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Performance characteristics of five triage tools for major incidents involving traumatic injuries to children

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ABSTRACT

Context Triage tools are an essential component of the emergency response to a major incident. Although fortunately rare, mass casualty incidents involving children are possible which mandate reliable triage tools to determine the priority of treatment.
Objective: To determine the performance characteristics of five major incident triage tools amongst paediatric casualties who have sustained traumatic injuries.
Design, setting, participants: Retrospective observational cohort study using data from 31,292 patients aged less than 16 years who sustained a traumatic injury. Data were obtained from the UK Trauma Audit and Research Network (TARN) database.

Interventions Statistical evaluation of five triage tools (JumpSTART, START, CareFlight, Paediatric Triage Tape/Sieve and Triage Sort) to predict death or severe traumatic injury (injury severity score >15).

Main outcome measures Performance characteristics of triage tools (sensitivity, specificity and level of agreement between triage tools) to identify patients at high risk of death or severe injury.
Results: Of the 31,292 cases, 1029 died (3.3%), 6842 (21.9%) had major trauma (defined by an injury severity score >15) and 14,711 (47%) were aged 8 years or younger. There was variation in the performance accuracy of the tools to predict major trauma or death (sensitivities ranging between 36.4 and 96.2%; specificities 66.0–89.8%). Performance characteristics varied with the age of the child. CareFlight had the best overall performance at predicting death, with the following sensitivity and specificity (95% CI) respectively: 95.3% (93.8–96.8) and 80.4% (80.0–80.9). JumpSTART was superior for the triaging of children under 8 years; sensitivity and specificity (95% CI) respectively: 86.3% (83.1–89.5) and 84.8% (84.2–85.5). The triage tools were generally better at identifying patients who would die than those with non-fatal severe injury.
Conclusion: This statistical evaluation has demonstrated variability in the accuracy of triage tools at predicting outcomes for children who sustain traumatic injuries. No single tool performed consistently well across all evaluated scenarios.

Introduction

The term 'big bang' major incident is used to describe a major incident caused by sudden catastrophic events with little or no warning, where the number of casualties is relatively constant from the time of the incident but has the potential to outstrip resources [1,2]. Such incidents test the response of emergency medical services and hospitals and it is essential that resources are used in an optimal way to target those with greatest need [3]. In order to achieve this, one of the first priorities is to undertake rapid and accurate triage to prioritise and provide care to as many casualties as possible with the intention of minimising loss of life and suffering, moderated by the available resources. However, there is uncertainty around the efficacy of commonly used triage systems, particularly in children

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[4], and a recent systematic review of the literature concluded that there is limited evidence of the validity of triage tools in major incidents of this nature [1].

This study aims to assess the performance accuracy of five manual/paper based triage tools when assessing paediatric casualties and to compare the level of agreement between them. The tools assessed are: JumpSTART (age ≤8 years) [5], START (age >8 years) [6], CareFlight [7], Paediatric Triage Tape/Sieve [8], Triage Sort [9].

Methods

Study design and data collection

A retrospective observational cohort study was undertaken. Approval was obtained from the Trauma Audit and Research Network (TARN; www.tarn.ac.uk) to analyse data from the TARN database. TARN collects and records data from hospitals across England and Wales for patients who sustain injury resulting in hospital admissions for >3 days, critical care admission or death. A dataset was obtained in August 2009 containing 31,560 paediatric trauma patient records for patients aged less than 16 years, and included respiratory rate (breaths per minute), systolic blood pressure (mmHg), cardiac arrest (yes/no), intubated (yes/no), age (years), capillary refill time (>2/<2 s), heart rate (beats per minute), Glasgow Coma Scale (GCS) score and Injury Severity Score (ISS). No personal identifiable information was provided. The GCS is used to assess the conscious state of a person and is a 13-point scale ranging between 3 and 15, where 3 indicates a state of deep unconsciousness [10]. The ISS assesses trauma severity and ranges between 1 and 75 (worst) [11]. Patient survival was recorded in the dataset as alive or dead [10]. The use of anonymised data from a research database does not require specific ethical approval in the UK (Governance Arrangements for Research Ethics Committees 2012).

