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A Consensus-Based Criterion Standard Definition for Pediatric Patients Who Needed the Highest-Level Trauma Team Activation

E. Brooke Lerner, PhD¹, Amy L. Drendel, DO, MS¹, Richard A. Falcone Jr., MD, MPH², Keith C. Weitze¹, Mohamed K. Badawy, MD³, Arthur Cooper, MD, MS⁴, Jeremy T. Cushman, MD, MS, EMT-P⁵, Patrick C. Drayna, MD¹, David M. Gourlay, MD¹, Matthew P. Gray, MD, MS¹, Manish I. Shah, MD⁶, and Manish N. Shah, MD, MPH⁵

E. Brooke Lerner: eblerner@mcw.edu; Amy L. Drendel: adrendel@mcw.edu; Richard A. Falcone: Richard.Falcone@cchmc.org; Keith C. Weitze: kweitze@mcw.edu; Mohamed K. Badawy: Mohamed.Badawy@UTSouthwestern.edu; Arthur Cooper: ac38@columbia.edu; Jeremy T. Cushman: Jeremy_Cushman@URMC.Rochester.edu; Patrick C. Drayna: pdrayna@mcw.edu; David M. Gourlay: dgourlay@mcw.edu; Matthew P. Gray: mgray@mcw.edu; Manish I. Shah: mxshah@texaschildrens.org; Manish N. Shah: Manish_Shah@urmc.rochester.edu

¹Medical College of Wisconsin, Milwaukee, WI

²Cincinnati Children's Hospital Medical Center, University of Cincinnati College of Medicine, Cincinnati, OH

³UT Southwestern Medical Center, Dallas, TX

⁴Columbia University Medical Center Affiliation at Harlem Hospital, New York, NY

⁵University of Rochester, Rochester, NY

⁶Baylor College of Medicine, Houston TX

Abstract

Background—Verbal prehospital reports on an injured patient's condition are typically used by trauma centers to determine if a trauma team should be present in the emergency department prior to patient arrival (i.e., trauma team activation). Efficacy studies of trauma team activation protocols cannot be conducted without a criterion standard definition for which pediatric patients need a trauma team activation.

Objective—To develop a consensus-based criterion standard definition for pediatric patients who needed the highest-level trauma team activation.

Methods—Ten local and national experts in emergency medicine, emergency medical services, and trauma were recruited to participate in a Modified Delphi survey process. The initial survey was populated based on outcomes that had been used in previously published literature on trauma

Address for Correspondence and reprints: E. Brooke Lerner, Ph.D.; Department of Emergency Medicine; Medical College of Wisconsin; 9200 W. Wisconsin Ave.; Milwaukee, WI 53226, Phone: (414) 805-0113, Fax: (414) 805-6464, eblerner@mcw.edu.

Presented: None

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team activation. The criterion standard definition for trauma team activation was refined iteratively based on survey responses until at least 80% agreement was achieved for each criterion.

Results—After five voting rounds a consensus-based definition for pediatric trauma team activation was developed. Twelve criteria were identified along with a corresponding time interval in which each criterion had to occur. The criteria include receiving specific surgery types, interventional radiology, advanced airway management, thoracostomy, blood products, spinal injury, emergency cesarean section, vasopressors, burr hole or other procedure to relieve intracranial pressure, pericardiocentesis, thoracotomy, and death in the emergency department. All expert panel members voted in all 5 voting rounds, except 1 member missed rounds 1 and 2. Each criterion had greater than 80% agreement from the panel.

Conclusion—A criterion standard definition for the highest-level pediatric trauma team activation was developed. This criterion standard definition will advance trauma research by allowing investigators to determine the accuracy and effectiveness of highest-level pediatric trauma team activation protocols.

