Heart rate in pediatric trauma: rethink your strategy

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ARTICLE INFO

ABSTRACT

Background: The optimal heart rate (HR) for children after trauma is based on values derived at rest for a given age. As the stages of shock are based in part on HR, a better understanding of how HR varies after trauma is necessary. Admission HRs of pediatric trauma patients were analyzed to determine which ranges were associated with lowest mortality.

Materials and methods: The National Trauma Data Bank was used to evaluate all injured patients ages 1–14 years admitted between 2007 and 2011. Patients were stratified into eight groups based on age. Clinical characteristics and outcomes were recorded, and regression analysis was used to determine mortality odds ratios (ORs) for HR ranges within each age group.

Results: A total of 214,254 pediatric trauma patients met inclusion criteria. The average admission HR and systolic blood pressure were 104.7 and 120.4, respectively. Overall mortality was 0.8%. The HR range associated with lowest mortality varied across age groups and, in children ages 7–14, was narrower than accepted resting HR ranges. The lowest risk of mortality for patients ages 5–14 was captured at HR 80–99.

Conclusions: The HR associated with lowest mortality after pediatric trauma frequently differs from resting HR. Our data suggest that a 7y old with an HR of 115 bpm may be in stage III shock, whereas traditional HR ranges suggest that this is a normal rate for this child. Knowing when HR is critically high or low in the pediatric trauma population will better guide treatment.

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1. Introduction

Clinical decision relies in part on physical examination, which includes four routinely recorded vital signs: heart rate (HR), respiration rate, blood pressure, and temperature [1,2]. In the pediatric population, these vital signs have high variability because of age-dependent physiology [3–5]. HR and respiratory rate are the key values used to assess the physiologic status of children in many clinical settings [6–9]. Many emergency departments (ED) use the Broselow Pediatric Emergency Tape, which uses the patient's height to rapidly provide appropriate equipment in the emergency management of children [10–13]. Additionally, newer versions of these tapes provide rough guidelines for what the appropriate vital signs at a certain height should be and may be used for resuscitation [10–13]. These normogram tapes are used in various clinical settings including patients with infectious illness, gastrointestinal illness, and after trauma as a

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guide for life-saving treatment [6,13–16]. The reference ranges are based on normal vital signs at rest. The validity of these normal ranges has been questioned because of lack of evidence in the literature [8,17] suggesting that a clinician may be misled in evaluating vital signs of an ill child, particularly in the setting of trauma [5,18–20]. Recently, a large scale evaluation of the normal reference ranges for pediatric HR was conducted [8]. However, these values do not reflect the deviations that may occur due to acute illness or trauma.

In addition, many EDs use a pediatric early warning score to assess children for critical illness [15,16,21,22]. This score was initially developed to rapidly assess impending clinical deterioration in inpatient pediatric patients [14,15,19]. The scoring system uses several readily accessible clinical data points. The first item on the score is to assess for an elevated or depressed HR, further suggesting the paramount importance of correctly gauging if an HR is normal or abnormal.

How HR after trauma differs from HR at rest in the pediatric population is unknown. We sought to identify the optimal HRs after trauma in children by reviewing admission HRs to determine the ranges associated with reduced mortality.

2. Materials and methods

A retrospective review of the National Trauma Data Bank data from January 1, 2007 to December 31, 2011 was performed. The database was queried for all injured patients ages 1 to 14 y who were admitted into the hospital. Patient characteristics including age, gender, mechanism of injury, admission HR, admission systolic blood pressure (SBP), Glasgow Coma Scale (GCS), Injury Severity Score (ISS), regional Abbreviated Injury Scale (AIS), and outcomes such as mortality, hospital length of stay (LOS), and intensive care unit (ICU) LOS were recorded for each age group. To ensure the applicability of the results to most injured trauma patients, we excluded any patient with an AIS of 6, ISS of 75, death in the emergency department, or missing HR or SBP data. Patients who were transferred to another hospital were also excluded.

