denoted as “other” (Figure 1a and 1b). For both spleen and liver injuries, attending physicians reported the largest proportion of grades, 50% and 52%, respectively (p=1.00). In comparison, radiologists graded only 22% and 15% of spleen and liver injuries, respectively (p=0.46). The proportion of cases with no reported grade was significantly larger for liver injuries (33%) in comparison to splenic injuries (8%) (p=0.01).

Table 2. Patient demographics

	Grade I n=3(%)	Grade II n=10(%)	Grade III n=10(%)	Grade IV n=29(%)	Not Reported n=13(%)
Age (mean years \pm SD)	12.3 \pm 5.5	10.5 \pm 5.2	10.4 \pm 3.9	11.3 \pm 4.1	12.2 \pm 3.1
Sex					
Male	2 (67%)	6 (60%)	5 (50%)	22 (76%)	6 (46%)
Female	1 (33%)	4 (40%)	5 (50%)	7 (24%)	7 (54%)
ISS 90 (mean \pm SD)	13.0 \pm 0	18.0 \pm 5.9	19.0 \pm 10.6	19.7 \pm 6.0	19.8 \pm 9.6
Length of Hospitalization (days) (median)	1.0 (1-5)	4.5 (2-16)	5.0 (3-49)	6.0 (2-67)	4.0 (1-18)
Method of Diagnosis					
CT	3 (100%)	9 (90%)	10 (100%)	29 (100%)	12 (92%)
Ultrasound	-	1 (10%)	-	-	-
Operative	-	-	-	-	1 (8%)
Mechanism of Injury					
MVC	3 (100%)	4 (40%)	3 (30%)	6 (20%)	8 (62%)
Pedestrian Accident	-	1 (10%)	1 (10%)	4 (15%)	2 (15%)
Fall	-	1 (10%)	2 (20%)	6 (20%)	2 (15%)
Bicycle Accident	-	2 (20%)	1 (10%)	8 (28%)	-
Other	-	2 (20%)	3 (30%)	5 (17%)	1 (8%)
Transfused	-	1 (10%)	2 (20%)	5 (17%)	3 (23%)
Hospital Readmission	1 (33%)	-	1 (10%)	5 (17%)	1 (8%)
Death	-	-	-	-	1 (8%)

Table 3. Patient complications

Complication	Organ Injured	Grade of Injury	Length of Hospitalization (days)
Left lower effusion	Spleen	4	8
Nosocomial pneumonia	Liver	4	6
Left pleural effusion	Spleen	4	8
Prolonged ileus	Spleen	3	11
Paralytic ileus, right hepatic artery aneurysm requiring embolization, right antecubital thrombophlebitis, SIADH	Liver	4	21
Urinary tract infection	Liver	Not Reported	5
Left pleural effusion	Spleen	4	7
Hepatic artery pseudo aneurysm rupture; pleural effusion, nosocomial bacterial infection, abdominal infection	Liver	4	67
Extensive bleeding during abdominal surgery	Liver	Not Reported	1*
Bacterial infection due to multiple exposed wounds	Liver	3	49

* Patient died during surgery

Forty-four (68%) cases were treated for additional injuries in conjunction with BSLI, with 32 (63%) cases given a documented organ injury grade (Table 4). Median length of hospitalization increased as the grade of injury increased; grade I, II, III and IV injuries had a median length of hospitalization of 1.0 (1-5), 4.5 (2-16), 5 (3-49) and 6 (2-67) days, respectively. The longest hospital stay was 67 days and involved a grade IV isolated liver injury.

Table 4. Additional injuries and length of hospitalization by grade of organ

Grade of Organ Injury	Median Length of Stay (days) (range)	APSA Guidelines Length of Stay (days)	Additional Injuries
Grade I (n=3)	1.0 (1-5)	2.0	3 (100%)
Grade II (n=10)	4.5 (2-16)	3.0	10 (100%)
Grade III (n=10)	5.0 (3-49)	4.0	8 (80%)
Grade IV (n=29)	6.0 (2-67)	5.0	11 (38%)