Level of Evidence/Study type—Qualitative

Keywords

Wounds and Injury; Triage; Emergency Medical Services; Emergency Medical Technicians; trauma centers; Delphi method

Background

Traumatic injury is the leading cause of death for children between the ages of 1 and 19, with over 13,000 fatalities annually.¹ Emergency medical services (EMS) systems attempt to reduce pediatric injury mortality rates by identifying patients who potentially have severe injury and rapidly transporting them to hospitals that are capable of providing immediate high-quality trauma care (i.e., pediatric trauma centers). Further, by relaying patient information to trauma centers before their arrival, EMS providers can initiate a trauma team activation to ensure that surgical and other specialized healthcare providers meet the patient in the emergency department (ED).

A trauma team is a multidisciplinary team of medical providers that, when alerted, set aside their current tasks and report to the ED to assist in providing care for a severely injured patient. Trauma team activations can provide safe, efficient and cost-effective care.^{2–6} Since treatment for serious injuries is time-sensitive, having a team of specialized healthcare professionals activated before a severely injured patient arrives in the ED has been shown reduce the time a severely injured child must wait before receiving vital treatment.⁶ Even when surgical intervention is not required, a pediatric surgeon in the resuscitation area can benefit trauma patients by directing non-operative procedures.⁷ Trauma team activation prior to patient arrival has been shown to decrease mortality in severely injured children.⁶ However, over-triage has the negative consequence of stopping these providers from providing care for other patients who also require healthcare resources.⁸ Therefore, trauma team activation criteria must be used to minimize both under- and over-triage.

A variety of pediatric trauma team activation protocols have been examined and implemented across the United States.⁷⁻²³ While many of these protocols share similar indicators, there is considerable variability between protocols. The 2006 edition of the *Resources for Optimal Care of the Injured Patient* published by the American College of Surgeons includes trauma team activation criteria.²⁴ This text's suggested protocol is primarily based on consensus opinion, since there is limited literature available to assist in developing the protocol.

There is a need to determine which trauma team activation protocol is best for identifying injured pediatric patients who will benefit from the highest-level trauma team activation, but the study of trauma team activation protocols requires researchers to use a criterion standard definition in order to calculate the accuracy, sensitivity, and specificity of the protocols. To date the criterion standard definitions used for trauma team activation research have not been consistent between research projects (Table 1). For example, Sola et al. assessed activation protocol accuracy by determining whether the patient needed an operating room or pediatric intensive care unit⁷, while Dowd et al. assessed accuracy using specific types of surgical procedures and specific resuscitative ED interventions.¹² Without a consistent criterion standard definition for pediatric trauma team activation it is difficult to compare results across studies. The objective of this study was to define a consensus-based criterion standard definition for the highest-level pediatric trauma team activation.

METHODS

This project used a modified Delphi technique to develop a list of criteria that would form the criterion standard definition for the highest-level pediatric trauma team activation. The Delphi technique is commonly utilized in the health sciences to synthesize knowledge through expert consensus.²⁵

Local and national experts in emergency medicine, emergency medical services, and trauma were recruited through email to participate in the expert panel (Table 2). Experts were identified using the principal investigators' contacts and their respective contacts. Only individuals who had established careers in pediatric or general emergency medicine, emergency medical services, or pediatric surgery were considered for panel participation.

An initial Delphi survey was developed based on a review of the available literature on pediatric trauma team activations. The outcomes that were used for those analyses were reviewed and each of the outcome criteria that were included in those studies was included in the first Delphi survey for this study (Table 1).

The surveys were distributed to each panel member through Survey Monkey®. The panel members voted to keep, remove, or modify each of the outcome criteria during each voting round. Panel members were also asked to suggest additional outcome criteria that should be added.

The lead author communicated with members of the panel concerning questions and clarifications of opinions, but did not participate in the voting rounds, in order to avoid potentially biasing the results of the project. Voting rounds were repeated until a high level

of consensus was reached among all participants. If an individual criterion received less than 50% of the panelists' votes for inclusion, it was removed from consideration in the subsequent voting rounds. If a criterion received at least 80% of the panelists' votes for inclusion, it was considered to have achieved consensus and no further voting was required on that criterion. If a criterion received greater than 50% of the panelists' votes for inclusion but less than 80%, it was revised based on the participants' comments and included in the next voting round along with any new criteria that were suggested by the panelists. To facilitate reaching consensus in later voting rounds, panelists were asked to provide reasons for their votes. These reasons were then collated by the lead author, and were presented in subsequent voting rounds as pros and cons along with the criteria to assist the panelists' deliberations.

