

## Serial hemoglobin monitoring in adult patients with blunt solid organ injury: less is more

Firas Madbak, Dustin Price, David Skarupa, Brian Yorkgitis, David Ebler, Albert Hsu, Andrew James Kerwin, Marie Crandall Surgery, University of  
Florida College of Medicine,  
Jacksonville, Florida, USA**Correspondence to**Dr Marie Crandall; marie.  
crandall@jax.ufl.edu

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**ABSTRACT**

**Background** Patients who sustain blunt solid organ injury to the liver, spleen, or kidney and are treated nonoperatively frequently undergo serial monitoring of their hemoglobin (Hb). We hypothesized that among initially hemodynamically stable patients with blunt splenic, hepatic, or renal injuries treated without an operation, scheduled monitoring of serum Hb values may be unnecessary as hemodynamic instability, not merely Hb drop, would prompt intervention.

**Methods** We performed a retrospective review of patients admitted to our urban Level 1 trauma center following blunt trauma with any grade III, IV, or V liver, spleen, or kidney injury from January 1, 2016 to December 31, 2016. Patients who were hemodynamically unstable and went directly to the operating room or interventional radiology were excluded. Patients who required any urgent or unplanned operative or angiographic intervention were compared with patients who did not require an intervention. Routine demographic and outcome variables were obtained and bivariate and multivariate regression statistics were performed using Stata V.10.

**Results** A total of 138 patients were included in the study. Age (39.3 vs 41.4,  $p=0.51$ ), mean injury severity score (26.7 vs 22.1,  $p=0.12$ ), and admission Hb (11.9 vs 12.8,  $p=0.06$ ) did not differ significantly between the two groups. The number of Hb draws (9.2 vs 10,  $p=0.69$ ) and the associated change in Hb (3.7 vs 3.5,  $p=0.71$ ) did not differ significantly between the two groups. Only splenic grade predicted need for urgent intervention (3.5 vs 2,  $p<0.001$ ). All patients who required an operative or radiologic intervention did so based on change in hemodynamics or severity of splenic grade, per our institutional protocol, and not Hb trend.

**Discussion** Among patients with blunt solid organ injury, a need for emergent intervention in the form of laparotomy or angioembolization occurs within the first hours of injury. Routine scheduled Hb measurements did not change management in our cohort.

**Level of evidence** Level III.

**INTRODUCTION**

The liver and spleen are the most commonly injured solid organs in blunt abdominal trauma, comprising up to 11% of all trauma admissions.<sup>1</sup> The overall liver-related mortality in most large series of nonoperatively managed blunt hepatic injuries is 0.5%.<sup>2</sup> In a study of a national database involving nearly 15,000 patients with splenic injury, the mortality was approximately 1%–3%.<sup>3</sup> The spectrum of treatment options are often based on the

AAST Organ Injury Scale and the patient's hemodynamic stability, with higher grade injuries more frequently requiring an intervention in the form of laparotomy or angioembolization (OR/IR). Nonoperative management success rates of 80%–100% have been reported with surgical intervention being reserved for the most severe injuries with presence of hemodynamic instability.<sup>4</sup>

The expansion of available management options has underscored the importance of sound clinical judgment. Despite the paucity of supportive data, patients with lower grade solid organ injuries that are managed nonoperatively in the current era, including at our institution, often undergo serial measurements of hemoglobin (Hb). Previous work from our institution has shown that selective angioembolization of grade IV and V injuries, in addition to injuries associated with angiographic contrast extravasation (“blush”), improves successful nonoperative management rates.<sup>5</sup> This is part of the management protocol for patients with blunt abdominal trauma at our institution, and stable patients with these injuries are referred for angioembolization as soon as possible. The timing of this may vary based on prioritization of other injuries, or availability of our Interventional Radiology colleagues, but would not exceed 12 hours post-injury.

Evidence-based protocols regarding frequency of hemodynamic monitoring and/or serial Hb draws have not been specifically studied. One recent study in pediatric patients proposed a safe alternative in which close monitoring of a patient's clinical signs and symptoms would prompt the need for an intervention.<sup>6</sup> Our goal was to determine if serial Hb monitoring in adults could similarly be avoided. We hypothesized that in patients with blunt splenic, hepatic, or renal injuries treated without an operation, scheduled monitoring of serum Hb values may not be required because emergent interventions in the form of laparotomy, angioembolization, or packed red blood cell (PRBC) transfusion would be prompted by changes in hemodynamics, not Hb levels alone.