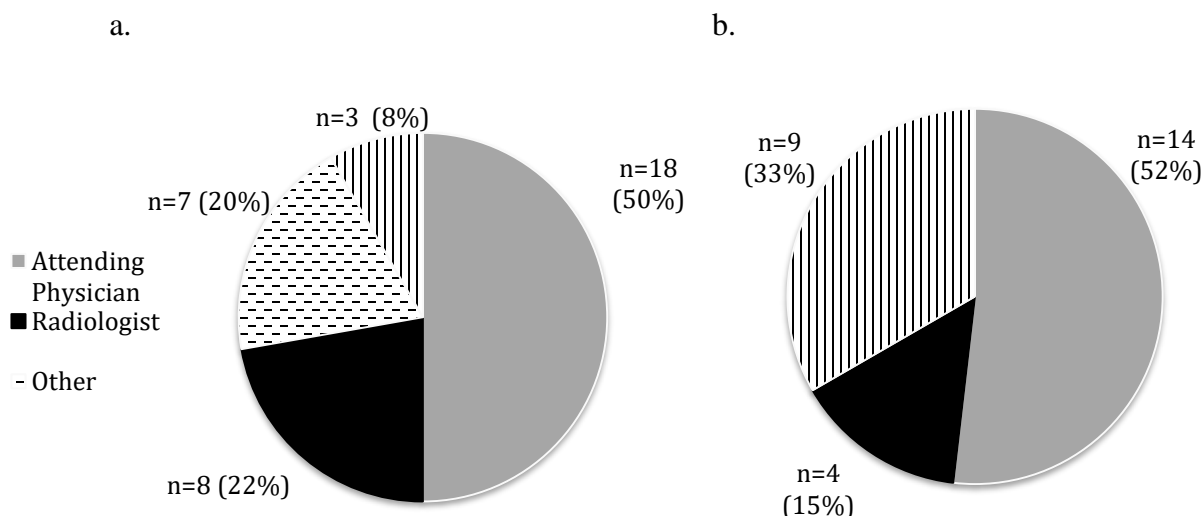


Figure 1. Breakdown of reporting of grade by specialty. a) Spleen injuries; b) Liver injuries

Only cases with a reported grade (n=52) were analyzed for compliance. Overall ICU compliance was 29%, length of hospital stay compliance was 21%, pre-discharge imaging compliance was 75%, post-discharge imaging compliance was 75%, and activity restriction compliance was 40% (Table 5). APSA guideline compliance was further assessed through stratification of cases by organ injury (Table 5). Chi square tests were conducted in order to assess statistically significant differences in compliance between spleen and liver injuries, and between grades. Although non-significant, a substantial difference in length of hospital stay guideline compliance between spleen and liver injuries was noted (30% vs. 6%, $p=0.072$).

Discussion

The APSA guidelines published in 2000 were initially adopted by many centers as the standard protocol for non-operative management of BSLI (2,7,11). These guidelines were validated and proven to be safe and effective in reducing hospital resource utilization and standardizing non-operative management of hemodynamically stable BSLI patients (2,6,8,10). However, few studies have assessed clinician compliance and adherence to the validated APSA guidelines (6,10,11). We therefore sought to retrospectively examine clinical practice and adherence to the guidelines at our institution over a ten-year period.

These guidelines recommend length of hospitalization, activity restriction, ICU admission, and pre-discharge, as well as post-discharge, imaging based on CT determined grades.(7,11) As a result, radiologists are the suggested professionals for reporting organ injury grades. Our results suggest that there may be a lack of formal reporting by radiologists at this center, with attending professionals reporting the majority of organ injury grades for both spleen

Table 5. Compliance with APSA guidelines

	Percent Compliance (%)				
	ICU	Length of Hospitalization	Pre-discharge Imaging	Post-discharge Imaging	Activity Restrictions
Overall Compliance (n=52)	29 (15)	21 (11)	75 (39)	39 (75%)	21 (40%)
Spleen (n=33)	27 (9)	30 (10)	78 (26)	25 (75%)	14 (42%)
Liver (n= 18)	28 (5)	6 (1)	50 (12)	13 (72%)	7 (39%)
Liver & Spleen (n=1)	100 (1)	0	100 (1)	100 (1)	0

and liver injuries. Furthermore, a substantial proportion of cases in this study population did not have a reported grade of organ injury. The disparity in reporting of grades is concerning, as previously conducted studies suggest that the grading of splenic and liver injuries is crucial for effective non-operative management and is most accurate when reported by radiologists using standardized scales (7,10,11,14).

