

# Pediatric Blunt Solid Organ Injury: Beyond the APSA Guidelines

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**Abstract** The APSA guidelines were published in 2000 making nonoperative management of pediatric blunt liver and spleen injury standard for most injured children. A review of recent literature supports significant changes in management of children with liver, spleen, as well as kidney injury. Of the >300 articles on pediatric abdominal injury since the publication of the APSA guidelines, no randomized controlled trials have been conducted. Six prospective studies, however, have been completed, and several large database studies add significant insights into our understanding of pediatric spleen, liver, and kidney injury. Significant decreases in use of resources can be safely applied to children with hemodynamic stability at presentation. Recent studies suggest management based on physiologic criteria rather than injury grade may result in improved resource utilization through shortened hospitalization, abbreviated periods of bedrest, decreased use of intensive care units, earlier return to school, fewer tests, and a lower transfusion threshold. New algorithms are now available to assist in management.

**Keywords** Blunt liver injury · Blunt spleen injury · Blunt kidney injury · Review · ATOMAC · APSA guidelines

## Introduction

Nonoperative management of pediatric solid organ injury began with a series published by Aronson et al. in 1977 [1], but became mainstream in 2000 with the publication of the American Pediatric Surgery Association (APSA) Trauma Committee guidelines [2]. This evidence-based guideline recommended a hospital length of stay (LOS) based on injury grade, with a LOS equal to injury grade +1 in days [2] for blunt liver and/or spleen injury (BLSI). Use of the intensive care unit (ICU) was reserved for grade 4 or higher injuries. The guideline went on to recommend activity restriction for a period of time dictated by grade of injury as well, suggested as injury grade +2 (in weeks). While bedrest was not included in the original guidelines, restricting patients to bedrest was commonly practiced at many centers during the period of hospitalization. The activity restrictions at home were often assumed to prevent return to school, even if it did not violate the extent of the guidelines [3•]. While later papers set benchmarks for NOM, none provided specific guidance to assist in reaching those benchmarks [4•].

## New Literature

A PubMed search of the literature since publication of the guidelines shows more than 300 abstracts relating to pediatric abdominal injury. Many of these were tangential to liver, spleen, or kidney injury; case reports or small series dominated the remainder. Several well-conducted prospective studies, retrospective studies, and large database studies, however, have greatly increased our understanding of pediatric blunt SOI. Additionally, data is also now available for NOM of blunt renal injury.

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## Management Based on Hemodynamics Instead of Grade

A landmark article in 2008 from the group in Arkansas questioned the use of injury grade for determining management of pediatric BLSI [8•]. The McVay et al. paper “Throwing out the ‘grade’ book,” actually followed an earlier article by Mehall et al. in suggesting management should be determined based on hemodynamic status of the patient rather than the imaging study [3••, 5•]. This theme of treating the patient rather than the radiography rang true for many clinician who were already questioning the lengthy hospitalization of children requiring no actually treatment prior to discharge [6].

In 2008, 243 patients were the evaluated retrospectively by St Peter et al. in Kansas City to test the feasibility of a management confirming safety [7]. This was followed in 2012 by a prospective study by the same center confirming the safety of management based on hemodynamic status at admission rather than radiographic grade of injury [8•]. In 2013, the group published favorable long term follow-up in 249 patients [9••]. With more patients and solid follow-up, the evidence solidified considerably and other centers began reporting use of similar algorithms [10]. The adult-focused guidelines had already come to a similar conclusion [11, 12]. The Arkansas group, Kansas City group, as well as many other pediatric centers now uses the ATO-MAC guideline based on this literature (Fig. 1).

For pediatric renal injury, high rates of organ salvage are reported [13]. In a recent prospective series, as well a large multicenter retrospective series, over 97 % of pediatric blunt renal injuries were managed nonoperatively [13, 14••]. Again, management appeared to be primarily determined by hemodynamics with all grades of injuries included in the nonoperative group. In the 70 cases enrolled in the prospective study by Graziano et al. only a single Grade 5 injury underwent nephrectomy, while AE was employed in one other. Those rare renal injuries which fail NOM do so early due to bleeding, shock, or concurrent injuries other than kidney [13]. Thus the prospective observational study by Graziano et al. also helped demonstrate management of blunt renal injury based on hemodynamic status was also safe and effective.