**METHODS**

Following approval of the University of Florida Institutional Review Board (#2015-47), we performed a retrospective review of adult patients admitted to our urban Level 1 trauma center following blunt trauma with grade III, IV, or V liver, spleen, or kidney injuries or combined higher-grade solid organ injuries from January 1, 2016 to

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December 31, 2016. Of note, we confined our study population to this group because we had noted no failures of nonoperative management for grade I or II injuries on initial chart review of all injuries, and this was a key aspect of our research question. We performed a power analysis to ensure that we would have an adequate number of patients and determined we would need approximately 100 patients to detect a risk difference. Patients with multisystem trauma in addition to isolated solid organ injuries were also included. Exclusion criteria included patients with penetrating trauma, patients on preinjury antiplatelet or anticoagulant agents, and patients who were hemodynamically unstable necessitating immediate operative intervention, defined as transit to the operating room directly from the trauma center within 30 min of arrival. Data were obtained from the trauma registry; variables not included in the registry were abstracted from retrospective review of the electronic medical record. Data collected include demographic information, vital signs, and laboratory studies on arrival, grade of liver, spleen and/or kidney injury, and need for intervention in the form of laparotomy, PRBC transfusion, or angioembolization as well as the indication for intervention and time from injury to intervention. Patients who required any urgent or unplanned operative or angiographic intervention (Int) were compared with patients who did not require an intervention (NoInt). Routine demographic and outcome variables were obtained and bivariate and multivariate regression statistics were performed using Stata V.10.

## RESULTS

A total of 138 patients were included from the study period of January 1, 2016 to December 31, 2016. The NoInt group included 103 patients (67 male, 36 female), and 35 patients (20 male, 15 female) were included in the Int group. Age distribution did not differ significantly ( $39.4 \pm 17.5$  years vs  $41.4 \pm 16$  years,  $p=0.51$ ) between the two groups (table 1).

In general, the Int group averaged higher injury severity scores (ISS) ( $26.7$  vs  $22.1$ ,  $p=0.12$ ), liver injury grade ( $3.0$  vs  $2.2$ ,  $p=0.07$ ), and spleen injury grade ( $3.5$  vs  $2$ ,  $p<0.001$ ) compared with the NoInt group, though only the spleen injury grade difference achieved statistical significance. No patients were observed for a high-grade renal injury during the study period. Admission Hb level was similar in both groups (Int  $11.9$  mg/dL vs NoInt  $12.8$  mg/dL,  $p=0.06$ ). Mean number of PRBC units transfused was higher in the Int group compared with the NoInt group (3 units vs 1 unit,  $p=0.09$ , not statistically significant), and the maximum number of transfused units was 22 in the Int group compared with 3 in the NoInt group. Intensive care unit and hospital length of stay did not differ significantly between the two groups.

Twenty patients underwent emergent laparotomy in the Int group. All but one patient went to the operating room within 4 hours of admission; that one patient underwent delayed repair of a pancreatic injury. Fifteen patients underwent angiography with embolization of the spleen, all within 4 hours of admission. Three patients underwent combined laparotomy followed by angiography for liver hemorrhage with two patients receiving some degree of hepatic embolization. In our cohort, one patient experienced delayed rupture of the spleen after a grade III injury. That patient required re-admission and angioembolization, which was not predicted at the initial hospitalization based on Hb trend. All of these 20 patients who underwent exploratory laparotomy had their intervention due to change in hemodynamics, not Hb trend. All but 3 of the 15 angioembolizations were planned based on institutional protocols according to

