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Trauma/Burns

So you need a surgeon? Need for surgeon presence as an alternative metric to predict outcomes and assess triage in the pediatric trauma population☆

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ABSTRACT

Background: Injury Severity Score (ISS) is the primary metric by which triage has been evaluated in trauma activations. We compared ISS to a previously described set of criteria defined as Need for Surgical Presence (NSP). We hypothesize that NSP may serve as a way to augment ISS in predicting mortality and assessing triage in pediatric trauma patients.
Methods: A total of 19,139 pediatric trauma patients in the 2016 National Trauma Quality Improvement Program Database (excluding transfers) had complete data for mortality, mode of transport, age, injury type, ISS, and NSP factors. NSP was defined as having one or more of the following: intubation, transfusion, operation for hemorrhage control/craniotomy, vasopressors, interventional radiology, spinal cord Injury, tube thoracostomy, emergency thoracotomy, intracranial pressure monitor, or pericardiocentesis.
Results: Overall mortality was 1.3% and 96% of all patients suffered blunt injury. A total of 2787 (14.6%) patients had an NSP indicator compared to 2036 (10.8%) with an ISS ≥16. NSP was noninferior to ISS in predicting mortality with the AUC of 0.91 (95% CI 0.89–0.92) and 0.90 (95% CI 0.88–0.92) respectively.
Conclusion: NSP predicts mortality in pediatric trauma patients as well as ISS, and may compliment ISS. NSP status can be assigned shortly after patient arrival. Proper assessment of over and undertriage allows for optimal resource utilization by the medical facility and ultimately benefits the hospital, physician and patient.
Study type: Retrospective national dataset study.
Level of evidence: Level II.

Accuracy of trauma triage in the pediatric population remains difficult assess. This is an important aspect of the triage system as this ultimately determines what care the patient needs and receives. With pediatric trauma remaining the leading cause of death, accurate pediatric trauma triage is paramount [1]. The current metric for identifying over/undertriage has been based on the adult injury severity score/Cribari matrix for decades [2]. Efforts have been made to produce different scoring systems in pediatric trauma to remedy the issues that arise when using the Cribari matrix. Some studies have suggested the ISS definition of severe injury in pediatric trauma may need to be raised from the standard ISS of ≥16 to ≥25 [3]. Some have produced a weighted injury severity score (ISS) [4]. Others have attempted to use different metrics entirely such as using the Cribari matrix in combination with need for trauma intervention [5].

Despite these efforts, appropriate methodology for pediatric field over/undertriage assessment has remained controversial [6]. There has been some evaluation of physiologic criteria for predicting resource needs in pediatric trauma [7]. However, these studies have continued to use the ISS/Cribari matrix as the gold standard to evaluate over and undertriage [7]. ISS does not account for physiologic derangement in trauma; thus, using the Cribari matrix to evaluate physiologic criteria triage accuracy is problematic.

Lerner et al. developed a consensus based definition for pediatric patients requiring the highest level of care [8]. Need for surgeon presence (NSP) as it is called was developed using a Delphi survey and is defined as patients requiring any one or more of the following factors: intubation, transfusion, operating room for hemorrhage control/craniotomy, vasopressor requirement, interventional radiology, spinal cord injury, tube thoracostomy, emergency department thoracotomy, cesarean delivery, intracranial pressure monitor, pericardiocentesis, or death in the trauma bay [8]. Recently, a similar study has been published

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including both adult and pediatric patients using need for trauma intervention (NFTI) as a metric for assessing triage appropriateness [9]. NFTI was defined as having one of the following: receiving packed red blood within four hours of arrival; ED discharge to operating room (OR) within 90 min; ED discharge to interventional radiology; ED discharge to intensive care unit (ICU) with ICU length of stay (LOS) ≥3 calendar days; nonprocedural mechanical ventilation within 72 h of arrival; and mortality within 60 h of arrival. According to the study, the NFTI criteria showed a slightly better prediction of complications, discharge to a continued care facility, and length of stay [9].

