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# Minimizing variance in Care of Pediatric Blunt Solid Organ Injury through Utilization of a hemodynamic-driven protocol: a multi-institution study

Aaron J. Cunningham [a], Katrine M. Lofberg [b], Sanjay Krishnaswami [a], Marilyn W. Butler [a,c], Kenneth S. Azarow [a], Nicholas A. Hamilton [a], Elizabeth A. Fialkowski [a], Pamela Bilyeu [d], Erika Ohm [c], Erin C. Burns [e], Margo Hendrickson [f], Preetha Krishnan [g], Cynthia Gingalewski [c], Mubeen A. Jafri [a,c,*]

[a] Division of Pediatric Surgery, Doernbecher Children's Hospital, Oregon Health Science University, Portland, OR
[b] Division of Pediatric Surgery, Phoenix Children's Hospital, Phoenix, AZ
[c] Division of Pediatric Surgery, Randall Children's Hospital at Legacy Emanuel, Portland, OR
[d] Division of Trauma, Critical Care and Acute Care Surgery, Department of Surgery, Oregon Health and Science University, Portland, OR
[e] Department of Pediatrics, Critical Care, Doernbecher Children's Hospital, Oregon Health Science University, Portland, OR
[f] Division of Pediatric Surgery, Kaiser Permanente Northwest, Portland, OR
[g] Department of Pediatrics, Critical Care, Randall Children's Hospital at Legacy Emanuel, Portland, OR

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ABSTRACT

*Background:* An expedited recovery protocol for management of pediatric blunt solid organ injury (spleen, liver, and kidney) was instituted across two Level 1 Trauma Centers, managed by nine pediatric surgeons within three hospital systems.
*Methods:* Data were collected for 18 months on consecutive patients after protocol implementation. Patient demographics (including grade of injury), surgeon compliance, National Surgical Quality Improvement Program (NSQIP) complications, direct hospital cost, length of stay, time in the ICU, phlebotomy, and re-admission were compared to an 18-month control period immediately preceding study initiation.
*Results:* A total of 106 patients were treated (control = 55, protocol = 51). Demographics were similar among groups, and compliance was 78%. Hospital stay (4.6 *vs.* 3.5 days, p = 0.04), ICU stay (1.9 *vs.* 1.0 days, p = 0.02), and total phlebotomy (7.7 *vs.* 5.3 draws, p = 0.007) were significantly less in the protocol group. A decrease in direct hospital costs was also observed ($11,965 *vs.* $8795, p = 0.09). Complication rates (1.8% *vs.* 3.9%, p = 0.86, no deaths) were similar.
*Conclusions:* An expedited, hemodynamic-driven, pediatric solid organ injury protocol is achievable across hospital systems and surgeons. Through implementation we maintained quality while impacting length of stay, ICU utilization, phlebotomy, and cost. Future protocols should work to further limit resource utilization.
*Type of study:* Retrospective cohort study.
*Level of evidence:* Level II.



Abdominal solid organ injury (SOI) is the most common result of blunt abdominal trauma, accounting for 10–15% of all pediatric trauma [1]. Historically in cases of splenic injury, management routinely involved urgent splenectomy due to the reported high mortality rate and concern for delayed hemorrhage in those that did not receive treatment [2]. However, King and Schumacher in 1952 reported 5 cases of overwhelming sepsis in infants following splenectomy, raising concerns about this routine practice. Subsequently, Douglas and Simpson published a series of patients managed in a safe nonoperative fashion in 1971. Since then, management of SOI has evolved towards nonoperative management (NOM). The American Pediatric Surgical Association (APSA) published guidelines [3] in 1999 for the management of blunt spleen or liver injury, becoming the most widely used protocol for treatment of these injuries. The guidelines provide recommendations for management based on grade of injury outlining ICU/hospital stay and activity limitations after discharge. The protocol was widely adopted [4,5], with good outcomes and failure rates of 5–13% [6–8]. More recently, research has focused on hemodynamic-driven [9] NOM with grade of SOI as the guiding principle in management being limited [10].

It was not until the last decade that interest in abandoning the practice of total bedrest set at one day beyond the grade of injury (*e.g.* grade 2 injuries mandating 3 days of rest) in favor of an abbreviated bed rest protocol (ABRP) was truly embraced [11,12]. While these protocols

* Corresponding author at: Division of Pediatric Surgery, Doernbecher Children's Hospital, Oregon Health Science University, 3181 SW Sam Jackson Park Road, Portland, OR, 97239, USA.
*E-mail address:* jafri@ohsu.edu (M.A. Jafri).

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were able to significantly reduce length of stay (LOS) and minimize use of hospital resources, there remain questions of the safety and efficacy of hemodynamic-driven protocols [6,9]. The purpose of this retrospective cohort study is to demonstrate the feasibility of a hemodynamic-driven SOI protocol implemented across several institutions and models of clinical practice.

## 1. Material and methods

A solid organ injury management protocol (Fig. 1) was created and implemented by pediatric surgery fellows with faculty oversight at two Level 1 trauma centers, as defined by American College of Surgeons verified trauma centers. An exhaustive literature review informed the creation of a hemodynamic-driven protocol similar to that created by Mehall et al. in 2001 [9]. Patients admitted to the ICU, examination of phlebotomy usage and hospital length of stay were incorporated to enhance the previous work. Grade was included to stratify patients, but hemodynamic status guided limitations on ICU stay, phlebotomy and near elimination of bed rest.