### Selective ICU Admission

In the APSA guidelines, ICU was utilized for grade 4 and 5 injuries. The 5 prospective BLSI studies showed ICU utilization should be dictated by physiologic status, not grade. A retrospective study by Fremgen et al. found that many hemodynamically stable patients with grade 4 liver injuries do not benefit from ICU monitoring and could have been

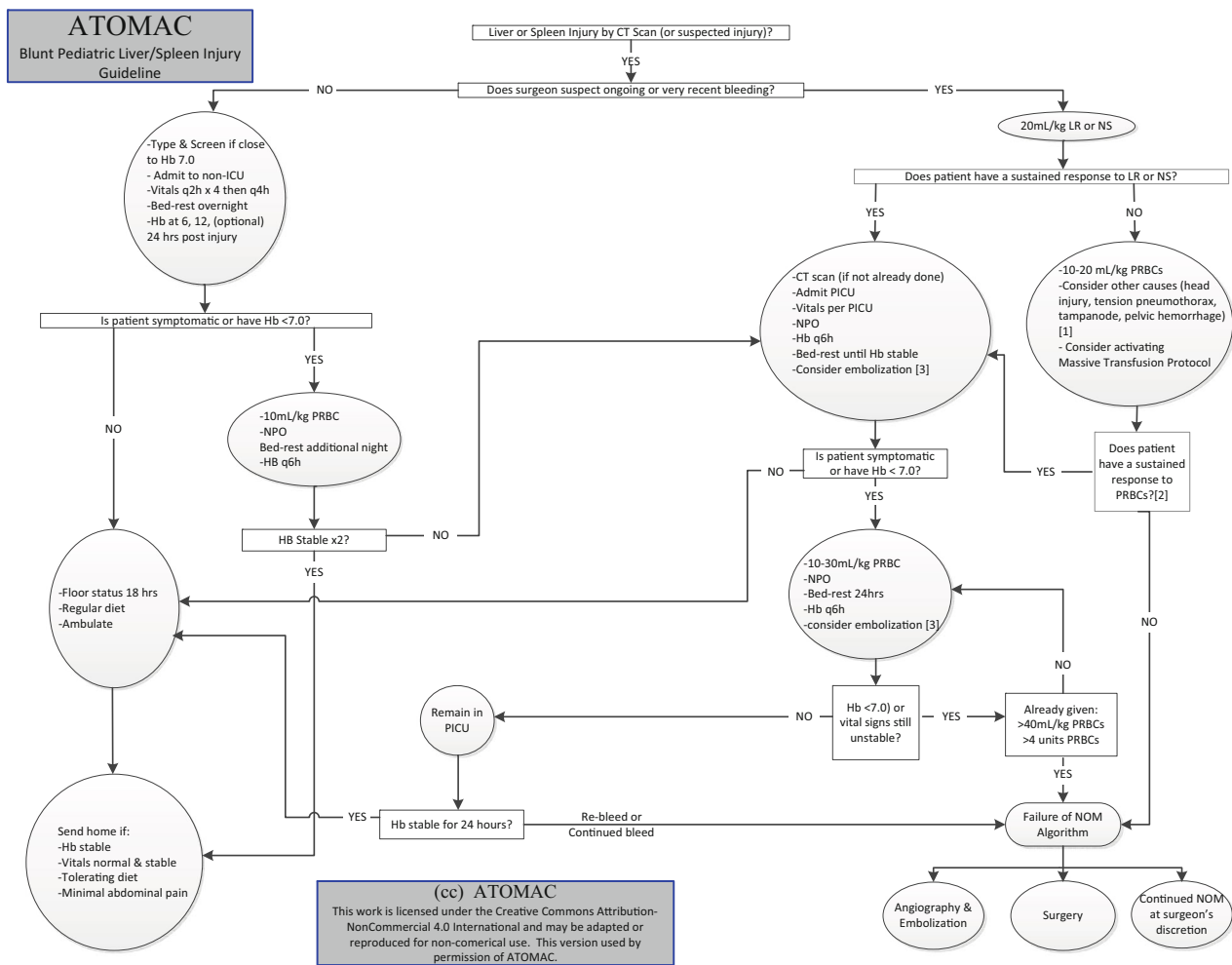
safely managed on a ward [15]. Golden reported similar findings as well, adding to the evidence [10]. These studies followed a multi-institutional study showing that most children who fail nonoperative management do so early, often in the first 12 hours. More importantly, patients who did go on to fail almost always showed signs of bleeding at presentation [10, 13]. Ultimately, hemodynamic status is a better determinant of the need for an ICU than grade alone.

