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ORIGINAL ARTICLE

Trends in pediatric-adjusted shock index predict morbidity in children with moderate blunt injuries

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Abstract

Purpose Trending the pediatric-adjusted shock index (SIPA) after admission has been described for children suffering severe blunt injuries (i.e., injury severity score (ISS) ≥ 15). We propose that following SIPA in children with moderate blunt injuries, as defined by ISS 10–14, has similar utility.

Methods The trauma registry at a single institution was queried over a 7 year period. Patients were included if they were between 4 and 16 years old at the time of admission, sustained a blunt injury with an ISS 10–14, and were admitted less than 12 h after their injury ($n = 501$). Each patient's SIPA was then calculated at 0, 12, 24, 36, and 48 h (h) after admission and then categorized as elevated or normal at each time frame based on previously reported values. Trends in outcome variables as a function of time from admission for patients with an abnormal SIPA to normalize as well as patients with a normal admission SIPA to abnormal were analyzed.

Results In patients with a normal SIPA at arrival, elevation within the first 24 h of admission correlated with increased length of stay (LOS). Increased transfusion requirement, incidence of infectious complications, and need for in-patient rehabilitation were also seen in analyzed sub-groups. An elevated SIPA at arrival with increased length of time to normalize SIPA correlated with increased length of stay LOS in the entire cohort and in those without head injury, but not in patients with a head injury. No deaths occurred within the study cohort.

Conclusions Patients with an ISS 10–14 and a normal SIPA at time of arrival who then have an elevated SIPA in the first 24 h of admission are at increased risk for morbidity including longer LOS and infectious complications. Similarly, time to normalize an elevated admission SIPA appears to directly correlate with LOS in patients without head injuries. No correlations with markers for morbidity could be identified in patients with a head injury and an elevated SIPA at arrival. This may be due to small sample size, as there were no relations to severity of head injury as measured by head abbreviated injury scale (head AIS) and the outcome variables reported. This is an area of ongoing analysis. This study extends the previously reported utility of following SIPA after admission into milder blunt injuries.

Keywords Pediatric · SIPA · Shock index · Trauma · Injury

Introduction

The shock index (SI), defined as heart rate (HR: beats per minute) divided by systolic blood pressure (SBP: in mmHg), was initially described by Allgower and Buri in 1967 [1]. Within the adult population, a normal SI ranges from 0.5 to 0.7 and an SI ≥ 0.9 has been considered a "break point" for increased severity of illness [2–4]. Application of SI within the pediatric trauma population is difficult secondary to differences in HR and SBP in children as a function of age. Within the last 5 years, Acker et al. have defined pediatric-adjusted SI (SIPA) values for children based on vital signs across accepted age ranges and validated this

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model as a predictor for injury severity in blunt trauma [5]. Subsequent research has found SIPA useful in identification of severe head injury, identification of severe isolated blunt liver/spleen injury, need for trauma team activation, and need for abdominal CT after blunt trauma injury [6–10]. The most recent research has validated SIPA utilizing the Pediatric Trauma Quality Improvement Program (TQIP) database across a more diverse pediatric trauma population and as a triage tool for intensive care unit admission after isolated high-grade solid organ injury [9, 11]. Cut-off values for SIPA are as follows: 1.22 (ages 4–6 years), 1.0 (ages 7–12), and 0.9 (ages 13–16) with values above these cutoffs considered abnormal.

The previous research from our institution suggests that following SIPA after admission serves as a prognostic tool for multiple indices of morbidity and mortality in pediatric patients with severe blunt injury [12]. This study utilized a cohort of patients that mirrored those reported by Acker et al. [5]. However, a more recent study has shown that SIPA has utility for patients beyond this study's criteria (i.e., age, injury severity, and injury mechanism) [11]. Because SIPA may have utility in patients beyond those in which it was initially described, we hypothesize that trends in SIPA will have value as a prognostic tool for patients with moderate blunt injury [i.e., injury severity score (ISS) 10–14].