Since NSP factors can be acquired near real time in pediatric trauma patients, we sought to evaluate the utility of NSP as a metric for predicting mortality and assessing triage in the pediatric trauma patient. We hypothesized that NSP may be as accurate as ISS in predicting outcomes, including mortality, in pediatric trauma. We will do this by looking at NSP and ISS criteria alone as well as combining the two in areas such as: mortality, length of stay, emergency department disposition, and discharge status.

1. Methods

1.1. Study design and setting

This was retrospective study comparing the prognostic value of NSP to ISS utilizing the National Trauma Quality Improvement Program (TQIP) database. A total of 51,168 pediatric trauma patients were reported to the TQIP database in 2016. Patients transferred from other facilities and patients older than 16 years were excluded. Fig. 1 summarizes our inclusion and exclusion criteria. After applying our exclusion criteria 19,139 patients were available for analysis. A total of 71 different facilities participated in the data received in the pediatric TQIP dataset.

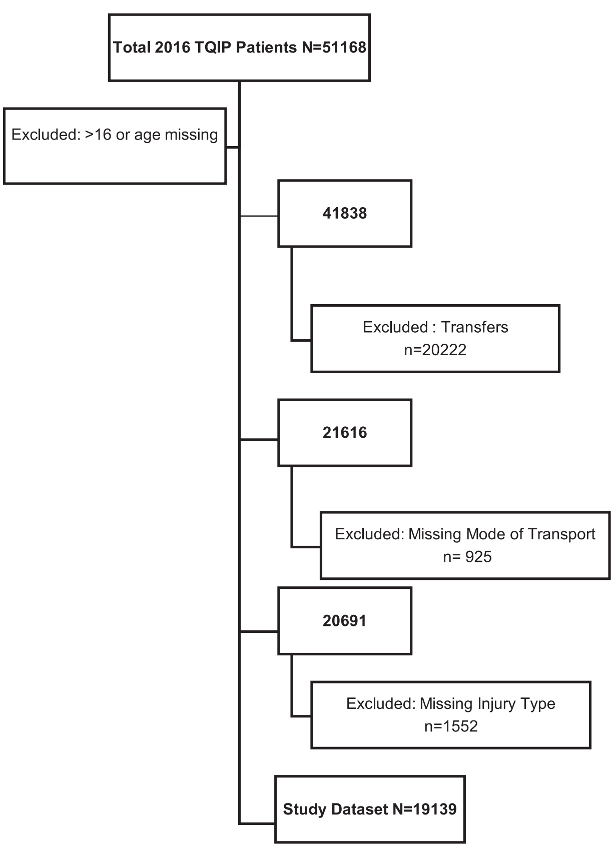

Fig. 1. Inclusion criteria.

1.2. Variables and statistical analysis

The primary outcome of interest was in-hospital mortality. ICD-9 and ICD-10 procedure codes as well as TQIP indicator variables were used to identify patients with one or more of the previously stated NSP criteria: intubation, transfusion, operation for hemorrhage control/craniotomy, vasopressors, interventional radiology, spinal cord injury, tube thoracostomy, emergency thoracotomy, intracranial pressure monitor, or pericardiocentesis. Patients were labeled according to the presence (NSP+) or absence (NSP−) of an NSP indicator.

Other covariates of interest included age, sex, race, ISS, length-of-stay (LOS) in days, blunt/penetrating injury, age-specific hypotension, emergency department disposition (EDD), hospital disposition (HD), and a Glasgow Coma Scale <13. Age-specific hypotension was defined as follows: SBP < 60 for age < 1, SBP < 70 for age 1–2, SBP < 75 for age 3–5, SBP < 80 for age 6–12, and SBP < 90 for age13–16 [10].

In order to further evaluate differences in using NSP or an ISS threshold of 16 the patients were divided into patients with an ISS < 16 and those with an ISS ≥ 16. Patients were then split within each ISS group into those NSP− and NSP+ and compared with respect to mortality, LOS, EDD, and HD.

