Efficacy of anatomic and physiologic indicators versus mechanism of injury criteria for trauma activation in pediatric emergencies

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BACKGROUND: In pediatric trauma patients, adult triage criteria that use mechanism of injury (MOI) have been shown to result in overactivation of trauma teams. Anatomy- and physiology-based (APB) triage criteria have been recommended to improve the accuracy of trauma activations. At our Level 1 academic tertiary pediatric trauma referral center, we recently changed our triage criteria by emphasizing APB criteria and de-emphasizing MOI. This study was conducted to analyze the resulting change in accuracy of activations.

METHODS: This was a criterion standard, cohort-controlled retrospective study comparing patients triaged by MOI criteria (January 2006 to March 2009) to those triaged by APB criteria (April 2009 to June 2010). Patients were subdivided according to trauma activation level as major (TMaj), minor (TMin), or consult (TC). Demographic, vital sign, injury pattern, trauma activation level, and emergency department disposition data were collected. Triage criteria were retrospectively applied to the patients according to the criteria that were in effect when they arrived. Patients were assigned to either high-risk (HR) or low-risk (LR) groups based on the need for urgent intervention (emergency department procedure, emergent operation, or blood transfusion), admission to intensive care unit, Injury Severity Score [ISS] of greater than 12, or death. Sensitivity and specificity of major activations were calculated using the following groups: true positive, trauma activation and HR; false positive, trauma activation and LR, false negative, no trauma activation and HR; true negative, no trauma activation and LR. Comparisons were then made between the MOI to the APB patients.

RESULTS: The MOI and APB patients were similar in race ($p = 0.201$), sex ($p = 0.639$), and age ($p = 0.643$). The APB criteria resulted in 14% TMaj, 35% TMin, and 51% TC, compared with 41%, 23%, and 36%, respectively, for MOI. Median ISS in the APB group was 16 for TMaj, 5 for TMin, and 4 for TC compared with 8, 4, and 4, respectively, for MOI. Sensitivity for trauma activation of HR patients was 89.2% versus 89.1% (equivalent), while specificity increased from 45.8% to 65.8% for MOI versus APB, respectively.

CONCLUSION: For pediatric trauma patients, the emphasis on APB triage criteria and de-emphasis on MOI results in selection of higher-acuity patients for major activation while maintaining acceptable undertriage and overtriage rates overall. This improved accuracy of major activation results in a more cost-efficient resource use and fewer unnecessary disruptions for the surgeon, operating room, and other staff while maintaining appropriate capture and evaluation of trauma patients. The low sensitivity noted in both the MOI and APB groups is largely caused by the broad definition of HR patients used in this study. We recommend the use of APB criteria for pediatric trauma triage. (*J Trauma Acute Care Surg*. 2012;73: 1471–1477. Copyright © 2012 by Lippincott Williams & Wilkins)

LEVEL OF EVIDENCE: Therapeutic study, level IV.

KEY WORDS: Pediatric trauma; triage; health care costs; anatomy- and physiology-based triage; mechanism of injury.

In treating pediatric trauma, the activation of a trauma team is essential to provide rapid assessment and treatment of injured patients; however, trauma team activations involve numerous health care providers and consume a large quantity of hospital resources. While a certain amount of "overtriage" is essential to minimize the potential of missing life-threatening injuries, frequent overactivation leads to the disruption of hospital and practitioner activities, practitioner "burn out" from unnecessary participation, and increased costs in providing this essential service. We hypothesized that the use of adult triage and mechanism of injury (MOI)–based criteria for trauma activations leads to inappropriate trauma team activations for pediatric trauma patients and that anatomy- and physiology-based (APB) criteria were more accurate for children and reduced unnecessary trauma activations.