RESULTS

The expert panel was comprised of ten local and national experts in the fields of emergency medicine, EMS, and/or trauma (Table 2). All panelists were invited to vote in each round of the modified Delphi survey; however, one member missed the first and second rounds. Nine panelists voted on criteria from the first survey, which included the entire list of criteria gleaned from the preliminary literature review (Table 1).

After five rounds of voting, the panelists arrived at consensus for each criteria and its respective time interval. A total of 12 criteria were identified for inclusion in a consensus-based criterion standard definition for the highest-level pediatric trauma team activation (Table 3).

DISCUSSION

A consensus-based criterion standard definition was developed for use in defining when trauma team activation was appropriate for the care of an injured pediatric patient. This criterion standard definition is not intended for use in clinical practice, since it can only be determined after the patient has received all care and the procedures they required are identified. It is meant to be used for research on trauma activation protocols. This criterion standard definition will enable trauma researchers to compare the accuracy of distinct pediatric trauma team activation protocols as well as specific elements within those protocols. While there is a protocol for the highest-level trauma team activation that has been suggested by the American College of Surgeons Committee on Trauma, the protocol has not been validated and research in this area is limited.²⁴ Further, because researchers have used a wide variety of outcomes it is difficult to compare findings between previous studies. Use of the criterion standard definition will facilitate research and ensure that comparisons can be made across studies.

It is important to note that the criterion standard definition that was developed is only for determining if the patient should have had the highest-level trauma team activation. Hence, it can only be applied after the determination to transport to a trauma center has been made. Another criterion standard definition exists for the evaluation of the field triage guidelines that assist EMS providers in identifying patients who need the resources of a trauma

center.²⁶ All of the patients who are eligible for a trauma team activation will be at a facility where the full breadth of resources are available but the team that can provide the resources will need to be assembled either prior to the patients arrival or while the patient is waiting. Therefore, the goal of the criterion standard definition for trauma team activation was to identify interventions that the patient will need immediately after arrival, since trauma team activation prior to patient arrival will improve outcome only for those patients with conditions that are extremely time sensitive. Further, since the criterion standard definition will only be determined in trauma centers, and all trauma resources will be readily available to make the determination of what interventions the patient needs, there was less need to account for conditions that may have delayed identification.

The development of this criterion standard definition was focused on identifying procedures that indicate a patient needed a trauma team activation. Obviously, there are likely to be different and less robust data available in the prehospital setting. The data that are used to initiate a trauma team activation from the prehospital setting are likely not going to be completely accurate in identifying pediatric patients that meet the criterion standard definition. When identifying the most appropriate prehospital identified indicators for a trauma team activation, emphasis should be placed on minimizing under-triage, which will likely increase the number of children who need to be evaluated by a trauma team to determine if the criterion standard interventions are needed. Further, the criterion standard definition is not meant to undermine the value of a trauma team providing an evaluation and guiding the development of a care plan for patients who do not ultimately need an intervention. The criterion standard definition focuses primarily on interventions because it is our hope that it will contribute to identifying trauma team activation criteria that can most accurately identify patients who need those interventions and limit the strain on resources that results from significant numbers of patients being over-triaged.

Some may be concerned that low blood pressure and Glasgow Coma scale (GCS) score were not included in the criterion standard definition. The panel felt that while these are very likely to be valuable indicators for trauma team activation, they are unlikely to be good criterion standards for assessing the need for a trauma team activation. This is because blood pressure and GCS characterize the physiologic condition of the patient at the time of evaluation and are likely surrogates for a needed intervention and thus should not be included in the criterion standard definition. For example, given the significant negative outcomes related to pediatric traumatic brain injury it seems important that the highest-level trauma team be immediately available for a child with a severe traumatic brain injury. However, because of the documented inaccuracies of GCS reporting, it is likely that the reported GCS may not accurately reflect the condition of the patient making GCS an unrealistic candidate for the criterion standard definition.²⁷⁻³⁰ Further, those who truly had a low GCS would likely receive one of the other treatments listed in the criterion standard definition, either intubation or a procedure to relieve increased intra-cranial pressure.