Bivariate associations of mortality with covariates were assessed using Chi-Square or Cochran–Mantel–Haenszel tests for categorical variables and t-tests or Wilcoxon Ranked-Sum tests for continuous variables. ANOVA was used to test for differences in mean LOS for the four NSP/ISS combinations. Receiver Operating Characteristic (ROC) analysis was used to compare the prognostic value of ISS > = 16 to NSP while accounting for other predictors. All analyses were performed using SAS software version 9.4 (SAS 9.4, SAS Institute, Cary, NC).

2. Results

A total of 18,900 patients survived while 239 patients died resulting in an overall mortality rate of 1.2% among these patients (Table 1). Patients who died were on average slightly older (9.6 vs 8.6 years, p = 0.02) and the reported race was more frequently black (32.3% vs 19.9%, p < 0.0001) when compared to survivors. Injury type also differed significantly (p < 0.0001) with a higher proportion of penetrating trauma among patients who died (24.3%) versus those who survived (3.8%). Hypotension and GCS < 13 were both significantly more common among patients who died (p < .0001). No significant differences were found for sex or transport to a Pediatric Level 1 or 2 facility versus nonverified facilities.

Table 1
Summary statistics for TQIP (admitted) patients transported directly from the scene.

Variables	Alive *n* = 18,900	Died *n* = 239	p-value
Age, Mean (±SD)	8.6 (4.7)	9.5 (5.2)	**0.02**
Male, n (%)	11,938 (63.2)	154 (64.4)	0.69
Race, n (%)			<**.0001**
White	11,813 (64.8)	117 (53.2)	
Black or African American	3629 (19.9)	71 (32.3)	
American Indian	109 (0.6)	2 (0.9)	
Asian	452 (2.5)	2 (0.9)	
Native Hawaiian or Pacific Islander	38 (0.2)	1 (0.5)	
Other Race	2199 (12.1)	27 (12.3)	
Penetrating Injury, *n* (%)	714 (3.8)	58 (24.3)	<**.0001**
Hypotension Age Adjusted, *n* (%)	127 (0.7)	51 (24.4)	<**.0001**
GCS < **13,** *n* (%)	1087 (6.2)	217 (94.8)	<**.0001**
Mode of Transport, *n* (%)			<**.0001**
Helicopter	1717 (9.1)	78 (32.6)	
Ground EMS	8489 (44.9)	155 (64.9)	
POV	8694 (46.0)	6 (2.5)	
Pediatric Level I or II, *n* (%)	12,749 (68.5)	172 (72.9)	0.15
Patients with NSP criteria, *n* (%)	2560 (13.5)	227 (95.0)	<**.0001**
Patients with ISS ≥ 25, *n* (%)	757 (4.0)	192 (80.3)	<**.0001**
Patients with ISS ≥ 16, *n* (%)	1847 (9.8)	216 (90.4)	<**.0001**

Table 2
Various combinations of NSP and ISS as it relates to mortality.

Variables	Alive $n = 18,900$	Died $n = 239$	p-value
ISS and NSP Combined, *n* (%)			<**.0001**
ISS < 16 and NSP−	15,370 (81.3)	4 (1.72)	
ISS ≥ 16 and NSP−	970 (5.1)	8 (3.4)	
ISS < 16 and NSP+	1683 (8.9)	19 (7.9)	
ISS ≥ 16 and NSP+	877 (4.6)	208 (87.0)	

Table 2 shows the four possible combinations of ISS and NSP markers and how they relate to patient mortality. As shown, patients having an ISS < 16 and NSP− accounted for only 1.72% of the deaths, while patients having an ISS < 16 and NSP+ resulted in nearly 8% of the deaths. In addition, patients having an ISS ≥ 16 and NSP− resulted in 3.4% of the deaths, whereas patients having an ISS ≥ 16 and NSP+ resulted in 87% of the deaths.