At our hospital, the trauma guidelines were recently modified to emphasize anatomic and physiologic indicators of injury severity (airway integrity, open wounds, neurologic status, hemodynamics, skeletal integrity, and contusions to the head and/or torso) and to de-emphasize MOI criteria. The goal of this study was to compare the sensitivity and specificity of current APB activation guidelines in identifying significant injury with the previous MOI-based guidelines and, if necessary, modify them to attain optimal levels of overtriage and undertriage with our trauma activations.

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Trauma activation criteria for mechanism of injury-based (MOI)

Trauma STAT	Trauma Minor
Glasgow Coma Score ≤ 13	If Physiologic Impairment does not meet Trauma STAT criteria and the following has occurred:
Loss of consciousness > 5 minutes	Auto crash: • Initial speed > 40 mph • Major auto deformity > 20 in. • Passenger compartment intrusion > 12 in. • Death in same car • Extrication time > 20 min. • Ejection from automobile or auto rollover
Report from outside hospital of any kind of intracranial bleed on CT	Auto-pedestrian/auto-bicycle injury with >5 mph impact
Signs and symptoms of shock : • Hypotension • Weak or absent peripheral pulse • Tachycardia • Capillary refill > 3 seconds • Altered mental status • Cool, clammy skin • Significant blood loss or active hemorrhage	Motorcycle or All-Terrain Vehicle crash: • >20 mph • Separation of rider from bike
All intubated patients	Assault with loss of consciousness
Respiratory distress: • Grunting respirations/retractions • Cyanosis • Airway compromise • Flail chest • Hemothorax or pneumothorax • Maxillofacial or upper airway injury	Fall > 10 feet
Penetrating injuries to head, neck, torso, abdomen or groin	Pelvic Fractures
CSF leak	Proximal open fractures
Extremity trauma with loss of distal pulse	All degloving or crush injuries
All amputations	Penetrating injuries to extremities proximal to elbow or knee
Two or more long-bone fractures (humerus/femur)	Injury in hostile environment (heat, cold water, etc.)
Paralysis or signs of spinal cord injury	Head injury: • Loss of consciousness < 5 minutes • Glasgow Coma Score ≥ 14
Fractures of axial skeleton	Pediatric Trauma Score ≥ 9
Burns • > 20% body surface area • children < 10 years of age • any signs of inhalation injury/burns of face	
200 volt or higher electrical injury	

Figure 1. Trauma activation criteria for MOI-based protocol.

This study was approved by the institutional review board of Saint Louis University (IRB # 16827).

PATIENTS AND METHODS

This was a criterion standard, cohort-controlled retrospective study comparing patients triaged by MOI criteria (January 2006 to March 2009, Fig. 1) with those triaged by APB criteria (April 2009 to June 2010, Fig. 2). All data had been prospectively entered into our trauma registry contemporaneously. The trauma registry contained the records of all trauma activations, trauma consults, and admissions for traumatic injury. Demographic data, vital signs, injury pattern, trauma activation level, and emergency department disposition data were collected.

All patients younger than 19 years were included. Patients seen for ingestions, bites, stings, asphyxiation, and near drowning were excluded from the analysis. Consultations for nonaccidental trauma were also excluded because these patients often have acute and chronic injury and commonly present in a delayed time frame relative to their injury. In addition, readmissions and direct admissions were not considered.

Patients were placed into either MOI or APB groups by their date of arrival. When the prospectively generated activation data on our patients was reviewed, it was found that many activations were inappropriate or justification for the activation level was incomplete. Therefore, trauma activation level (major [TMaj], minor [TMin], or consult [TC]) was retrospectively assigned to each patient according to the criteria that were in effect when they arrived.