Homann et al. found that increased use of the validated American Association for the Surgery of Trauma's (AAST) organ injury scale by radiologists was correlated with an increase in precision and ability to properly diagnose the severity of BSLI (14). Proper diagnosis of injury grade has substantial implications for non-operative treatment, as recommendations for management differ by grade of injury. It is possible that this lack of radiologist involvement at our site is due to a lack of promotion of the APSA guidelines, as management of BSLI has long been delegated to the domain of the surgeons, and there are few studies examining the guidelines at Canadian centers (15).

Length of hospitalization at this institution consistently exceeded the recommended length of stay according to APSA guidelines for grade II-IV injuries, which was exemplified by the subsequent low compliance rate. Compliance with ICU admission guidelines was also low, demonstrating that many individuals were either admitted to the ICU without indication or exceeded the recommended length of ICU stay. Unnecessitated ICU admission and length of hospitalization, as dictated by APSA guidelines, results in an over-expenditure of hospital resources. It must be noted, however, that the APSA guidelines dictate management of isolated spleen and liver injuries. In order to increase generalizability of results, this study also included multiply injured individuals. Inclusion of all cases treated for BSLI may be responsible for the observed increased median length of hospital stay.

Similar to previous studies examining guideline compliance, our findings demonstrated that compliance was highest for pre-discharge and post-discharge imaging guidelines. Stylianos et al. found that practitioners were most compliant with guidelines for follow-up imaging (87%) (11). Literature suggests that follow-up imaging is unnecessary and costly for patients undergoing non-operative management of BSLI (16). Contrastingly, compliance with proposed intervals for activity restriction was considerably lower in comparison to previous studies. In their prospective examination, Stylianos et al. found that 78% of cases were managed in compliance with proposed activity restriction, and compliance was higher for less severe injuries (87% for grades I and II vs. 72% in grades III and IV) (11). Our study found that less than half of all cases were compliant with proposed intervals of activity restriction, and compliance rates were similar between spleen and liver injuries. Low compliance with the proposed interval of activity restriction may be due to the guidelines themselves. The APSA guidelines state that the proposed interval of activity restriction is for return to unrestricted “normal” age-appropriate activities, but that return to full-contact activities is left to the discretion of the individual pediatric trauma surgeon (7,11). A lack of consensus around what comprises “normal” age-appropriate activities may lead to confusion regarding how long a child must wait to return to activities and may contribute to the low rate of guideline compliance. Assessing activity restriction compliance is also challenging, as many physicians fail to state the prescribed interval of activity restriction at discharge, and, when they do, few explicitly state which activities the patient must abstain from.

Although the APSA guidelines have served as the standard for non-operative management at many institutions since their initial publication, less “conservative” recommendations, such as the abbreviated bedrest protocol and the ATOMAC guidelines, are gaining increasing attention and implementation (2,8,9). The recently validated ATOMAC guidelines dictate treatment based upon hemodynamic stability rather than organ injury grade. These guidelines have been proposed in order to further standardize care and improve resource utilization, as the benchmarks set by the APSA guidelines were rarely met in many clinical settings (9). Our findings support this assertion, as compliance with guidelines for hospital stay, activity restriction, and ICU admission remained low. Prior to adopting a new protocol, we felt it necessary to assess current practice and compliance with institutional guidelines in order to identify disparities in clinical practice. Implementation of the ATOMAC protocol at our institution may be warranted; however, education with regards to the practice management pathway is crucial in order to adhere to this newly proposed guideline for non-operative management of pediatric BSLI patients.

There are several important limitations of this study, including its retrospective nature and small sample size. Our analysis was also limited by missing data, particularly for reported grade. Since a substantial proportion of cases had no reported grade in the medical charts or the Trauma Registry, compliance to guidelines could not be measured for all included cases; this may have introduced selection bias if reporting was associated with grade of organ injury. In addition, this study’s small sample size resulted in low power to detect differences, which may have resulted in missed differences across organs and injury grades. Despite these limitations, literature is sparse

on this topic, so these findings provide valuable insight into current clinical treatment of paediatric BSLI and local APSA guideline compliance.