Patients were stratified into eight groups according to age 1 y, 2–3 y, 4 y, 5–6 y, 7–8 y, 9–11 y, 12–13 y, and 14 y. To determine which admission HR ranges were associated with the lowest risk for mortality within each age group, the odds ratio (OR) of mortality and the corresponding 95% confidence intervals (CIs) were calculated using logistic regression analysis. In the logit model, the log odds of the outcome for mortality were modeled as a linear combination of predictor variables (e.g., heart rate). The reference ranges used in each age group were determined according to previously defined standard HR ranges [8,23]. Additionally, similar logistic regression analyses were conducted to assess risk for secondary outcomes, including admission to the ICU and disposition from the ED to the operating room. All statistical analysis was performed using SAS, version 9.1 (SAS Institute, Cary, NC). This study was approved by the Institutional Review Board of Cedars-Sinai Medical Center.

3. Results

Over the 5-year study period, 323,061 patients had data available. After previously described exclusions, the admission HRs from 214,254 pediatric trauma patients were analyzed (Figure). The average age of patients was 8.2 y with a preponderance of male cases (65.0%). The average HR and systolic blood pressure at admission were 104.7 ± 23.3 and 120.4 ± 16.8, respectively. Of all patients, 10.2% had an ISS ≥ 16 and 20.3% of cases had a head AIS ≥ 3. For patients admitted to the ICU the average ICU length of stay was 3.3 d. Hospital length of stay was 3.1 d on average for the entire cohort. Overall mortality rate was 0.8%. Males represented most patients in all age group ranges. Mean HR decreased with increasing age from 137.5 at age 1 y to 91.7 at 14 y (Table 1). Penetrating injuries were rare, making up only 3.6% of all admissions, with a fairly steady rate of 2.4%–3.2% at younger ages and increasing in teenage years.

Lowest mortality was attained at different ranges of heart rate and strongly depended on age. Among patients of age 1, HR of 120–139 resulted in the lowest risk of mortality (OR = 0.9, CI: 0.6–1.4) whereas a 50–59 HR produced the highest mortality (OR = 31.8, CI: 7.6–132.8). In children ages 2–3 y, the
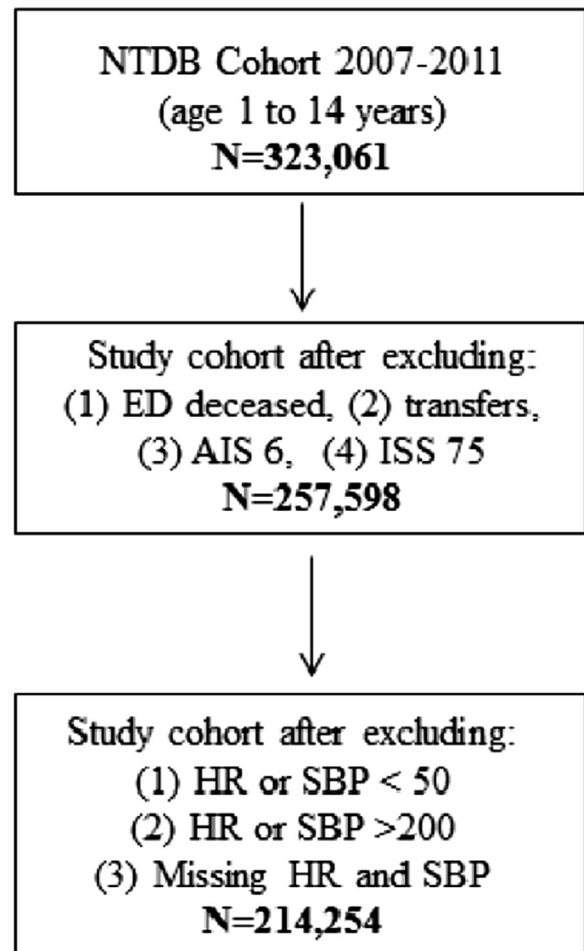

Figure – Study inclusion criteria depicting final sample size.