Patients were classified into either a "high-risk" category (injury warrants trauma team activation) or a "low-risk" category (injuries could successfully be evaluated and managed

Trauma activation criteria for anatomy and physiology-based (APB) protocol

Trauma Major from Field	Trauma Major Transfer	Trauma Minor
AIRWAY • All intubated patients from the scene • Respiratory distress • Airway compromise • Hemothorax or symptomatic pneumothorax • Cyanosis	AIRWAY • Continued respiratory distress • Continued airway compromise • Symptomatic pneumothorax / hemothorax • Difficulty Ventilating • Continued desaturation • Continued cyanosis	AIRWAY • Easy stabilization - Stable vital signs • Subcutaneous emphysema
CIRCULATORY • Signs and symptoms of shock • Hypotension for age	CIRCULATORY • Signs and symptoms of shock • Hypotension for age	CIRCULATORY • Normal Vital Signs • Blood loss does not require replacement • Controlled bleeding
CENTRAL NERVOUS SYSTEM • GCS ≤ 13 • Open skull fracture • CSF leak • Paralysis or signs of spinal cord injury	CENTRAL NERVOUS SYSTEM • Any intracranial injury with increasing ICP • Acute paralysis or signs of spinal cord injury (weakness, paralysis, sensory loss)	CENTRAL NERVOUS SYSTEM • Altered LOC (GCS 14 or 15) • Basilar skull fracture • Closed head injury with lethargy or LOC < 5 minutes • Assault with history of LOC
PENETRATING MECHANISM OF INJURY • Penetrating injuries to head, neck, torso, abdomen or groin (tee shirt boxer shorts region)	PENETRATING MECHANISM OF INJURY • Penetrating injuries to head, neck, torso, abdomen or groin (tee shirt boxer shorts region)	CHEST • Pneumothorax - simple non-tension • Any rib fracture(s) • All degloving/crush injuries
EXTREMETIES • Extremity trauma with loss of distal pulse • All amputations excluding fingers and toes	EXTREMETIES • Extremity trauma with loss of distal pulse • All amputations excluding fingers and toes	ABDOMEN and PELVIS • Pelvic fractures without shock • Abdomen tender and/or distended, hemodynamically stable • Known or suspected solid organ injury, hemodynamically stable
BURNS • Second degree burns (scald) > 40% TBSA • Second or third degree burns (flame) > 15% TBSA • Electrical injury > 200 volts		EXTREMITIES • Long bone fractures in more than one extremity • Penetrating injury to extremity below t-shirt or boxer short region
OTHER • ED attending request after discussion with trauma attending		MECHANISM OF INJURY • Auto crash > 40 mph • Auto deformity > 20 in. • Passenger compartment intrusion > 12 in.
		• Death in same vehicle • Extrication time > 20 min. • Ejection from automobile or auto rollover • Auto-pedestrian or Auto-bicycle injury with impact > 5 mph • MCC or ATV crash >20 mph or with separation of rider from bike • Fall > 10 feet • Injury in hostile environment (heat, cold water, etc.)

Figure 2. Trauma activation criteria for APB protocol.

TABLE 1. Criteria for High-Risk and Low-Risk Classification

High risk	
	ISS > 12
	Emergent operative intervention from the ED
	Admission to the ICU
	Endotracheal intubation on arrival
	Chest tube placement
	Intracranial pressure monitoring
	Blood product administration
	Diagnostic peritoneal lavage
	Mortality related to the trauma
Low risk	
	ISS < 12
	No need for urgent intervention
	No outcome of mortality

by the emergency department staff without morbidity or detriment to outcome). Patients were classified as "high risk" if they had an Injury Severity Score (ISS) of greater than 12, need for urgent intervention related to the trauma, admission to the intensive care unit (ICU) or transitional care unit (TCU), emergent operative intervention, endotracheal intubation on arrival, chest tube placement, intracranial pressure monitoring, blood product administration, diagnostic peritoneal lavage in the first 24 hours of admission, or mortality (Table 1). Patients were considered "low risk" if they exhibited an ISS of less than 12, no need for urgent intervention, and no outcome of mortality. Of note, "emergent operative intervention" included only those procedures considered life threatening or limb and/or organ sparing. Those patients who were taken directly to the operating room from the emergency department at surgeon convenience (i.e., minor fracture stabilization or who were otherwise stable enough for floor admission) were considered "low risk."