### Risk of Re-Bleeding

One of the most feared complications of NOM of SOI is re-bleeding. This is especially true for splenic injury. Davies et al. set out to review all of the reported cases of delayed splenic bleeding in children, and also used their own data to calculate the incidence [16••]. From the literature, the authors culled 14 cases, but over half appear to actually be late diagnosis of bleeding, or bleeding which never stopped. If the three post-injury day 2 “re-bleeds,” are excluded, the median time of a delayed splenic bleed was 9 days—meaning fewer than half of the patients would have still been hospitalized according the APSA guidelines (maximum 6 days). A critical reviewer looking at the Davies et al. data might suggest no patient in the literature under age 18 years has ever had a delayed bleed severe enough to cause hemodynamic instability during the period of hospitalization recommended by the APSA guideline (after post-injury day 2, but prior to post-injury day 6). While a few of the reported patients underwent surgery for pain or peritonitis during this period and were noted to have splenic injuries, none had convening evidence of ongoing bleeding or a true re-bleed between days 2 and 6. The Davies et al. retrospective review found that only 1 blunt splenic injury had a delayed bleed in evaluating more than 300 cases, suggesting an incident of 0.3 %. This does not imply re-bleeds do not occur, but when they do occur, they often occur late. In the Davies et al. review, for example, their index patient bled on post-injury day 23 (well beyond the typical period of hospitalization). The bleed was fatal.

### Utility of Reimaging

The initial APSA guidelines had already recommended no routine follow-up imaging [2]. To evaluate what was being missed, Safavi et al. did a study in which all patients were re-imaged routinely [17]. In doing so, the authors identified splenic artery pseudoaneurysms in nine patients. Eight of the nine splenic pseudoaneurysms thrombosed spontaneously, suggesting that reimaging leads to more



**Fig. 1** ATOMAC guideline for nonoperative management of blunt pediatric liver/spleen injuries

reimaging, but few clinically important results. For liver injury, the findings are a bit more worrisome. Among the small numbers of high grade (4 or 5) liver injuries, pseudoaneurysm formation was common, occurring in almost 25 %. But unlike the often benign course of splenic pseudoaneurysms, 2 of 3 hepatic artery pseudoaneurysms ruptured, suggesting there may be a role for reimaging in selected cases of high grade liver injury. In the McVay article, they recommended ultrasound to allow earlier discharge, but since no interventions resulted from their follow-up imaging, this argument for routine reimaging now falls short. Martin et al. performed a meta-analysis of pseudoaneurysms and the utility of reimaging was found inconclusive [18]. In final analysis, the APSA guidelines recommending no routine reimaging is clearly valid, but current recommendations for high grade liver injuries are less clear. Even the original paper validating the APSA guideline encouraged reimaging in select cases [4•].

**Abbreviated Bedrest**

No evidence as ever shown bedrest is treatment for SOI. In fact, the only study to specifically evaluate the association of bedrest with NOM failure in adults found no correlation [19]. All three St Peter et al. studies as well as the two Arkansas studies and a smaller study done in Seattle showed safety for an abbreviated period of bedrest in more than 600 unique patients with good follow-up [3••, 5•, 7, 10, 20, 21]. Children with low grade (1 or 2) injuries can ambulate after the day of injury while children with higher grade injuries can safely ambulate when serial hemoglobin measurements are stable [3••, 8•, 10]. The studies found that children with BLSI injury do not appear to benefit from bedrest after the day of injury. In the multicenter Phoenix/Kansas City prospective study of 70 patients with blunt renal injury, no bedrest at all was required, with no adverse outcomes [14••]. Thus, there is now good evidence for abbreviating bedrest to the day of injury (or perhaps

sooner in renal injury) for all patients with stable hemoglobin. All children with solid organ injury may be allowed to ambulate once the hemoglobin stabilizes.

