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Helicopter transport in pediatric trauma: A new methodology using Need for Surgeon Presence to evaluate the necessity of air transport

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ABSTRACT

Background: When to transport pediatric trauma patients directly from scene to a trauma center via helicopter (HT) has been a long debated topic. This study proposes Need for Surgeon Presence (NSP) matrix as an alternative method to assess appropriate utilization of HT of pediatric trauma patients directly from the scene of injury.
Method: We utilized the 2016 TQIP database. 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. The outcome of interest was the presence or absence of a NSP indicator.
Results: The NSP + patients had a: longer LOS, GCS<14, positive SIPA index value, went to OR/ICU from the ED, and had penetrating injury. Among patient with an ISS≥16, mortality for those also NSP+ was 18.8% versus 1.4% among the NSP-.
Conclusion: The disparity between NSP and traditional ISS thresholds supports NSP as an additional metric to validate pre-hospital triage criteria and may be a better indicator of overall hospital resource utilization.

Introduction

When to transport pediatric trauma patients directly from scene via helicopter has been a long debated topic. The evaluation of outcomes of triage following helicopter transport (HT) from scene remains in question.[1–3] Previous studies have shown a benefit of HT only in patients with an ISS≥16.[4] A more accurate method of triaging pediatric trauma patients is needed in order to improve HT resource utilization and outcomes in this patient population.[2,5,6] Not only is there a need for improvement of field criteria to deem HT necessary but also there is a need for a more accurate assessment of over and under triage rates regarding HT.[7] In addition, the geographical location of the injury as it relates to the trauma may play a significant role in where and why the patient receives HT.[8] HT is not without risk, as several crashes have occurred with patients on board. Many times these patient were being transport by helicopter with only minor injuries from their original trauma.[9,10]

Across the nation significant variability exists with regard to indications for HT. No clear protocol has been implemented for HT for pediatric trauma. HT transport is expensive, and the incidence of over triage can be quite high. This could be related to the rurality of the location, limited ground EMS resources, or other factors. Regardless over-utilization of resources may occur.[11] Previous studies have shown a mortality benefit to pediatric patients who are transported by helicopter in some cases.[1] Although many patients with less severe injuries are transported by HT, the mortality benefit appears to be limited to severely injured patients alone.[2] However, the majority of previous literature focuses on mortality in HT. Data on other outcome regarding HT is limited. Therefore, the current system may not be appropriately triaging pediatric patients in need of HT.

This study proposes Need for Surgeon Presence (NSP) as an additional method to assess appropriate utilization of HT of

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pediatric trauma patients directly from the scene of injury. Lerner et al. defined NSP as having any one of the following factors: intubation (whether in the field or immediately upon arrival in the trauma bay), transfusion within 4 h of arrival, emergent operation with the trauma team/craniotomy with the neurosurgery team, vasopressor requirement, interventional radiology, spinal cord injury, tube thoracostomy placed, emergency department thoracotomy, urgent need for intracranial pressure monitor, or pericardiocentesis.[12] The goal of this study was to apply NSP to the pediatric patients present in the American College of Surgeons Trauma Quality Improvement Program (TQIP) Dataset, and evaluate the utility of NSP compared to injury severity score (ISS) alone as an alternative method to assess appropriate utilization of HT of pediatric trauma patients directly from the scene of injury.

Methods

We utilized the ACS TQIP Participant Use File (PUF) for the admission year 2016. (N = 51,168). Patients older than 16 years and inter-facility transfers were excluded. The primary mode of transport was then used to identify patients arriving directly from the scene of injury by HT (n = 1972). A total of 77 different facilities participated in the data received in the pediatric TQUIP dataset. Institutions contributing to this dataset used a specific set of inclusion criteria and definitions of variables which are outlined in the TQUIP data dictionary.