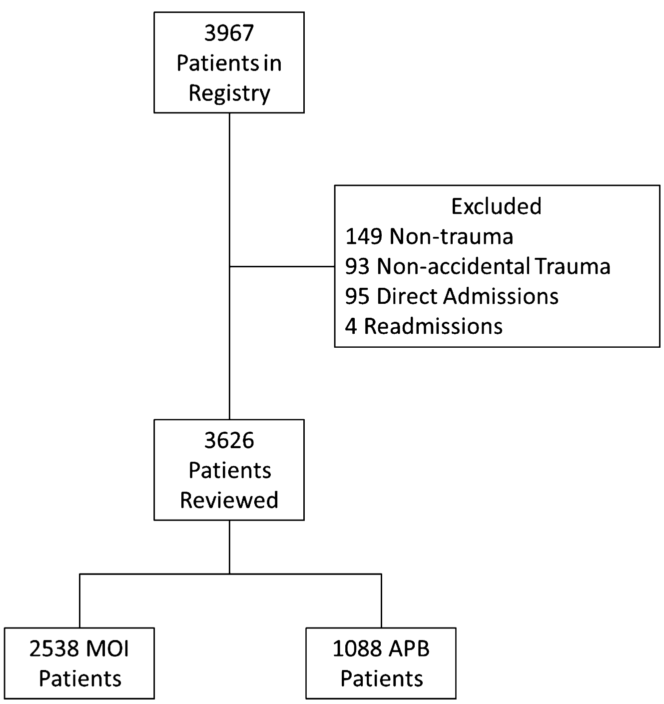

Figure 3. Flow chart of study population. After removal of patients with nontrauma diagnoses, nonaccidental trauma victims, direct admissions and readmissions, 3,626 patients remained in the study population, 2,538 in the MOI-based protocol group and 1,088 in the APB protocol group.

Patients were considered "overtriaged" if any trauma activation occurred but they were identified as low risk. Patients were considered "undertriaged" if they were found to be high risk but no trauma team activation occurred. All high-risk patients for whom trauma activation occurred were considered "appropriate activations."

Sensitivity and specificity of all trauma activations were calculated (major and minor together) using the following groups: true positive, any trauma activation and high risk; false positive, any trauma activation and low risk; false negative, no trauma activation and high risk; true negative, no trauma activation and low risk. We then compared the MOI with the APB patients. We also reviewed the records of all patients with false-negative (undertriaged) activations to identify injuries that were missed by the triage criteria.

In addition, a cost analysis using hospital-billed costs and charges provided by the hospital financial services department was calculated. The cost values used were derived from 2010 financial reports for major and minor trauma activations. Direct and indirect costs were combined to ascertain the cost for each of these activations. Charges were taken from a preassigned fee for major and minor trauma activations added to each patient's bill when one of these activations is determined. Savings were calculated for both charges and costs by calculating the changes in the relative proportions of patients activated as trauma major or minor, then determining the per patient differences that were realized.

Statistical Analysis

χ^2 test was used when comparing proportions or frequencies and Fisher's exact test when indicated. Student's *t* test was used for continuous variables with normal distribution and Mann-Whitney U-test for continuous variables lacking a normal distribution. χ^2 test was used to calculate the statistical significance of sensitivity and specificity ratings clinically and by protocol for both the MOI-based and APB criteria.

RESULTS

A total of 3,967 charts were included in the trauma registry for the study period. Four were excluded from the

TABLE 2. Comparison of Demographics for MOI and APB Groups

Demographic	MOI (n = 2,538)	APB (n = 1,088)	*p*
Age mean (SD), y	8.77 (5.6)	8.86 (5.5)	0.643
Female, n (%)	852 (33.6)	374 (34.4)	0.639
Race, n (%)			0.201
White	1,605 (63.2)	712 (65.4)	
Nonwhite	933 (36.8)	376 (36.6)	
ISS, median (range)	4 (1–75)	4 (1–75)	0.576