Methods

In evaluating this cohort, the inclusion/exclusion criteria created by Acker et al. and used in a previous study evaluating trends in SIPA were utilized with the exception that only patients with ISS 10–14 were included [5, 12]. The trauma registry from a single institution (Riley Hospital for Children at IU Health, Indianapolis, Indiana) was queried for all patients sustaining blunt injuries with an ISS of 10–14 from January 1, 2010 to December 31, 2016. Children were excluded from the study cohort if they were less than 4 years old or greater than 16 years old. In addition, patients were excluded if they were presented to our institution more than 12 h (h) after injury. SIPA values were calculated for each patient at the time of arrival and every 12 h thereafter until 48 h after admission. These scores were then categorized as either "elevated" (i.e., above normal SIPA score for age range) or normal. In addition, outcome variables related to SIPA previously reported by Acker et al. were reviewed along with demographic data (Table 1) [5]. Measured outcome variables included: Intensive Care Unit (ICU) length of stay (LOS), total hospital LOS, total days on mechanical ventilation, discharge to rehabilitation, blood transfusion within the first 24 h of admission, in-hospital mortality, and infectious complications [i.e., ventilator-associated pneumonia (VAP), urinary tract infection (UTI), surgical site infection (SSI), and a composite of any of these infections]. Patients were then categorized into two groups based on their SIPA score at admission (i.e., elevated or not elevated). During the course of data analysis, it was noted that those

Table 1 Patient demographics and outcome variables (significant variables in bold)

	SIPA elevated at arrival ($n=95$)	SIPA not elevated at arrival ($n=406$)	*p* value
Age (years: mean, [standard deviation])	9.9 [3.3]	9.7 [3.6]	0.486
Female (*n*, [%])	44 [46.3%]	131 [32.2%]	**0.009**
ISS (median, [IQR])	10 [10–14]	10 [10–13]	0.433
Head AIS (median, [IQR])	0 [0–3]	2 [0–3]	**0.003**
Transfusion in first 24 h of arrival (n, [%])	8 [8.4%]	8 [2.0%]	**0.001**
VAP (*n*, [%])	2 [2.1%]	4 [1.0%]	0.365
UTI (*n*, [%])	2 [2.1%]	3 [0.7%]	0.227
SSI (*n*, [%])	1 [1.1%]	0 [0%]	**0.038**
Bacteremia (*n*, [%])	0 [0%]	0 [0%]	N/A
Any (*n*, [%])	4 [4.2%]	7 [1.7%]	0.135
LOS (median, [IQR])	2.6 [1.8–4.9]	2.0 [1.4–3.6]	**0.010**
ICU LOS (median, [IQR])	0 [0–0.25]	0 [0]	0.408
Total days on ventilator (days: mean, [standard deviation])	0.4 [1.2]	0.2 [1.8]	**0.003**
Discharge to rehab (*n*, [%])	3 [3.2%]	3 [3.2%]	0.465
Death prior to discharge (*n*, [%])	0 [0%]	0 [0%]	N/A
Death within 48 h of admission (*n*, [%])	0 [0%]	0 [0%]	N/A

patients without an elevation in SIPA at arrival had higher head AIS than those who did. Therefore, sub-group analysis of shock index values for those with and without head injuries was completed within each of these two groups and outcomes were measured as a function of head AIS in a similar fashion. Trends for outcomes for all groups at each subsequent 12-h time interval based on the presence or absence of an elevated SIPA were compiled. Chi-squared analysis and Kruskal–Wallis tests were performed where appropriate with a p value < 0.05 considered statistically significant. When a variable was identified as statistically significant, but median variables were the same and averages with standard deviations were reported.

Results

Demographics

During the study period, 501 patients were identified that met inclusion/exclusion criteria (Table 1). Within this cohort, 95 (19.0%) patients presented with an elevated SIPA and 406 (81.0%) did not. Analysis of patient demographics revealed a significant difference in gender (46.3% vs. 32.2% female), and head AIS (0 vs. 2) for patients who had an elevated SIPA at arrival and those that did not, respectively (Table 1). There was no difference in these groups with respect to age and ISS. Analysis of outcome variables revealed a difference in LOS (2.6 vs. 2.0 days), total days on ventilator (0.4 vs. 0.2 days), need for transfusion within 24 h of arrival (8.4% vs. 2.0%), incidence SSI (1.1% vs. 0%), and need for transfusion within the first 24 h (8.4% vs. 2.0%) for patients who had an elevated SIPA at arrival and those that did not, respectively (Table 1). There were no difference in ICU LOS, discharge to rehabilitation, mortality, incidence of VAP, UTI, bacteremia, and composite infectious complications. Of note, no deaths occurred in the study cohort (Table 1).