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. ICD-9 and ICD-10 procedure codes as well as TQIP indicator variables were used to identify whether or not a patient had a NSP indicator. Patients were grouped according to the presence (NSP+) or absence (NSP-) of a NSP indicator. Covariates included age group (<12 or ≥13), sex, race, length-of-stay (LOS), ISS, blunt/penetrating, emergency department disposition (EDD), hospital disposition (HD), ISS, shock index pediatric adjusted (SIPA), and a GCS<14. SIPA was calculated by dividing heart rate with systolic blood pressure with thresholds of shock adjusted based on specific pediatric age groups previously defined.[13]

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

Statistical analyses

Bivariate associations of NSP status with covariates were assessed using Chi-Square or Cochran-Mantel-Hansezal tests for categorical variables and t-tests or Wilcoxon Ranked-Sum tests for continuous variables. A multivariable logistic regression model was fit to identify covariates independently associated with NSP. All analyses were performed using SAS software version 9.4 (SAS 9.4, SAS Institute, Cary, NC).

Results

Among the 1972 HT patients, 614 (31%) were NSP+ and 1358 (69%) were NSP-. There was no significant difference between age, gender, and race. In comparing NSP + to NSP- in the HT group, the NSP + patients: had longer LOS, more often had a GCS<14, more often had a positive SIPA index value, were more likely to go to the OR/ICU from the ED, more frequently had penetrating injury, less likely to be discharged home, and less likely to be discharged alive in <24 h (p-value<0.0001) (Table 1).

A total of 1351 patients had an ISS<16 and 16% were NSP+ (Table 2). In the ISS <16 group, over 76% of NSP + patients went to the OR, ICU, or died from the ED versus just 38.1% of NSP- patients. Median length of stay was twice as long for NSP + patients and fewer of these patients were discharged home; 84.7% versus 97.4% for the NSP- patients.

There were 621 patients with an ISS≥16 and 64% were also NSP+ (Table 2). In the ISS >16 group, mortality was nearly 20% for the NSP + patients and only 1.4% for NSP- patients. NSP + patients were also more likely to be sent to the OR, ICU or die in the ED (94.2% versus 70.4%) and were less likely to be discharged home (43.7% versus 86.1%) than NSP- patients.

We then stratified our analysis by region. The regions included in the TQUIP database were the Midwest, Northeast, South, and West. No significant difference was noted between gender, ISS status, trauma type, and survival. There was a significant difference in race with South and West regions being more diverse than the

Table 1
Scene Transports by Ground or Helicopter Ambulance, Age 16 or less, NSP Indicator No/Yes.

	Helicopter Ambulance N = 1972		P-value
	NSP -1358 (68.9)	NSP +614 (31.1)	
Age, mean(SD)	9.8 (4.6)	10.1 (4.8)	0.2200
Gender, n(%)			0.6837
Female	521 (38.4)	230 (37.5)	
Male	835 (61.6)	384 (62.5)	
Race, n(%)			0.6430
White	1015 (77.4)	440 (75.0)	
Black/African American	142 (10.8)	72 (12.3)	
Native American	11 (0.84)	3 (0.51)	
NH/PI	0 (0)	0 (0)	
Asian	11 (0.84)	5 (0.85)	
Other	132 (10.1)	67 (11.4)	
Missing	47	27	
Injury Type, n(%)			<0.0001
Blunt	1217 (97.4)	496 (91.0)	
Penetrating	33 (2.6)	49 (9.0)	
Missing	108	69	
ISS Group, n(%)			<0.0001
ISS 1-8	581 (43.2)	54 (9.0)	
ISS 9-14	554 (41.2)	162 (27.1)	
ISS 16-24	154 (11.5)	134 (22.4)	
ISS >24	56 (4.2)	248 (41.5)	
Missing	13	16	
Patients with ISS ≥ 16, n (%)	223 (16.4)	398 (64.8)	<0.0001
Patients with ISS ≥ 25, n (%)	69 (5.1)	264 (43.0)	<0.0001
ED GCS < 14, n(%)			<0.0001
Yes	194 (14.5)	368 (60.8)	
No	1149 (85.6)	237 (39.2)	
Missing	15	9	
ED Disposition, n(%)			<0.0001
Morgue	0 (0)	7 (1.1)	
Floor	675 (49.7)	65 (10.6)	
ICU	366 (27.0)	346 (56.4)	
OR	223 (16.4)	187 (30.5)	
Observation	41 (3.0)	3 (0.5)	
Telemetry	52 (3.8)	5 (0.8)	
Discharged Alive < 24 h			<0.0001
Yes	325 (24.2)	19 (3.2)	
No	1020 (75.8)	581 (96.8)	
Missing	13	14	
LOS Days, mean(SD)[a]	3.6 (4.6)	12.1 (13.2)	<0.0001
ICU LOS Days, mean(SD)[b]	2.9 (3.2)	7.5 (9.0)	<0.0001