TABLE 3. Sensitivity and Specificity of MOI and APB Protocols

	MOI (n = 2,538)	APB (n = 1,088)	p
Sensitivity, %	89.1	89.2	0.93
Specificity, %	45.8	65.4	<0.001
Undertriage	10.9	10.8	0.93
Overtriage	54.2	34.6	<0.001

study as readmissions and 95 as direct admissions from other facilities. Another 149 were removed from the analysis for diagnoses that we excluded from our review (ingestions, 67; drowning/near drowning, 35; bites/stings, 24; not otherwise classified, 11; strangulation/hanging, 6; smoke inhalation, 4; and asphyxiation, 2). An additional 93 patients were removed from analysis because they were consults for nonaccidental trauma. This left 3,626 children in our review (Fig. 3).

The MOI and APB cohorts were compared based on age, sex, race, and ISS. There were 2,538 patients triaged by MOI criteria (January 2006 to March 2009) and 1,088 by APB criteria (April 2009 to June 2010, Fig. 3) The MOI and APB patients were similar in age (mean, 8.77 years vs. 8.86 years, respectively; $p = 0.643$), sex (33.6% vs. 34.4% female; $p = 0.639$), race (63.2% vs. 65.4% white; $p = 0.201$) and ISS (median, 4 for each group; $p = 0.576$; Table 2).

When the performance of the MOI and APB triage criteria were compared looking at any activation (TMaj + TMin) versus TC, sensitivity for the MOI and APB protocols in correctly triaged low- and high-risk children was found to be similar (89.1% and 89.2%, respectively, $p = 0.93$). Specificity for this same analysis was 45.8% for the MOI group but increased significantly in the APB group to 65.4 ($p < 0.001$). This corresponds to an undertriage rate of 10.9% and 10.8%, and overtriage rate of 54.2% and 34.6%, respectively, for our MOI and APB criteria (Table 3). The APB criteria resulted in a lower proportion of trauma patients being seen as trauma activations (either TMaj or TMin) with 49.1% of cases being trauma activations compared with 64.0% of the MOI cases ($p < 0.001$, Table 4).

When TMaj and TMin activations were analyzed separately, the APB protocol activated a smaller proportion to the TMaj category and larger proportion to TMin (13.9% and 35.2%, respectively), as compared with the MOI protocol (41.1% and 22.9%, respectively; Table 5). When the relative acuity of patients (high risk vs. low risk) was examined, the APB protocol identified a higher percentage of high-risk patients to the activation categories (76.2% TMaj and 37.1%TMin) than did the MOI protocol (47.6% TMaj and 24.3%TMin, Table 6) The median ISS of the APB group (16 TMaj and 5 TMin) was also higher than that in the MOI group (8 TMaj and 4 TMin, Table 7).

TABLE 4. Proportion of Activations for MOI and APB Groups

	MOI (n = 2,538)	APB (n = 1,088)	p
Not activated, n (%)	913 (36.0)	554 (50.9)	<0.001
Any activation, n (%)	1,625 (64.0)	534 (49.1)	

TABLE 5. Percent Classification as TMaj, TMin, and TC for MOI and APB Groups and Proportion of High-Risk Patients Within Those Classifications

	MOI (n = 2,538)	APB (n = 1,088)	p
TMaj, n (%)	1,044 (41.1)	151 (13.9)	<0.001
TMin, n (%)	581 (22.9)	383 (35.2)	
TC, n (%)	913 (36.0)	554 (50.9)	

Review of the patients with false-negative activations (undertriaged) identified only one patient in the MOI group who did not meet trauma activation criteria yet did require urgent surgery. This patient presented with an isolated tibiofibular fracture and neurovascularly intact leg yet developed compartment syndrome shortly after arrival in the emergency department and was taken for emergent fixation and decompression. There were no trauma consult patients in the APB who underwent emergency operation. There were no deaths in any patient who did not meet trauma activation criteria in either the MOI or APB groups. The remaining patients with false-negative activations were those who did not meet trauma activation criteria but either required nonfloor admission (TCU or ICU) or had ISS of greater than 12.