**Table 1** Demographic comparisons of patients with splenic injuries

	No intervention	Urgent or unplanned OR/IR for liver or spleen injury*	P value†
Age	39.3±17.5	41.4±16	0.51
Sex			
Male	67	20	0.4
Female	36	15	
ISS	22.1±14.0	26.7±15.5	0.12
Shock index	0.80±0.23	0.84±0.23	0.4
GCS	13.5±3.5	12.9±4.4	0.44
Admission Hb (mg/dL)	12.8±1.6	11.9±2.3	0.06
Liver grade	2.2±1.2	3±1.3	0.07
Spleen grade	2±1.1	3.5±1.4	<0.001
Mortality			
Lived	100	32	0.16
Died	3	3	
No of Hbs drawn	9.2±8.1	10±8.4	0.69
Change in Hb	3.7±2.5	3.5±2.3	0.71
Units transfused	1±2	3±6	0.09
ICU LOS	4.64±7.3	5.9±6.8	0.42
Hospital LOS	8.4±7.3	8.7±6.8	0.92

\*20 patients underwent emergent exploratory laparotomy, 15 underwent emergent angiography, 3 patients underwent exploratory laparotomy with planned IR afterwards.

†P value results from Student's t-test for continuous variables and Pearson's  $\chi^2$  for categorical variables.

GCS, Glasgow Coma Scale; ICU, intensive care unit; ISS, injury severity score; LOS, length of stay.

splenic grade or blush; the remaining 3 were the patients noted above with either combined laparotomy and angiography or angiography of the liver and spleen. No patients in our cohort underwent OR/IR solely based on Hb trends.

## DISCUSSION

Monitoring serial Hb levels in blunt solid organ injury makes intuitive sense, though its evolution was not guided by robust clinical research. We found that no patients underwent operative intervention or angioembolization based on decreasing Hb alone. Similar to the findings from the pediatrics paper by Acker *et al*, all interventions in the form of OR/IR occurred within 4 hours of admission, which were prompted by a combination of imaging findings and patient hemodynamics. No patients underwent an OR/IR intervention based on Hb trends alone.

A number of patients did undergo PRBC transfusions, which were often given based a Hb level  $<7$  mg/dL, irrespective of symptoms. Our practice has evolved since that time to not transfuse solely for Hb level; our transfusion threshold has progressively become more conservative in recent years so that Hb levels as low as 5–6 mg/dL in an asymptomatic patient do not trigger a transfusion.

While the data presented here do support our hypothesis, there are some obvious inherent limitations such as the retrospective, single-center nature of the study that may be further addressed in follow-up investigation. First, our two groups, the NoInt and Int groups, have markedly different population numbers; however, this was expected given the increasing success with nonoperative management of patients with blunt solid organ injuries. Second, our study was powered to detect a

20% difference in risk of an intervention; if the true risk difference was much smaller, we would require a much larger sample size to truly assess associations. While more than 30% of failures of nonoperative management occur after the first day,<sup>3</sup> 95% of failures occur within 72 hours.<sup>7</sup> As our mean lengths of stay in both groups were over a week, we feel that we would have been able to clinically detect most failures. Third, because selective angioembolization was part of our protocol for some patients, we could not always say with certainty the role that Hb values played for those patients; this may have biased our study toward the null. Though Hb alone was never a sole indication for an intervention, it is possible that Hb trend may have contributed to the decision to intervene in the hemodynamically unstable patient. Fourth, additional details about the architecture of the injuries might also have helped provide information about the risk of failure of nonoperative management. Finally, if we consider transfusion an intervention, many patients who did not require any subsequent therapy did receive a transfusion. Despite these limitations, we do feel our conclusions are accurate and substantial enough for changes in practice management.

Need for an intervention in the form of laparotomy or urgent angioembolization for blunt solid organ injury will typically manifest within the first several hours of admission following the initial trauma. Based on our results, monitoring Hb levels for the purpose of deciding on an invasive intervention in the hemodynamically stable patient may not be warranted. A proposal based on our data would suggest checking Hb levels not at set intervals, but only when clinically indicated, such as an abrupt change in a patient's clinical condition or hemodynamics.

**Contributors** FM, DS devised the project. FM, DP, DS, BY, DE, AH performed chart abstraction and data entry. MC performed statistical analysis. FM, DP authored the manuscript. DS, BY, DE, AH, AJK, MC edited the manuscript.

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#### ORCID iD

Marie Crandall <http://orcid.org/0000-0002-6536-3123>

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