Review of all patients with ISS 10–14

Among patients with an elevated SIPA at the time of arrival (n = 95), there was a significant trend in LOS as time to normalize SIPA increased (Table 2). In addition, there was an increased incidence in SSI and composite infectious complications as time to normalize SIPA increased. Upon review of patients with a normal SIPA at arrival (n = 406), elevations in SIPA within the first 24 h of admission were associated with increased length of stay, need for transfusion within the first 24 h of arrival, incidence of UTI, and composite infectious complications (Table 3). Discharge to rehabilitation approached, but did not reach statistical significance (Tables 2, 3).

Review of patients with ISS 10–14 and without head injury

Among patients with an elevated SIPA at the time of arrival without an associated head injury (n = 54), there was a significant trend in LOS as time to normalize SIPA increased (Table 4). There was also an increased incidence in composite infectious complications as time to normalize SIPA increased. For patients with a normal SIPA at arrival without a head injury (n = 167), elevations in SIPA within the first

Table 2 Analysis of all patients with elevated SIPA at arrival (significant variables in bold)

	SIPA elevated at arrival (n = 95)					
	Normalized by 12 h (n = 59)	Normalized by 24 h (n = 15)	Normalized by 36 h (n = 10)	Normalized by 48 h (n = 4)	Normalized beyond 48 h (n = 59)	p value
LOS (days: median [IQR])	2.2 [1.7–4.35]	2.6 [1.5–3.9]	2.5 [1.9–4.3]	3.0 [2.0–4.6]	10.0 [7.0–15.5]	0.020
SSI (n, [%])	0 [0%]	0 [0%]	0 [0%]	0 [0%]	1 [14.3%]	**0.013**
Any infection (n, [%])	1 [1.7%]	0 [0%]	0 [0%]	0 [0%]	3 [42.9%]	**< 0.001**

Table 3 Analysis of all patients with elevated SIPA at arrival (significant variables in bold)

	SIPA not elevated at arrival (n = 406)			
	SIPA Always Normal (n = 305)	SIPA Elevated at 12 h (n = 60)	SIPA Elevated at 24 h (n = 12)	p value
LOS (days: median [IQR])	2.0 [1.0–3.0]	2.6 [1.6–4.2]	3.4 [2.0–4.5]	**< 0.001**
Transfusion in first 24 h	3 [1.0%]	1 [1.7%]	2 [16.7%]	**< 0.001**
UTI (n, [%])	0 [0%]	3 [5.0%]	0 [0%]	**0.002**
Any infection (n, [%])	3 [1.0%]	4 [6.7%]	0 [0%]	**0.035**
Discharge to rehab (n, [%])	3 [1.0%]	3 [5.0%]	0 [0%]	0.078

Table 4 Analysis of patients with head AIS = 0 and elevated SIPA at arrival (significant variables in bold)

	Head AIS = 0 and SIPA elevated at arrival ($n = 54$)					
	Normalized by 12 h ($n = 7$)	Normalized by 24 h ($n = 30$)	Normalized by 36 h ($n = 9$)	Normalized by 48 h ($n = 4$)	Normalized beyond 48 h ($n = 4$)	p value
LOS (days: median [IQR])	2.0 [1.7–3.0]	2.6 [1.9–3.0]	3.4 [2.0–5.0]	3.0 [2.0–4.6]	9.5 [8.0–10.0]	**0.003**
Any infection (n, [%])	0 [0%]	0 [0%]	0 [0%]	0 [0%]	3 [75.0%]	**< 0.001**

Table 5 Analysis of patients with head AIS = 0 and normal SIPA at arrival (significant variables in bold)

	Head AIS = 0 and SIPA not elevated at arrival ($n = 167$)			
	SIPA always normal ($n = 114$)	SIPA elevated at 12 h ($n = 30$)	SIPA elevated at 24 h ($n = 5$)	p value
LOS (days: median [IQR])	2.0 [1.5–3.0]	3.0 [2.0–4.0]	4.0 [3.0–4.0]	**0.001**
Transfusion in first 24 h	1 [0.9%]	0 [0%]	1 [20.0%]	**< 0.001**

Table 6 Analysis of patients with head AIS > 0 and elevated SIPA at arrival (significant variables in bold)

	Head AIS > 0 and SIPA elevated at arrival ($n = 41$)					
	Normalized by 12 h ($n = 29$)	Normalized by 24 h ($n = 6$)	Normalized by 36 h ($n = 6$)	Normalized by 48 h ($n = 0$)	Normalized beyond 48 h ($n = 0$)	p value
LOS (days: median [IQR])	2.7 [1.7–6.0]	4.5 [1.8–10.1]	2.5 [1.8–3.0]	N/A	N/A	0.828
Any infection (n, [%])	1 [3.4%]	0 [0%]	0 [0%]	N/A	N/A	0.809