The 2010 cost for a trauma major activation was $5,084 (direct cost, $2,180; indirect cost, $2,904). The cost for a minor activation was $3,340 (direct cost, $1,411; indirect cost, $1,928). The charge for major trauma activation was $9,332 and was $5,599 for minor activation. When APB and MOI criteria were compared, the APB criteria resulted in a decrease of TMaj activations from 411 to 138 per 1,000 trauma patients, an increase of TMin activations from 229 to 352 per 1,000 patients, and an increase in TC activations (i.e., no added activation costs or charges incurred) from 360 to 510 per 1,000 patients. The APB criteria resulted in a net savings in charges of $1,858,959 and savings in total costs of $977,385 per 1,000 trauma patients ($6,740,585 charges: $3,543,998 costs for this patient cohort, Table 8).

DISCUSSION

In some cases, pediatric trauma teams are activated based solely on MOI information, which have been historically used for fear of missing injuries.[1,2] Several studies have demonstrated that trauma team activation based solely on MOI criteria has led to overuse of trauma activations and likely resulted in an unnecessary consumption of resources.[3–5] In response to this, some authors have investigated more sensitive and specific trauma activation guidelines. To date, however, no criterion standard has been established.[6,7] It has also been shown that

TABLE 6. Proportion High Risk Patients Within TMaj, TMin and TC Classifications for MOI and APB Protocols

High risk patients in:	MOI	APB	p
Trauma Major, n (%)	497 (47.6)	115 (76.2)	<0.001
Trauma Minor, n (%)	141 (24.3)	142 (37.1)	<0.001
Trauma Consult, n (%)	79 (8.7)	31 (5.6)	<0.04

TABLE 7. Comparison of Median ISS Between MOI and APB Criteria

	MOI (n = 2,538)	APB (n = 1,088)	p
TMaj	8 (1–75)	16 (1–75)	<0.001
TMin	4 (1–30)	5 (1–34)	<0.001
TC	4 (1–25)	4 (1–25)	0.086

adult trauma activation guidelines do not translate well to pediatric patients, lending to a movement to establish separate criteria for pediatric patients.[8]

Simon et al.[2] developed a modified pediatric trauma score for the triage of pediatric cases in the emergency department. It determines the necessity for trauma team activation based on 5 physiologic indicators (airway integrity, open wounds, neurologic status, hemodynamics, and skeletal integrity) with good sensitivity and specificity and with an acceptable level of overtriage. In a further study, Nasr et al.[9] applied this score to a different population and found it necessary to add two more indicators (history of loss of consciousness and contusions to the head and/or torso) to the scoring to reach this same safety level. These criteria however are overly complex and have not proven realistic for field triage.

At our facility, the trauma guidelines were modified on April 1, 2009, to include physiologic indicators (airway integrity, open wounds, neurologic status, hemodynamics, gross skeletal integrity, and contusions to the head and/or torso). We think that these criteria were simple and easily evaluated in the field by basic life support prepared responders. The primary goal of this study was to assure that these physiologic and more easily identifiable criteria would not miss any significant injuries and compromise the safety of our patients while still allowing for appropriate evaluation in the field.

We evaluated this efficacy by comparing the sensitivity and specificity of our new APB trauma activation guidelines with the previous MOI-based method. Our findings demonstrate that the emphasis on APB triage criteria for pediatric patients and de-emphasis on MOI results in no loss of sensitivity for high-risk patients while improving the specificity. The new criteria also resulted in the appropriate selection of higher-acuity patients for both categories of trauma team activation. These APB criteria also maintained acceptable undertraige and overtriage rates.