Following institutional review, the trauma registries for Doernbecher Children's Hospital/Oregon Health & Science University (DCH), IRB#112736, and Randall Children's Hospital at Legacy Emanuel (RCH), IRB#1280 were queried for all solid organ injuries (liver, spleen, kidney) admitted to the pediatric trauma surgery service for 18 months prior to (July 2013 – December 2014) and 18 months after (March 2015 – September 2016) the implementation of a city-wide solid organ injury protocol, excluding a 3 month transitional period. All patients managed on the pediatric trauma service (age 0–15 years at DCH and 0–12 years at RCH) with blunt solid organ injury defined and graded by abdominal CT were evaluated for inclusion. Hemodynamically unstable patients, those who required immediate surgical or radiologic intervention as part of the initial trauma evaluation, prior to or upon admission, or both, were excluded from analysis. The remaining patients underwent thorough chart review evaluating their hospitalization for SOI and most recent postoperative clinic follow-up within 60 days of discharge. Demographic data was collected including age, sex and grade of injury. Outcomes examined included length of stay, injury severity score (ISS), time in PICU, use of phlebotomy, compliance with protocol, need for transfusion, direct hospital cost and NSQIP-defined complications including surgical site infections, hospital associated infection and readmission within 30 days.

SOI grade was assigned according to the classification defined by the American Association for the Surgery of Trauma (AAST) [13,14]. Initial designation of hemodynamic stability was a clinical decision made by the attending pediatric surgeon at the time of presentation, similar to the parameters defined by the Mehall et al. [9] Stable hematocrit was defined as a change less than 3.0% from the prior measurement, which is in accordance with prior studies [9,15]. Patients on protocol who required transfusion greater than 40 ml/kg or with persistent hypotension not responding to resuscitation were recorded as having failed NOM and proceeded to either angiographic embolization or operative management. Compliance was deemed adequate if the attending surgeon referenced use of the protocol in the medical record, the number of additional blood draws did not exceed 3 more than advised and if the patient was triaged to the appropriate ward by the managing pediatric surgeon.

Descriptive statistics, including mean and standard deviation, were used to describe/characterize XYZ variables. P values and 95% confidence intervals were calculated for parametric data using a two-sample, equal variance Student's t-Test assuming a one-tailed

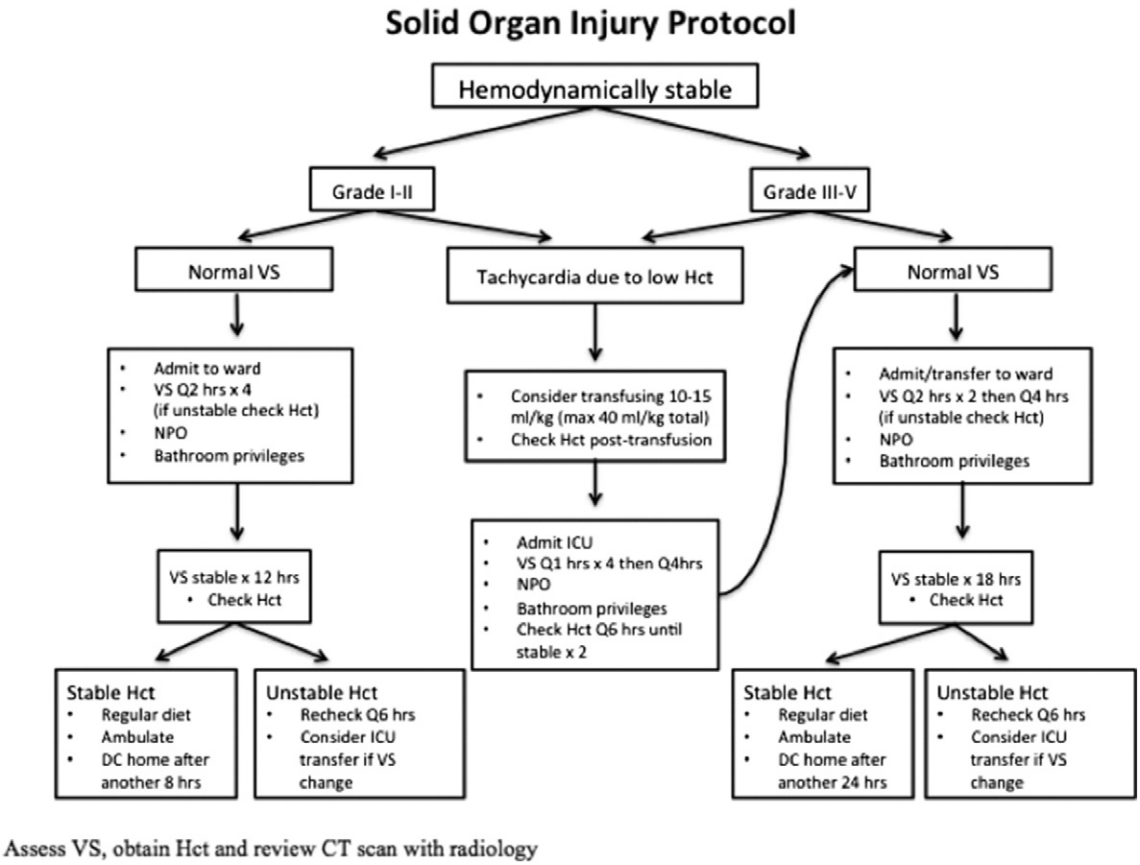


**Fig. 1.** Oregon Solid Organ Injury Protocol. Flowchart for management of pediatric trauma patients with solid organ injury at pediatric hospitals in Portland, OR. Hemodynamic stability was determined by the trauma surgeon based on clinical appearance at initial presentation. Tachycardia was defined via age-adjusted parameters and as reported in Mehall et al. 2001. Stable hematocrit was defined as a change <3.0%. VS: vital signs, ICU: intensive care unit, Hct: hematocrit, NPO: nil per os, CT: computed tomography.