
Validation of Rules to Predict Emergent Surgical Intervention in Pediatric Trauma Patients

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BACKGROUND: Trauma centers use guidelines to determine when a trauma surgeon is needed in the emergency department (ED) on patient arrival. A decision rule from Loma Linda University identified patients with penetrating injury and tachycardia as requiring emergent surgical intervention. Our goal was to validate this rule and to compare it with the American College of Surgeons' Major Resuscitation Criteria (MRC).

STUDY DESIGN: We used data from 1993 through 2010 from 2 level 1 trauma centers in Denver, CO. Patient demographics, injury severity, times of ED arrival and surgical intervention, and all variables of the Loma Linda Rule and the MRC were obtained. The outcome, emergent intervention (defined as requiring operative intervention by a trauma surgeon within 1 hour of arrival to the ED or performance of cricothyroidotomy or thoracotomy in the ED), was confirmed using standardized abstraction. Sensitivities, specificities, and 95% confidence intervals were calculated.

RESULTS: There were 8,078 patients included, and 47 (0.6%) required emergent intervention. Of the 47 patients, the median age was 11 years (interquartile range [IQR] 7 to 14 years), 70% were male, 30% had penetrating mechanisms, and the median Injury Severity Score (ISS) was 25 (IQR 9 to 41). At the 2 institutions, the Loma Linda Rule had a sensitivity and specificity of 69% (95% CI 45% to 94%) and 76% (95% CI 69% to 83%), respectively, and the MRC had a sensitivity and specificity of 80% (95% CI 70% to 92%) and 81% (95% CI 77% to 85%), respectively.

CONCLUSIONS: Emergent surgical intervention is rare in the pediatric trauma population. Although precision of predictive accuracies of the Loma Linda Rule and MRC were limited by small numbers of outcomes, neither set of criteria appears to be sufficiently accurate to recommend their routine use. (*J Am Coll Surg* 2013;216:1094–1102. © 2013 by the American College of Surgeons)

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Trauma is the leading cause of death among children greater than 1 year of age.^{1,2} Pediatric trauma accounts for approximately 10 million emergency department (ED) visits and 300,000 hospitalizations in the United States each year.³ Yet, only approximately 0.4% of all pediatric trauma patients require immediate surgical intervention.^{4,5} Consequently, secondary trauma triage protocols have been developed to help determine which patients might require urgent or emergent operative intervention in order to decrease the burden on surgical staff.⁵

The American College of Surgeons has specified 6 major resuscitation criteria (MRC) to determine if a trauma surgeon's presence is needed at the bedside when a patient arrives at the ED (Table 1).⁶ However, the MRC were not empirically derived and have not been validated or compared with other criteria for use in a pediatric trauma population.⁷

Abbreviations and Acronyms

ED = emergency department
 GCS = Glasgow Coma Scale
 MRC = Major Resuscitation Criteria
 PALS = Pediatric Advanced Life Support

In 2006, investigators from Loma Linda University derived a clinical decision rule to predict the need for emergent operative or procedural intervention for pediatric trauma patients presenting to the ED.⁵ Their rule included any penetrating mechanism and age-specific tachycardia, as defined by Pediatric Advanced Life Support (PALS), as the only 2 criteria for which a surgeon should be summoned to the ED in anticipation of a patient requiring emergent intervention. In the original study, the Loma Linda rule was reported to have a sensitivity of 100% and a specificity of 60%.⁵

The goal of this study was to validate the Loma Linda Rule and MRC in a large heterogeneous pediatric trauma population, with the hypothesis that the Loma Linda Rule would be more sensitive for identifying emergent intervention than the MRC.

METHODS

Study design and setting

This was a retrospective cohort study performed at Denver Health Medical Center in Denver, CO and the

Table 1. Individual Criteria Used to Define when a Trauma Surgeon Should Be Present in the Emergency Department when a Pediatric Trauma Patient Arrives

Major Resuscitation Criteria

1. Age-specific hypotension*
2. Respiratory compromise, obstruction, or intubation
3. Gunshot wound to the neck, chest, or abdomen
4. GCS score <8 with mechanism attributed to trauma
5. Transfer of patients from other hospitals who receive blood to maintain vital signs
6. Physician discretion

Loma Linda Rule

1. Penetrating injury
2. Age-specific tachycardia[†]

Refined Loma Linda Rule #1

1. Age-specific hypotension*
2. Age-specific tachycardia[†]
3. Penetrating injury to torso[‡]

Refined Loma Linda Rule #2

1. Age-specific hypotension*
2. Age-specific tachycardia[†]
3. Gunshot wound to torso[‡]

*Age-specific hypotension defined as (SBP + [2 × age]) < 70 mmHg for those ≤10 y of age and SBP <90 mmHg for those >10 y of age.

[†]Age-specific tachycardia defined by Pediatric Advanced Life Support.

[‡]Defined as penetrating injury to the neck, chest, or abdomen.

GCS, Glasgow Coma Scale; SBP, systolic blood pressure.

Children's Hospital of Colorado in Aurora, CO, and it was approved by the institutional review boards of both institutions. Denver Health Medical Center and the Children's Hospital of Colorado represent the majority of level 1 pediatric trauma care for the county of Denver and serve as the only 2 pediatric trauma referral centers for Colorado. Denver Health Medical Center is a 477-bed urban safety-net hospital and the Rocky Mountain Regional Trauma Center.⁸ It has approximately 30,000 annual pediatric ED visits, of which approximately 150 per year are included in the trauma registry. Among these 150 patients, 13% are classified as major trauma (defined by an Injury Severity Score [ISS] >15). The Children's Hospital of Colorado is an academic pediatric hospital with 318 beds and an approximate annual ED census of 85,000 visits. Approximately 800 per year are included in the trauma registry and of these, 18% are classified as major trauma.

Study population

All pediatric trauma registry patients (<15 years of age) who presented to Denver Health Medical Center from January 1, 1993 through December 31, 2010 and to Children's Hospital of Colorado from January 1, 2004 through December 31, 2010 were included in this study. Inclusion criteria for the registries are all trauma patients admitted to the hospital, those who remained in the ED for ≥12 hours, were transferred from another hospital, or died in the ED or hospital. During the study periods, each institution used criteria similar to the MRC to summon a trauma surgeon to the bedside on patient arrival.

Data collection and processing

Dedicated trauma registry staff members from both institutions are specifically trained in the oversight of each registry. They search the ED patient log daily to identify patients who meet criteria for inclusion in the trauma registry. Subsequently, data from the medical records of such patients are abstracted and entered into an electronic database (TraumaBase, Clinical Data Management). For quality assurance, members of the trauma registry staff internally review approximately 20% of the registry records, and the trauma registry committee reviews all discrepancies and makes corrections through a consensus process.

Data included in the trauma registry and extracted for purposes of this study were demographics (age and sex); trauma mechanism (penetrating or blunt); date and time of presentation to the ED; prehospital and ED vital signs (heart rate, respiratory rate, and systolic blood pressure); prehospital and ED Glasgow Coma Scale (GCS) score; prehospital or ED intubation or cricothyroidotomy; Abbreviated Injury Scale for head, neck, chest, abdomen,

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