Table 7 Analysis of patients with head AIS > 0 and normal SIPA at arrival (significant variables in bold)

	Head AIS > 0 and SIPA not elevated at arrival ($n = 239$)			
	SIPA always normal ($n = 191$)	SIPA elevated at 12 h ($n = 30$)	SIPA elevated at 24 h ($n = 7$)	p value
LOS (days: median [IQR])	1.9 [1.0–3.0]	2.1 [1.0–4.4]	3.0 [2.0–7.4]	**0.014**
Days on ventilator (days: median [IQR])	0 [0]	0 [0]	0 [0–0.75]	**< 0.001**
Transfusion in first 24 h	2 [1.0%]	1 [3.3%]	1 [14.3%]	0.093
UTI (n, [%])	0 [0%]	2 [6.7%]	0 [0%]	**0.007**
Any infection (n, [%])	2 [1.0%]	3 [10.0%]	0 [0%]	**0.031**
Discharge to rehab (n, [%])	3 [1.6%]	3 [10.0%]	0 [0%]	**0.017**

24 h of admission were associated with increased length of stay and incidence of composite infectious complications (Tables 4, 5).

Review of patients with ISS 10–14 and with head injury

Among patients with an elevated SIPA at the time of arrival with an associated head injury ($n = 41$), there was not a significant trend in LOS and time to normalize SIPA or incidence in composite infectious complications (Table 6). For patients with a normal SIPA at arrival with a head injury ($n = 239$), elevations in SIPA within the first 24 h of admission were associated with increased length of stay and days on ventilator. There was also in increased incidence of UTI, composite infectious complications, and discharge to in-patient rehabilitation (Table 7). The need for transfusion in the first 24 h of arrival approached, but did not reach statistical significance (Tables 6, 7).

Review of head AIS as a prognostic indicator

The study cohort was then analyzed for differences in the outcome previously mentioned as a function of head AIS (Table 8). When comparing all patients with a head injury to those who did not, there was a significant difference in ISS (11.3 vs. 10.8), incidence of elevated SIPA at arrival (14.6% vs. 24.4%), LOS (3.8 vs. 3.5 days), ICU LOS (1.0

Table 8 Comparison of all patients with and without a head injury (significant variables in bold)

	Head AIS > 0 (*n* = 280)	Head AIS = 0 (*n* = 221)	*p* value
Age (years: mean, [standard deviation])	9.7 [3.7]	10.0 [3.4]	0.072
Female (n, [%])	89 [31.7%]	86 [38.9%]	0.109
ISS (mean, [standard deviation])	11.3 [1.7]	10.8 [1.5]	**< 0.001**
Head AIS (median, [IQR])	3 [3]	0 [0]	N/A
Elevated SIPA at arrival	41 [14.6%]	54 [24.4%]	**0.005**
Transfusion in first 24 h of arrival (*n*, [%])	9 [3.2%]	7 [3.2%]	1.000
VAP (*n*, [%])	4 [1.4%]	2 [0.9%]	0.699
UTI (*n*, [%])	3 [1.1%]	2 [0.9%]	0.855
SSI (*n*, [%])	0 [0%]	1 [0.5%]	0.259
Bacteremia (*n*, [%])	0 [0%]	0 [0%]	N/A
Any (*n*, [%])	6 [2.1%]	5 [2.3%]	0.923
LOS (days: mean, [standard deviation])	3.8 [6.9]	3.5 [3.7]	**0.012**
ICU LOS (days: mean, [standard deviation])	1 [3.1]	0.3 [1.0]	**< 0.001**
Total days on ventilator (days: mean, [standard deviation])	0.4 [2.2]	0.1 [0.6]	**< 0.001**
Discharge to rehab (*n*, [%])	10 [3.6%]	1 [0.5]	0.465
Death prior to discharge (*n*, [%])	0 [0%]	0 [0%]	N/A
Death within 48 h of admission (*n*, [%])	0 [0%]	0 [0%]	N/A

vs. 0.3 days), and days on the ventilator (0.4 vs. 0.1 days) for patients with a head injury vs. those without, respectively. Sub-group analysis revealed a significant difference in need for transfusion (12.2% vs. 1.7%), LOS (2.8 vs. 2.0 days), and days on the ventilator (0.6 vs. 0.3 days) for those patients with a head injury who presented with an elevated SIPA vs. those that did not (Table 9). Further sub-group analysis did not find any correlation for severity of head AIS and reported outcome variables when comparing all head injuries to non-head injury patients as well as in comparing head injured patients with or without SIPA elevation at the time of arrival (data not reported).