### Early Discharge

In 2000, the APSA guidelines standardized and significantly shortened the LOS for children undergoing NOM of BLSI. The guidelines, however, were directed predominantly by expert opinion at the time. There was no literature about early discharge, and case reports of delayed bleeding provided no denominators to gauge the risk [22]. The same studies that evaluated an abbreviated period of bedrest, also evaluated early discharge [3•, 5•, 7, 10, 20, 21]. Hospitalization LOS was already declining for pediatric SOI across the U.S [23]. In the papers by McVay et al., St Peter et al., and Mehall et al. discharge was allowed after serial hemoglobins were stable for a day or less. This often cut days off of the expected LOS. Calculations done by Ostlie et al. suggest more than 36,000 days of hospitalization in the US may be eliminated with the abbreviated periods of bedrest shown in the aforementioned studies [23].

### Transfusion at 7.0 g/dL

Guidelines for when to transfuse a trauma patient at risk of continued bleeding have been lacking. A landmark study done in pediatric ICU patients, however, randomized critically ill medical and surgical patients to a transfusion threshold of either 9.5 or 7.0 g/dL [24, 25]. While these were not trauma patients, the studies went a long way in showing higher values did not provide a survival benefit. The 7.0 g/dL threshold was essentially the same threshold used by McVay, Mehall, and St Peter in their prospective studies of trauma patients [3•, 5•, 7, 20, 21].

### Following Blunt Renal Injuries

Use of serial urinalysis for hematuria is a common practice at many centers. The prospective study by Graziano, however, shows these studies do little to impact the clinical decision-making [14•]. A long term follow-up of these same patients is ongoing. Based on current literature, hospitalization until resolution of gross, or microscopic hematuria results in lengths of stays which cannot be justified. Like other solid organ injuries, renal injuries bleed early.

### Defining Failure

The APSA guidelines set benchmarks for successful NOM, but it did not provide guidance to achieve them [4•]. Literature since that time has not definitively defined failure, but several studies have provided insights. Holmes et al. did a multicenter study and identified 85 patients who failed NOM [13]. Many of these failures were due to pancreatic injury or bowel injury, but the authors were successful in helping us understand when children fail NOM for bleeding. Generally, children fail NOM early, with 87 % failing within 24 h of injury. Failure is commonly due to shock or continued bleeding. But defining a quantity of transfusion which signifies failure had been elusive. Expert opinions in both the pediatric and adult trauma literature suggest 40 mL/kg or 5 units of red cells define a break point at which successful NOM becomes less likely [26, 27]. A recently published pediatric combat paper suggests 40 mL/kg of blood products discriminates children at risk of death [28•]. While 40 mL/kg doesn't define failure, it appears to define the pediatric group at highest risk of continued bleeding.

### Conclusion

Significant decreases in use of hospital resources can be safely applied to children with hemodynamic stability at presentation. Only children with hemodynamic signs of recent or ongoing bleeding require ICU monitoring for blunt SOI. Children with hemodynamic stability may discontinue bedrest after documented hemoglobin stability, and discharged the following day. Most children may safely return to school after discharge, provided activity restrictions can be accommodated. A transfusion threshold of 7.0 g/dL has been safely applied to children with SOI. Children with blunt renal injury do not require a period of bedrest, serial urinalysis, or prolonged hospitalization if hemoglobin stability is documented. New guidelines are now available to assist in nonoperative management of pediatric blunt solid organ injury.

### Compliance with Ethics Guidelines

**Conflict of Interest** David Notrica declares no conflict of interest.

**Human and Animal Rights and Informed Consent** This article does not contain any studies with human or animal subjects performed by any of the authors.

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