Table 3 demonstrates the relationship of 3 additional outcomes, again by the four possible combinations of ISS and NSP. The median length of stay (LOS) for patients with an ISS < 16 and NSP− was 2 days while patients with an ISS ≥ 16 and NSP+ had a median LOS of 14 days ($p < 0.0001$). Patients with an ISS < 16 and NSP + were more likely to have an emergency department (ED) disposition of OR, ICU, or death than if ISS < 16 and NSP − (29% vs 50% p-value<0.0001). Patients with an ISS ≥ 16 and NSP+ were much more likely to be sent to the OR or ICU, or die in the ED versus patients with an ISS ≥ 16 and NSP− (92% vs 64% $p < 0.0001$). Finally, patients who were ISS ≥ 16 and NSP+ were much less likely to be discharged home from the hospital with only 47% of patient being discharged home in this group compared to at least 92% of patients being discharged home in the other 3 groups ($p < 0.0001$).

2.1. ROC analysis

In the absence of NSP or ISS, we identified age group, mode of transport, and injury type as independent predictors of overall mortality in our study sample. After adjusting for these independent predictors, our results show that NSP is noninferior to the ISS ≥ 16 threshold in predicting mortality. There was no difference ($p > 0.05$) between the area under the curve (AUC) for ISS > =16 (0.9030, 95% CI: 0.8842–0.9219) when compared to the AUC for NSP+ (0.9072, 95% CI: 0.8931–0.9213). (Fig. 2). Both models were well-calibrated (Hosmer–Lemeshow GOF test $p > 0.05$). Hosmer–Lemeshow GOF p-value for the NSP model was 0.2177 and for ISS16 0.1487.

3. Discussion

In pediatric patients transported directly from the scene of injury, we found that NSP is just as strongly associated with mortality as an ISS of 16 or higher. Perhaps more importantly, we identified substantial differences in outcome measures other than mortality related to the different combinations of NSP and ISS status. These differences further suggest that using ISS alone may be inadequate and a hybrid approach may allow for a more accurate representation of trauma patients' true severity and their subsequent utilization of trauma center resources.

As alluded to above, there are a number of issues with the use of ISS alone to assess trauma over/undertriage. Several are related to the ISS itself such as the assumption of equal weighting of the underlying AIS values used to calculate the score, which has been shown to be inaccurate [11].This problem is evidenced by differing risks of mortality for both individual AIS of the same severity as well as for equal ISS values resulting from different AIS triplets [4,12]. In addition, it has also been shown that a high ISS resulting from a single severe injury can carry a similar risk of mortality than a similarly high ISS resulting from a combination of 3 less severe injuries [13]. Furthermore, the ISS system does not take into account major physiologic changes caused by an injury and may misrepresent the true condition of the patient. Penetrating injury is a well-known example of this issue where a relatively low ISS may be accompanied with severe physiologic derangement [14]. Finally, ISS values may be adjusted or even not calculated until after the patient leaves the hospital. This may cause a substantial delay in assessing triage accuracy. There have been instances at our institution where a patient's initial ISS has more than doubled after autopsy results were considered.

A recent multicenter study proposed Need for Trauma Intervention (NFTI) criteria as another alternative means of identifying major trauma patients [9]. They developed models comparing ISS > =16, RTS < 7.84, and their proposed NFTI and concluded the NFTI model outperformed both the ISS and RTS based models. Despite being a potential improvement on current definitions it seems the identification of the NFTI criteria would be delayed until much later in the hospital course. Furthermore, with each NFTI criterion incorporating a time component, accurate classification could prove more difficult within datasets not specifically designed for NFTI use.

In contrast to NFTI, NSP focuses on routinely recorded life-saving interventions occurring early after trauma center arrival. The importance of NSP criteria is not closely tied to specific time intervals and is more simply concerned with the fact the intervention employed. This makes it easier to identify NSP criteria within routinely collected data. Though beyond the scope of this study, the variability still seen in outcomes for NSP+ patients is interesting and could lead to discussion of interventions employed versus those truly necessary and is area for further research.