Triage tools

Five triage tools were evaluated: JumpSTART [5] (age ≤8 years), START [6] (age >8 years), CareFlight [7], Paediatric Triage Tape/Sieve [8] and Triage Sort [9]. Each triage tool leads to one of three priority outcomes, named slightly differently depending on the tool used: deceased (dead/unsalvageable), immediate (priority 1 or 2) or delayed (urgent/priority 3). For this research, the deceased and immediate outcomes were combined into a single ‘immediate priority’ outcome. The performance of each tool was assessed according to its ability to accurately distinguish between ‘immediate priority’ and ‘delayed priority’ patients.

The following assumptions informed the mapping of TARN data to the various triage tools: an open airway, or the ability to breathe, was indicated by a respiratory rate >0. The patient was assumed to have palpable pulse if the systolic blood pressure was >60 mmHg and no palpable pulse if systolic blood pressure was ≤60 mmHg. The ability to obey commands was indicated by a GCS score ≥14 and a patient was assumed to be unable to obey commands if the GCS score was <14 or if this was missing and the patient had been intubated.

Statistical analysis

31,292 patient records (99.2%) were eligible for analysis, 268 patients (0.8%) were excluded due to missing vital sign information or ISS. Multiple imputation [12,13] was used to replace missing values for the following variables (proportion missing): respiratory rate (27.4%), heart rate (15.2%), systolic blood pressure (25.6%) and intubated (10.3%) using a model with 29 variables to give five imputed datasets with results combined as proposed by Rubin [13]. If a patient had a missing GCS score but had been intubated, it would have been impossible to obtain the score and this was indicated as a separate category in the dataset.

The primary outcome of interest was patient survival (alive or dead). However, for comparison, the tools were also assessed against injury severity (ISS ≤15 or ISS >15). Descriptive statistics were used to explore the data by age (≤8 and >8 years) and survival (alive or dead). These included means (medians) with standard deviations (interquartile ranges) and frequencies with percentages. Sensitivities and specificities with 95% confidence intervals were calculated for each triage tool against both survival and injury severity. Sensitivity indicates the proportion of patients who died/had ISS >15 who were correctly assigned to the immediate priority group and specificity indicates the proportion of patients who did not die/had ISS ≤15 who were correctly assigned to the delayed priority group.

Since JumpSTART and START apply to different ages (≤8 and >8 years, respectively), analyses for all triage tools were conducted separately on these two age groups. Acknowledging that the PTT is weight and length based, the weight for each child was calculated as (age + 4) × 2 and the appropriate PTT algorithm was used [14]. A further analysis was undertaken to compare the tools using all cases (regardless of age) by combining JumpSTART and START into a single tool. A complete case analysis was also undertaken to compare the results with and without using multiple imputation. Patient records were assumed to be independent.

Agreement between each pair of triage tools for the two age groups (≤8 and >8 years) was estimated using the kappa statistic. A value of 1 indicates perfect agreement and a value of 0 indicates no agreement [15,16].

Data cleaning was undertaken using SPSS v.17. All other analyses were performed in the *R* statistical software (www.r-project.org; downloaded in UK). In particular, a bootstrapping approach was adopted to undertake the multiple imputation using the aregImpute function in the Hmisc package (http://cran.r-project.org/web/packages/Hmisc).

Results

A total of 31,292 patients aged less than 16 years were included in the study; 10,048 females (32.1%) and 21,244 males (67.9%), with mean ages 7.9 years (standard deviation 4.9 years) and 8.7 years (standard deviation 4.8 years), respectively. A total of 1029 patients (3.3%) died and the median ISS was 9 (IQR 5–13), with 6842 (21.9%) having an ISS >15. Within the group of patients who survived, 19.4% (5878/30,263) had an ISS >15 compared to 93.7% (964/1029) of those in the non-survivor group. Splitting the data by age, 14,711 patients (47%) were aged less than or equal to 8 years and 16,581 patients (53%) were aged over 8 years. Patient characteristics in the two age groups by survival (alive or dead) are shown in Table 1.

Paediatric triage tool accuracy

Sensitivities and specificities with 95% confidence intervals, calculated separately against survival (alive or dead) and injury severity (ISS ≤15 or ISS >15), are given in Tables 2–4.

Fig. 1 summarises the performance accuracy of the tools, particularly in their ability to correctly triage patients who died and those with an ISS >15, as indicated by the sensitivity values.

The results of the complete case analysis were very similar to those of the analysis using imputed data. This provides reassurance that the imputed analysis has produced accurate estimates whilst enabling the use of the full dataset.