Table 9 Comparison of all patients with head injuries with and without an elevated SIPA at arrival (significant variables in bold)

	Head AIS > 0 and elevated SIPA at arrival (*n* = 41)	Head AIS > 0 and normal SIPA at arrival (*n* = 240)	*p* value
Age (years: mean, [standard deviation])	9.5 [3.4]	9.5 [3.7]	0.921
Female (*n*, [%])	15 [36.6%]	74 [30.8%]	0.464
ISS (median, [IQR])	11 [10–14]	10 [10–13]	0.196
Head AIS (median, [IQR])	3 [3]	3 [3]	0.325
Transfusion in first 24 h of arrival (*n*, [%])	5 [12.2%]	4 [1.7%]	**< 0.001**
VAP (*n*, [%])	1 [2.4%]	3 [1.3%]	0.553
UTI (*n*, [%])	1 [2.4%]	2 [0.8%]	0.355
SSI (*n*, [%])	0 [0%]	0 [0%]	N/A
Bacteremia (*n*, [%])	0 [0%]	0 [0%]	N/A
Any (*n*, [%])	1 [2.4%]	5 [2.1%]	0.884
LOS (days: median, [IQR])	2.8 [1.7–5]	2 [1.0–3.3]	**0.025**
ICU LOS (days: median, [IQR])	0 [0–2]	0 [0–1]	0.072
Total days on ventilator (days: mean, [standard deviation])	0.6 [1.6]	0.3 [2.3]	**< 0.001**
Discharge to rehab (*n*, [%])	3 [7.3%]	7 [2.9%]	0.148
Death prior to discharge (*n*, [%])	0 [0%]	0 [0%]	N/A
Death within 48 h of admission (*n*, [%])	0 [0%]	0 [0%]	N/A

Discussion

The purpose of this study was to determine if trending SIPA in a pediatric patient population with moderate blunt injury, as measured by ISS, has utility in predicting morbidity and/or mortality. Feasibility of this study was based on previous work completed at our institution as well as a recent multi-institutional collaboration that validated the shock index across a broad spectrum of pediatric trauma patients [11, 12]. Indeed, when comparing patients within our study cohort with an elevated SIPA at arrival to those who did not, there were multiple markers of increased morbidity. These markers included increased LOS, total ventilator days, need for transfusion in the first 24 h of arrival, and SSI. While this study does not encompass the breadth or the number of patients analyzed by Nordin et al., these findings corroborate the use of SIPA beyond the patient population in which it was initially described [5, 11].

Within this study, two groups of patients were analyzed; those that had an elevated SIPA upon arrival and those that did not but possibly developed an elevated SIPA within 48 h of admission, with concentration on elevation of SIPA within the first 24 h of admission based on findings from our previous study. The trends in SIPA either normalizing from an initial abnormal value or becoming abnormal when initially normal were analyzed. Upon review of patient demographics, it was noted that those children who presented with an elevated SIPA had a lower head AIS than those that did not. Given this finding, we chose to perform sub-group analysis dividing the elevated/non-elevated SIPA patients further into those that had a head injury (i.e., head AIS > 0) and those that did not (head AIS = 0) and perform sub-group analysis.