[a] LOS limited to stays of 90 days or less.
[b] Only patients with ED disposition of ICU and limited to 90 days.

Table 2
Comparison of NSP with ISS in HT.

	ISS <16 (n = 1351)		ISS ≥ 16 (n = 621)		P-Value
	NSP-(N = 1135)	NSP+ (N = 216)	NSP-(n = 223)	NSP+ (n = 398)	
Mortality n(%)	0 (0)	6 (2.8)	3 (1.4)	79 (19.9)	<0.0001
Length of Stay, Mean (SD)	3.0 (3.2)	6.8 (7.3)	6.4 (7.8)	15.0 (14.3)	<0.0001
ED Disposition, n(%)					
OR, ICU, or Died	432 (38.1)	165 (76.4)	157 (70.4)	375 (94.2)	<0.0001
Discharged Home, n (%)	1105 (97.4)	183 (84.7)	192 (86.1)	174 (43.7)	<0.0001

Kappa 0.48 (95% CI 0.44–0.52).

Midwest and Northeast. The South also had significantly more NSP + indicators present. The emergency department disposition differed significantly between region with the Northeast having significantly more floor admission, less ICU admission and operating room visits than the other regions (Table 3).

Discussion

This study indicates that NSP + patients may benefit from HT, but most patients transported by HT are NSP-. Our findings demonstrate the utility of NSP matrix as a metric for patient severity and provides further evidence of over-utilization of HT. The disparity between NSP and traditional ISS thresholds also supports NSP as an additional metric to augment pre-hospital triage criteria and may be a better indicator of overall hospital resource utilization. Previous work has shown that up to 22% of children transported by HT were not severely injured according to ISS.[14] When utilizing the NSP matrix in addition to ISS we find that many of those less severely injured patients, according to ISS, may need surgeon presence upon arrival. This is shown by 35% NSP + patients having an ISS of <16. Additionally, in severely injured patients (ISS≥16) who were NSP + mortality was nearly 20%. In severely injured patients who were NSP- mortality was only around 2%.

Previously hypotension, penetrating trauma, and low GCS (GCS ≤12) have been shown to be predictive of being NSP+.[15] The addition of using this prediction model of shock status (based on SBP), penetrating trauma, and GCS alone may lead to a better triage evaluation of the pediatric HT trauma patient.

Also, ISS is entirely retrospective whereas NSP indicators would be known shortly after arrival and could provide a means for more timely feedback for EMS providers. Further evaluation of pre-hospital factors as well as details of final diagnoses for NSP+ and NSP- patients may aid in refinement of prehospital triage decisions.

Over-utilization results in burdensome costs for patients that could have been safely transported by ground.[5,6] Pediatric trauma patient are consistently discharged from the emergency

Table 3
Regional Data based on TQUIP Designation.