In our previous work, we identified prehospital factors predictive of NSP [12]. NSP can be determined soon after arrival of the pediatric trauma patient to the emergency department. In our previous work, prehospital factors found to be most predictive of NSP were GCS ≤12, age adjusted hypotension, and penetrating trauma [12]. Prehospital prediction of NSP may aid in early identification of patients with an elevated mortality risk. The findings of our current study combined with the results of our previous work suggest that consideration of NSP may significantly augment the current triage assessment methodology using ISS and that NSP may also be used directly as a triage metric. [6]. NSP status can be predicted using prehospital factors and in turn NSP reliably predicts outcomes, in particular mortality.

Table 3
Combinations of NSP and ISS as it relates to various outcomes.

	ISS < 16 ($n = 17,076$)		ISS ≥ 16 ($n = 2063$)		
	NSP− ($N = 15,374$)	NSP+ ($N = 1702$)	NSP− ($n = 978$)	NSP+ ($n = 1085$)	P-value and NSP+/− (ISS < 16 vs ISS ≥ 16)
LOS Days, Median (range)	2.0 (2.1)	4.0 (6.1)	5.1 (6.1)	14.0 (13.9)	<0.0001
ED Disposition, *n* (%)					<0.0001
OR, ICU, or Died	4466 (29.0)	848 (49.8)	625 (63.9)	1005 (92.6)	
Discharged Home, *n* (%)	15,224 (99.0)	1592 (93.5)	904 (92.4)	514 (47.4)	<0.0001

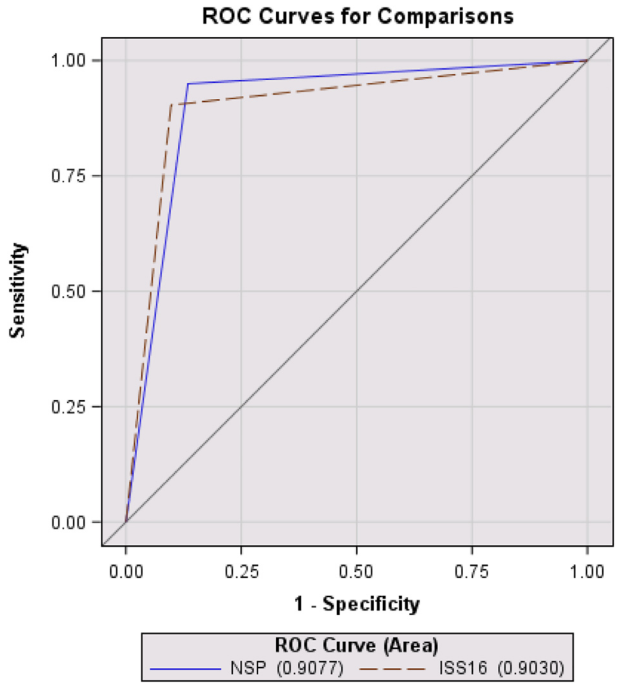

Fig. 2. ROC curve comparing mortality of NSP+ to ISS ≥ 16. *2546 excluded for missing information.

3.1. Limitations

The data utilized were drawn from national data set and are retrospective in nature. The data collection was not specifically designed to look at NSP, which could impact the accuracy of NSP classification. Despite these inherent limitations, the data were reported by 71 different institutions, which do help with the generalizability of the study and in general the data were very complete. In addition, we did have some missing data; however, the percentage of missing variables did not exceed 10% for any of the variables included in the analysis.

Although NSP may be calculated in near real time it is still retrospective in nature. However, the ability to assign NSP status is much faster than the current ISS based system. A limitation of both the NSP and ISS system is that neither looks at mechanistic criteria. Though some studies suggest that mechanism may not play a significant role in trauma center admission [15], the role of mechanism in pediatric trauma has yet to be defined.

4. Conclusion

NSP predicts mortality in pediatric trauma patients as well as ISS. NSP status can be assigned shortly after a patient arrives, which is an additional advantage when combined with ISS. Proper assessment of over and undertriage allows for optimal resource utilization by the medical facility and ultimately benefits the hospital, physician and the pediatric trauma patient.

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