Among patients with an elevated SIPA at arrival, the time to normalize SIPA had direct relation total LOS when analyzing the entire study cohort. This is a similar trend to our previous study in children with severe blunt trauma [12]. This direct relation of increased LOS was also seen in sub-group analysis in patients without head injuries, but not in those patients with a head injury. The loss of statistical significance is not completely understood, but may be due to the small sample size of patients with a head injury who also had an elevated SIPA at arrival. This group represented only 8.2% of the entire study cohort and 14.6% of patients with head injuries. As a result of this small sample, several time intervals analyzed had 6 or fewer patients, which limit the ability to analyze trends. Another possibility is that patients with head injuries and an ISS 10–14 do not follow the same trends with regards to SIPA as others within the study and those who have been previously reported. To determine if the presence of a head injury was correlated with outcome variables independent of SIPA, all patients with a head injury were compared to those without regardless of their SIPA at arrival. This analysis suggests that patients with a head injury had a higher ISS, longer LOS/ICU LOS/days on ventilator, and were less likely to have an elevated SIPA at arrival. While the lower incidence of an elevated SIPA in the setting of multiple markers of increased morbidity appears counter-intuitive a possible, but unproven reason may be the associated hypertension seen in patients with head injuries, which could alter SIPA. Similarly, when comparing all the patients with a head injury and elevated SIPA at arrival to patients with a head injury and a normal SIPA at arrival, patients with an elevated SIPA had an increased need for early transfusion, LOS and days on the ventilator. The finding of patients with a head injury and an elevated SIPA fairing worse with regard to the reported outcome variables is consistent with data reported by Acker et al. [7]. However, there was no identified trend in with increasing head AIS and increased markers of morbidity. Recognizing the limitations of the study cohort sample size, these combined analyses suggest that while head injury in the presence of an elevated SIPA has increased morbidity, increasing head injury does not predict outcome markers like those seen in the other cohorts with respect to trends in SIPA. Indeed, further analysis is warranted. Across all the analyzed cohorts of patients with a normal SIPA at arrival, elevation of SIPA within 24 h of arrival correlated with increased LOS. While the head injured cohort did have a statistically different ISS, the overall clinical difference may be negligible (i.e., ISS mean 11.3 vs. 10.8).

In addition, several other markers for morbidity were noted in patients with a normal SIPA at arrival who then developed an elevated SIPA after admission. Similar to our previous study, this was most pronounced if SIPA elevated in the first 24 h after admission [12]. Markers for morbidity in these groups included increased days on the ventilator, transfusion requirements, infectious complications, and need for rehabilitation after discharge. Of note, none of the infectious diagnoses were made during the initial 48 h after admission, suggesting that trends in SIPA may reflect physiologic stress and subsequent predisposition to infection.

Our study is not without limitation. Due to the retrospective nature of this study, only correlations between trends in shock index and the measured outcome variables can be made. An additional weakness of our study was the inability to determine why patients with head injuries and an elevated SIPA at arrival do not follow the trends seen in the other studied groups. While we believe that this is most likely a result of small sample size, this cannot be confirmed. However, within the constraints of this study, the severity of the head injury as measured by head AIS (with or without an elevated SIPA at arrival) did not correlate with increased morbidity. Taken together with the fact that head injured patients with an elevated SIPA at arrival had higher indices for morbidity compared to those that did not suggest that sample size is a possible cause for this discrepancy. An area of focus at our institution following this study will be to apply this study design against a broader cohort of patients with respect to ISS and head AIS.

In a manner similar to our previous study, sample size across the study period prohibited further in-depth analysis of SIPA within the specific age ranges and a larger study would allow analysis within the three age ranges. Results of this study suggest that following SIPA beyond hospital admission serves as an additional marker for injury and helps with prognostication early in the hospital course among patients with an ISS 10–14, with the exception that patients with head injuries and an elevated SIPA at arrival may not follow these trends, although these patients fair worse than those with a normal SIPA at arrival.

The goal of future research may include determining if the magnitude of elevation in SIPA correlates with outcomes, resuscitation metrics, and indices of ongoing bleeding. This will require multi-institutional collaboration and should be the next step in determining if there is an additional value in following SIPA after admission beyond prognosis.

Conclusion

Patients with a normal SIPA at time of arrival who then have an elevated SIPA in the first 24 h of admission are at increased risk for morbidity 48 h of admission for patients with an ISS 10–14 regardless of the presence of a head injury including LOS and infectious complications. Similarly, time to normalize an elevated admission SIPA appears to directly correlate with LOS in patients without head injuries in children with moderate blunt injuries. However, no correlations with the reported markers for morbidity could be identified in patients with a head injury and an elevated SIPA at arrival. This lack of correlation may be due to small sample size, as there were no relations to severity of head injury, as measured by head AIS, and the outcome variables reported. This subset of patients is an area of ongoing analysis. Overall, this study compliments the previous work at our institution for following SIPA after admission in pediatric blunt trauma.

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Compliance with ethical standards

Conflict of interest Robert Vandewalle declares that he has no conflict of interest. Julia Peceny declares that she has no conflict of interest. Jodi Raymond declares that she has no conflict of interest. Thomas Rouse declares that he has no conflict of interest.

Ethical approval This article does not contain any studies with human participants performed by any of the authors.

Informed consent Waiver of consent was obtained prior to the initiation of this study by the Indiana University School of Medicine Institutional Review Board.

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