	Helicopter Ambulance N = 1972				P-value
	Midwest (N = 332)	Northeast (N = 303)	South (N = 908)	West (N = 429)	
Gender, n(%)					0.44
Female	137 (41)	106 (35)	344 (38)	164 (38)	
Male	235 (59)	197 (65)	562 (62)	265 (62)	
Race, n(%)					0.0001
American Indian	1 (0.3)	0 (0)	7 (0.77)	6 (1.4)	
Asian	0 (0)	6 (1.98)	4 (0.44)	6 (1.4)	
African American	17 (5.1)	15 (4.95)	155 (17.07)	27 (6.29)	
Not Recorded	16 (4.82)	15 (4.95)	12 (1.32)	31 (7.23)	
Other	4 (1.2)	12 (3.96)	103 (11.34)	80 (18.65)	
White	294 (88.55)	255 (84.16)	627 (69.05)	279 (65.03)	
Trauma Type, n(%)					0.45
Blunt	315 (96)	282 (95)	719 (95)	397 (96)	
Penetrating	12 (4)	14 (5)	41 (5)	15 (4)	
ACS verified Pediatric Trauma Center, n(%)					0.0001
I	152 (46)	62 (20)	523 (58)	258 (62)	
II	109 (33)	41 (14)	127 (14)	42 (10)	
Not Applicable	71 (21)	200 (66)	259 (28)	114 (21)	
NSP Status, n(%)					0.0004
NSP+	97 (29)	80 (26)	325 (35)	112 (26)	
NSP-	235 (71)	223 (74)	583 (64)	317 (74)	
ISS Status, n(%)					0.8443
≥16	222 (67)	207 (68)	622 (69)	300 (70)	
<16	110 (33)	96 (32)	286 (31)	129 (30)	
Emergency department disposition, n(%)					0.0108
Deceased/Expired	2 (0.6)	0 (0)	4 (0.44)	1 (0.23)	
Floor	115 (34.6)	141 (46.53)	348 (38.33)	136 (31.7)	
Intensive Care Unit	137 (41.27)	99 (32.67)	303 (33.37)	173 (40.33)	
NA	0 (0)	0 (0)	1 (0.11)	1 (0.23)	
Observation unit	11 (3.31)	8 (2.64)	18 (1.98)	7 (1.63)	
Operating room	60 (18.07)	48 (15.84)	202 (22.25)	100 (23.31)	
Telemetry/Step Down	7 (2.11)	7 (2.31)	32 (3.52)	11 (2.56)	
Survival, n(%)					0.2618
Alive	312 (94)	292 (96)	865 (95)	415 (97)	
Dead	20 (6)	11 (4)	43 (5)	14 (3)	

department after air transport much more often than adults.[16] This was further demonstrated in our study and reinforces the need for an improvement on the triage system for HT. This is of particular importance in rural communities in which HT may be a logistics problem. The community may not be able to spare the one or two ground emergency transport vehicles for a long transport of a patient to a higher level of care. This may lead to an unnecessary transport by criteria, but may be necessary for the community.[17]

Limitations

We did use a national dataset not originally designed to evaluate helicopter transport. This may limit the generalizability of the study. Additionally, although 77 institutions did participate in the TQIP database, this is not all inclusive of every pediatric trauma center in the country. Finally, although we found little difference base on regional data available in the TQIP utilization of HT, flying distance and flying time was not available in the TQIP dataset. We also limited our data to patients transported directly from scene alone. NSP status may play a role in the transferring of patients to a higher level of care but this assessment was beyond the scope of this study.

Conclusion

HT is a scarce, expensive resource. Over-utilization results in burdensome costs for patients that could have been safely transported by ground. Our findings demonstrate the utility of an NSP matrix as a metric for patient injury severity and provides further evidence of over-utilization of HT in pediatric trauma. The disparity between NSP and traditional ISS thresholds also supports NSP as an additional metric to validate pre-hospital triage criteria and may be a better indicator of overall hospital resource utilization. Further evaluation of pre-hospital factors as well as details of final diagnoses for NSP+ and NSP- patients may aid in refinement of prehospital triage decisions as well as accuracy of over and under triage in pediatric trauma.

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Declaration of competing interest

The authors declare there are no conflicts of interest to report.

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