This improved accuracy of trauma activation results in more cost-efficient resource use and fewer unnecessary disruptions for the surgeon, operating room, and other staff while maintaining appropriate capture and evaluation of significantly injured children. A recent cost analysis study of pediatric trauma activations found that overactivation at the trauma major level (TMaj) resulted in increased charges during the first 24 hours of trauma management of $4,700 and increased costs of $800 for each overactivation.[6] Our study found that the APB criteria shifted the overall burden of trauma patients from activation to trauma consult. While we noted an increase in the proportion of minor activations overall, the net effect of shifting the balance from major activation to minor activation and consult resulted in a savings in emergency department charges of $1,859 and emergency department costs of $977 per activation. Furthermore, for every 1,000 trauma patients, we noted a decrease of 273 major activations with no detriment to patient safety.

This study has several limitations. First is the retrospective design. Although the data on each patient were prospectively generated, we found in our pilot study that a review of the appropriateness of each activation as it was initially assigned was incomplete and often inaccurate. To improve the accuracy, we retrospectively reviewed each chart and rigidly applied the appropriate triage criteria. While this approach provided consistency to the evaluation of each triage scheme, it could be argued that this risks introduction of observer bias.

Second, the definition of "high risk" used was quite broad to effectively capture all patients whose acuity warrants activation. ISS of greater than 12 and the inclusion of TCU admissions in the ICU admission groups may falsely augment the size of our high-risk population. We feel this resulted in our low sensitivity in both the MOI and APB groups as compared with recommendations from the American College of Surgeons' Committee on Trauma.[10] They recommend a 0% to 5% undertriage rate and a 25% to 50% overtriage rate. Their criteria translate to a 95% sensitivity and 50% to 75% specificity. Our study identified an undertriage rate of 11% for both the MOI and APB criteria, but the overtriage rate dropped from 54.2% to 34.2%. The results of this study show that APB criteria increases specificity without a concomitant decrease in sensitivity.

Investigation of the undertriaged patients identified only one child who did not meet major or minor activation criteria

TABLE 8. Cost Comparison Between MOI and BP Criteria

Criteria										
Trauma Activation	MOI					APB				
	n	Direct Costs, $	Indirect Costs, $	Total Costs, $	Charges, $	n	Direct Costs, $	Indirect Costs, $	Total Costs, $	Charges, $
TMaj	411	895,980	1,193,544	2,089,935	3,835,452	138	300,840	400,752	701,730	1,287,816
TMin	229	323,348	441,512	764,860	1,282,171	352	497,024	678,656	1,175,680	1,970,848
All	640	1,219,328	1,653,056	2,854,795	5,117,623	490	797,864	1,079,408	1,877,410	3,258,664
Savings in ED direct costs, $								421,464		
Savings in ED indirect costs, $								555,648		
Savings in ED total costs, $								977,385		
Savings in ED charges, $								1,858,959		

yet required urgent intervention. There were no deaths among the undertriaged patients. The remaining undertriaged patients were considered "high risk" based either on their eventual admission to our TCU or ICU or an ISS of greater than 12. While this latter group does potentially represent seriously injured patients, none of these children seemed to necessitate the immediate presence of a trauma surgery attending physician upon their arrival at the emergency department or the accompanying resource use of a trauma activation.

Third, we excluded consultations for nonaccidental trauma because these patients generally present with conflicting histories, vague and not trauma-related complaints, and in a delayed manner. Many have subacute, chronic, or acute on chronic injuries. Most nonaccidental trauma patients are hemodynamically stable, and their injuries are not immediately life threatening. Those that do present with hemodynamic instability most commonly present with nontrauma-related complaints, which are found only later on examination to be related to injuries. Their injury patterns often give them high ISSs. This would have made these patients "high risk" in our study and give the appearance of significant undertriage because almost all of these patients are referred after being worked up for a medical condition. For this reason, they were excluded them from our analysis a priori.

In conclusion, our study supports the safe use of APB criteria in determining trauma activations in this pediatric population. Our findings also demonstrate that the de-emphasis of MOI for trauma activations results in a decrease in overactivations and a selection of higher-acuity patients for all levels of trauma activation. These criteria create better use of resources and reduce overuse of physician time and hospital resources.