The criterion standard definition identifies interventions that indicate a trauma team was definitely needed, while trauma team activation protocols used in actual practice identify conditions that indicate a trauma team is likely to be needed. Including in the criterion standard definition criteria that *might* indicate the need for a trauma team, would create

circular logic and inhibit research, since trauma team activation protocols that were studied could never be better than the criterion standard definition against which they were measured. Therefore, the criterion standard definition should be as close to the “right answer” for needing a trauma team activation as can possibly be achieved.

The charge of the panel and the intent of this study were to consider only pediatric patients. Future efforts are needed to evaluate how well this criterion standard definition would work for adult patients. Intuitively, an adult criterion standard definition would likely be very similar, if not the same but this would need to be formally determined.

While we believe this criterion standard definition for pediatric trauma team activation is comprehensive, we recognize there were limitations with this project. First these results need to be vetted by a larger group of stakeholders. Our expert panel was comprised of professionals in emergency medicine and pediatric surgery from around the nation, but it may not have been comprehensive enough to represent all stakeholder opinions. Further, the Delphi process is intended to develop consensus, which means that minority opinions are dropped from the result. It is possible that other stakeholders might want to evaluate those minority opinions. Finally, there is the possibility that important criteria were overlooked or not considered during this process. To avoid this we recruited a broad range of providers and we allowed them to suggest missing criteria at the end of each survey until no new criteria were suggested. We recommend external validation of the developed criterion standard definition to overcome this limitation.

CONCLUSION

A criterion standard definition for highest-level pediatric trauma team activation was developed. This criterion standard definition will advance trauma research by allowing investigators to determine the accuracy and effectiveness of highest-level pediatric trauma team activation protocols.

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Table 1
Outcomes Identified after Reviewing the Previous Literature that were Included in the First Voting Round Survey

Study	Surgical Procedure	PICU Admission	Death	ISS	GCS	AIS	CPR	Advanced Airway	Volume Resuscitation	Thoracotomy (Clavicle, Neck, or Finger)	Resuscitative pharmacologic agent	ED Thoracotomy	Diagnostic peritoneal lavage	ICP Monitoring	Blood Product Administration	CV Line Placement	Cesarean Section	Cricothyrotomy	IO Insertion	Pericardiotomy		
Sola 1994 ⁷	X	X																				
Qazi 1998 ¹⁹	X	X																				
Dowd 2000 ¹²	X (selective)							X	X	X	X				X							
Nuss 2001 ¹⁸				X																		
Chen 2004 ¹¹	X	X	X	X	X																	
Simon 2004 ²⁰	X	X	X	X				X		X			X	X	X	X						
Steele 2006 ²²	X																	X				
Nasr 2007 ¹⁶	X	X	X	X				X		X			X	X	X	X						
Steele 2007 ²¹	X																					
Bevan 2009 ⁹	X (selective)	X (selective)	X	X																		
Kouzmiov a 2009 ³¹	X	X	X	X	X			X														
Mulherjee 2010 ¹⁵	X		X																			
Williams 2011 ²³	X	X	X	X																		
Bozeman 2012 ¹⁰	X	X	X	X	X	X		X		X		X	X		X							
Krieger 2012 ¹⁴	X	X	X	X				X		X			X	X	X							
Falcone 2012 ⁸	X						X	X	X	X		X	X		X	X			X			X

* Note: PICU – Pediatric Intensive Care Unit; ISS – Injury Severity Score; GCS – Glasgow Coma Score; AIS – Abbreviated Injury Scale; CPR – Cardio-Pulmonary Resuscitation; ICP – Intracranial Pressure; CV – Central Venous; IO – Intraosseous