Conclusion

The findings of this study have provided valuable insight regarding compliance rates and the grading of organ injuries at this institution. These findings suggest that the reporting of organ injury grades by radiologists is lacking and compliance with interval of activity restriction, ICU admission, and length of hospital stay remains low. In order to improve compliance and the ability to assess practitioner adherence to APSA guidelines, there must be an increased reporting of grades. We suggest that a standard organ injury scale be adopted and that grade of BSLI be documented consistently in CT reports.

The findings of this study also indicate the need for increased compliance with proposed interval of activity restriction and consensus on what be recommended as “normal age-appropriate activities.” Subsequently, patient handouts, which specify the details of activity restriction duration, as well as what activities to avoid, should be distributed to increase patient compliance. A future prospective study is warranted to ensure standardized radiology reporting and adherence to clinical practice guidelines to enhance the quality of patient care at this institution.

References

1. Sivit CJ. Imaging children with abdominal trauma. *AJR Am J Roentgenol.* 2009;192(5):1179-1189.
2. Dodgion CM, Gosain A, Rogers A, St Peter SD, Nichol PF, Ostlie DJ. National trends in pediatric blunt spleen and liver injury management and potential benefits of an abbreviated bed rest protocol. *J Pediatr Surg.* 2014;49(6):1004-1008; discussion 1008.
3. Ludwig S. Pediatric abdominal trauma. *Topics in Emergency Medicine.* 1993;15(2):40-47.
4. Coburn MC, Pfeifer J, DeLuca FG. Nonoperative management of splenic and hepatic trauma in the multiply injured pediatric and adolescent patient. *Arch Surg.* 1995;130(3):332-338.
5. Stassen NA, Bhullar I, Cheng JD, et al. Selective nonoperative management of blunt splenic injury: an Eastern Association for the Surgery of Trauma practice management guideline. *J Trauma Acute Care Surg.* 2012;73(5 Suppl 4):S294-300.
6. Stylianos S. Outcomes from pediatric solid organ injury: role of standardized care guidelines. *Curr Opin Pediatr.* 2005;17(3):402-406.
7. Stylianos S. Evidence-based guidelines for resource utilization in children with isolated spleen or liver injury. The APSA Trauma Committee. *J Pediatr Surg.* 2000;35(2):164-167; discussion 167-169.
8. St Peter SD, Sharp SW, Snyder CL, et al. Prospective validation of an abbreviated bedrest protocol in the management of blunt spleen and liver injury in children. *J Pediatr Surg.* 2011;46(1):173-177.
9. Notrica DM, Eubanks JW, 3rd, Tuggle DW, et al. Nonoperative management of blunt liver and spleen injury in children: Evaluation of the ATOMAC guideline using GRADE. *J Trauma Acute Care Surg.* 2015;79(4):683-693.
10. Leinwand MJ, Atkinson CC, Mooney DP. Application of the APSA evidence-based guidelines for isolated liver or spleen injuries: a single institution experience. *J Pediatr Surg.* 2004;39(3):487-490; discussion 487-490.
11. Stylianos S. Compliance with evidence-based guidelines in children with isolated spleen or liver injury: a prospective study. *J Pediatr Surg.* 2002;37(3):453-456.
12. Notrica DM, Sayrs LW, Krishna N, et al. Adherence to APSA activity restriction guidelines and 60-day clinical outcomes for pediatric blunt liver and splenic injuries (BLSI). *J Pediatr Surg.* 2019;54(2):335-339.

13. Linnaus ME, Langlais CS, Garcia NM, et al. Failure of nonoperative management of pediatric blunt liver and spleen injuries: A prospective Arizona-Texas-Oklahoma-Memphis-Arkansas Consortium study. *J Trauma Acute Care Surg.* 2017;82(4):672-679.
14. Homann G, Toschke C, Gassmann P, Vieth V. Accuracy of the AAST organ injury scale for CT evaluation of traumatic liver and spleen injuries. *Chin J Traumatol.* 2014;17(1):25-30.
15. Li D, Yanchar N. Management of pediatric blunt splenic injuries in Canada--practices and opinions. *J Pediatr Surg.* 2009;44(5):997-1004.
16. Thaemert BC, Cogbill TH, Lambert PJ. Nonoperative management of splenic injury: are follow-up computed tomographic scans of any value? *J Trauma.* 1997;43(5):748-751.