AUTHORSHIP

A.R.K. contributed in the literature search, study design, data collection, data analysis, data interpretation, article preparation, and figures. H.E.W. contributed in the study design, statistical analysis, data interpretation, article preparation, and figures. M.C.G. contributed in the literature search and data collection. A.L.G. performed the statistical analysis. D.W.V. contributed in the study design, data interpretation, and article preparation.

DISCLOSURE

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REFERENCES

1. Haller JA Jr., Shorter N, Miller D, Colombani P, Hall J, Buck J. Organization and function of a regional pediatric trauma center: does a system of management improve outcome? *J Trauma*. 1983;23:691–696.
2. Simon B, Gabor R, Letourneau P. Secondary triage of the injured pediatric patient within the trauma center: support for a selective resource-sparing two-stage system. *Pediatr Emerg Care*. 2004;20:5–11.
3. Dowd MD, McAneney C, Lacher M, Ruddy RM. Maximizing the sensitivity and specificity of pediatric trauma team activation criteria. *Acad Emerg Med*. 2000;7:1119–1125.
4. Boyle MJ. Is mechanism of injury alone in the prehospital setting a predictor of major trauma—a review of the literature. *J Trauma Manag Outcomes*. 2007;1:4.
5. Shatney CH, Sensaki K. Trauma team activation for 'mechanism of injury' blunt trauma victims: time for a change? *J Trauma*. 1994;37:275–281; discussion 281–272.
6. Mukherjee K, Rimer M, McConnell MD, Miller RS, Morrow SE. Physiologically focused triage criteria improve utilization of pediatric surgeon-directed trauma teams and reduce costs. *J Pediatr Surg*. 2010;45: 1315–1323.
7. Furnival RA, Schunk JE. ABCs of scoring systems for pediatric trauma. *Pediatr Emerg Care*. 1999;15:215–223.
8. Phillips S, Rond PC 3rd, Kelly SM, Swartz PD. The need for pediatric-specific triage criteria: results from the Florida Trauma Triage Study. *Pediatr Emerg Care*. 1996;12:394–399.
9. Nasr A, Mikrogianakis A, McDowall D, Wales P. External validation and modification of a pediatric trauma triage tool. *J Trauma*. 2007;62:606–609.
10. American College of Surgeons. *Resources for Optimal Care of the Injured Patient 2006*. Chicago: American College of Surgeons; 2007.

EDITORIAL CRITIQUE

The development of pediatric-specific management practices in traumatic injury has lagged within the larger framework of the evolution of pediatric surgery as a discipline, related yet distinct from general surgery. A major reason is likely differential volume due to age with pediatric trauma representing a fraction of the overall trauma statistic in this country, as well as age related differences in at risk behavior leading to injury. While application of trauma management principles across age groups has advantages related to larger experience, children can benefit from age specific management with improved outcomes.

This paper addresses the utility of triage emphasis on anatomic derangement and physiologic response in allocating precious hospital resources in response to pediatric injury; many pediatric trauma surgeons would agree it is best to let the child's status tell us what is wrong. Mechanism of injury is de-emphasized and, while that raises the historical concern of missed injury, acceptable under- and over-triage rates were maintained. The recognition that vital signs or anatomic indicators in a child may be more indicative of injury than mechanism is not a new concept, but one that has been slow to develop in the literature, making this paper a welcome addition. Caveats on this paper might include broad applicability of the suggested criteria. These findings are from an urban Level l pediatric trauma center. While such centers are well experienced with the acutely injured child, low volume, non-specialty centers may do well to apply broader trauma alert criteria. Additionally, the study included data on patients under 19 years of age. The older adolescent arriving in a pediatric trauma center acts physiologically and often behaviorally as an adult. The argument to separate these triage criteria out as pediatric may be better served by analyzing a younger subset of the study group. This is a needed contribution to the continued refinement of pediatric injury management.

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