TABLE 2

Local and National Experts Participation in the Delphi Process

Name	Institution	Specialty	First Round	Second Round	Third Round	Fourth Round	Fifth Round
Mohamed Badawy, MD	University of Texas Southwestern Medical Center	Pediatric Emergency Medicine	X	X	X	X	X
Arthur Cooper, MD, MS	Columbia University Medical Center Affiliation at Harlem Hospital	Pediatric Surgeon			X	X	X
Jeremy T. Cushman, MD, MS, EMT-P	University of Rochester Medical Center	Emergency Medicine	X	X	X	X	X
Patrick C. Drayna, MD	Medical College of Wisconsin	Pediatric Emergency Medicine	X	X	X	X	X
Amy L. Drendel, MS, DO	Medical College of Wisconsin	Pediatric Emergency Medicine	X	X	X	X	X
Richard A. Falcone, MD	Cincinnati Children's Hospital Medical Center	Pediatric Surgeon	X	X	X	X	X
David M. Gourlay, MD	Medical College of Wisconsin	Pediatric Surgeon	X	X	X	X	X
Matthew P. Gray, MD	Medical College of Wisconsin	Pediatric Emergency Medicine	X	X	X	X	X
Manish I. Shah, MD	Baylor College of Medicine	Pediatric Emergency Medicine	X	X	X	X	X
Manish N. Shah MD, MPH	University of Rochester Medical Center	Emergency Medicine	X	X	X	X	X

TABLE 3

Consensus-Based Criterion Standard Definition For Pediatric Patients Who Needed The Highest-Level Trauma Team Activation

Indicator	Time Frame
Received or has in place any advanced airway management device (e.g., surgical airway, intubation, supraglottic airway, etc.) within 2 hours of trauma center arrival. This excludes intubation solely for surgical procedures.	2 h of hospital arrival
Received a thoracostomy procedure (needle, finger, or chest tube thoracostomy) related to their injury within 2 hours of trauma center arrival or received a thoracostomy prior to arrival at the trauma center and has unstable vitals upon arrival.	2 h of hospital arrival
Received more than 1 unit of a blood product or at least 10 ml/kg of packed red blood cells, plasma, and/or platelets prior to or within 2 hours of trauma center arrival.	2 h of hospital arrival
Did not meet the ACS-COT/ACEP/NAEMSP/AAP criteria for termination of resuscitation for traumatic cardiopulmonary arrest and received a pericardiocentesis for treatment of their initial injury prior to or within 2 hours of trauma center arrival. ³²	2 h of hospital arrival
Did not meet the ACS-COT/ACEP/NAEMSP/AAP criteria for termination of resuscitation for traumatic cardiopulmonary arrest and received a thoracotomy for treatment of their initial injury prior to or within 2 hours of trauma center arrival. ³²	2 h of hospital arrival
Received vascular, neurologic, abdominal, thoracic, pelvic, spine, or limb-conserving surgery within 4 hours of trauma center arrival (i.e., on a limb that was found to be pulseless distal to the injury prior to surgery).	4 h of hospital arrival
Received interventional radiology for interventional or diagnostic purposes related to their injury within 4 hours of trauma center arrival.	4 h of hospital arrival
Received an emergency C-section due to their injuries within 4 hours of trauma center arrival.	4 h of hospital arrival
Received vasopressors within 4 hours of trauma center arrival.	4 h of hospital arrival
Received a burr hole or other procedure to relieve intra-cranial pressure or intra-cranial pressure monitoring prior to or within 4 hours of trauma center arrival.	4 h of hospital arrival
Has a confirmed spinal cord injury or unstable spinal fracture on any neuroimaging or has a suspected spinal cord injury with one or more new onset flaccid extremities.	None
Patients who had an injury that typically required any of the treatments listed above as needing a trauma center and arrived at the hospital not in cardiac arrest, but ultimately died of their injury in the emergency department.	None

* ACS-COT- American College of Surgeons-Committee on Trauma, ACEP – American College of Emergency Physicians, NAEMSP- National Association of EMS Physicians, AAP-American Academy of Pediatrics