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Original research

The modified rapid emergency medicine score: A novel trauma triage tool to predict in-hospital mortality

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ABSTRACT

Background: Trauma systems currently rely on imperfect and subjective tools to prioritize responses and resources, thus there is a critical need to develop a more accurate trauma severity score. Our objective was to modify the Rapid Emergency Medicine (REMS) Score for the trauma population and test its accuracy as a predictor of in-hospital mortality when compared to other currently used scores, including the Revised Trauma Score (RTS), the Injury Severity Score (ISS), the "Mechanism, Glasgow Coma Scale, Age and Arterial Pressure" (MGAP) score, and the Shock Index (SI) score.

Methods: The two-part study design involved both a modification step and a validation step. The first step incorporated a retrospective analysis of a local trauma database (3680 patients) where three components of REMS were modified to more accurately represent the trauma population. Using clinical judgment and goodness-of-fit tests, systolic blood pressure was substituted for mean arterial pressure, the weighting of age was reduced, and the weighting of Glasgow Coma Scale was increased. The second part comprised validating the new modified REMS (mREMS) score retrospectively on a U.S. National Trauma Databank (NTDB) that included 429,711 patients admitted with trauma in 2012. The discriminate power of mREMS was compared to other trauma scores using the area under the receiver operating characteristic (AUC) curve.

Results: Overall the mREMS score with an AUC of 0.967 (95% CI: 0.963–0.971) was demonstrated to be higher than RTS (AUC 0.959 [95% CI: 0.955–0.964]), ISS (AUC 0.780 [95% CI 0.770–0.791]), MGAP (AUC 0.964 [95% CI: 0.959–0.968]), and SI (AUC 0.670 [95% CI: 0.650–0.690]) in predicting in-hospital mortality on the NTDB.

Conclusion: In the trauma population, mREMS is an accurate predictor of in-hospital mortality, outperforming other used scores. Simple and objective, mREMS may hold value in the pre-hospital and emergency department setting in order to guide trauma team responses.

Introduction

Trauma kills over 175,000 Americans every year and is the leading cause of death for individuals under 45 years of age [1]. In addition, trauma results in significant morbidity, disability, and financial and social costs [2,3]. Trauma mortality rates depend on injury severity, time to assessment, and time to reach an appropriate care center. Prompt assessment and appropriate triage can decrease rates of mortality and long-term disability [4,5]. Validated trauma scoring systems can quickly assess injury severity and indicate prognosis. Several such systems have been developed. These differ in their complexity, design, and accuracy but no studies have compared the accuracy of the commonly-used scoring systems in predicting mortality on a national scale in the United States [5,6].

Early trauma scores, such as the Abbreviated Injury Score (AIS) in 1969 and the Injury Severity Scores (ISS) in 1971 focused on anatomical features [6,7]. Later scores, such as the Acute Physiology and Chronic Health Evaluation (APACHE) score, the Revised Trauma Score (RTS), the Shock Index (SI), and the "Mechanism of injury, Glasgow Coma Scale, Age, and Systolic Blood Pressure" (MGAP) score incorporated measures of functional

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status [8–11]. A single universally-agreed valid trauma scoring system would greatly benefit trauma services nationwide.

The Revised Trauma Score (RTS) is designed to be used for pre-hospital trauma triage. It includes the variables respiratory rate (RR), systolic blood pressure (SBP), and the Glasgow Coma Scale (GCS) that are each weighted differently and summed up to a maximum score of 12 [8]. As one of the oldest trauma scores, the Injury Severity Score (ISS) is an anatomically based scoring system that was designed to predict outcomes of automobile crash victims with multiple injuries [7]. The ISS divides the human body into 6 regions, head/neck, face, chest, abdomen and pelvic contents, extremities or pelvic girdle, and external surfaces. The score is based off of the Abbreviated Injury Score [6] (AIS), and includes the highest AIS severity score in the three most severely injured body regions, for a maximum score of 75. The MGAP score was developed as a simple score to be used in the pre-hospital setting. Unlike the other scores, MGAP incorporates mechanism of injury, blunt or penetrating, into its model. It is the sum of points assigned for values of mechanism of injury, Glasgow Coma Scale, age, and systolic arterial blood pressure [10]. Since its development in 2010, it has been tested and validated prospectively in Europe, but has yet to be tested in the United States [10,12]. The Shock Index (SI) is a simple calculation of heart rate divided by blood pressure and has historically been used for prediction of injury severity [9].

The Rapid Emergency Medicine Score (REMS) (2004) is a triage score that has proved to be a powerful predictor of in-hospital mortality for medical (non-trauma) hospital admissions [13]. The composite score consists of the variables age, mean arterial pressure (MAP), heart rate (HR), respiratory rate (RR), oxygen saturation (O_2 sat), and Glasgow Coma Scale (GCS). This score was shown to be a simple and accurate predictor of in-hospital mortality in trauma patients. (15) This retrospective study indicated areas for improvement and ways to optimize the score for trauma patients. In particular, the age appeared to be over-weighted and the GCS under-weighted when REMS was applied to trauma patients [14].

The new modified Rapid Emergency Medicine Score (mREMS) is an adapted version of the REMS score designed to be a practical real-time triage score that could be a more accurate predictor of in-hospital mortality than more complex scores that often require invasive measurements. The purpose of this study was to develop a modified REMS (mREMS) for the trauma population and to validate it on a nationally representative trauma dataset. Secondary objectives include to compare the predictive ability of the new mREMS score to the currently-used trauma scores (RTS, ISS, MGAP and SI) and to examine the predictive accuracy of mREMS for hospital mortality when stratified by blunt or penetrating trauma.

Methods

Development of mREMS

The modification of REMS to mREMS was based on factor analysis of patient information in an urban trauma database of 3680 patients treated over a 4-year period at an academic ACS level 1 trauma center. A pilot study indicated that the weighting of GCS was too low, the weighting of age was too high, and that mechanism of injury should be incorporated into the score to better represent trauma patients [14]. For the mREMS score, the distribution of categories for age and GCS were determined by identifying mortality rates for each incremental value and creating the categories by clinical judgement and confirming the best fit using logistic regression. Using clinical judgement and goodness of fit tests, the relative weighting of age was decreased and the weighting of GCS increased, to provide a more accurate predictor of mortality in trauma patients. The mREMS also replaces MAP with SBP because SBP is almost universally measured and is a proven indicator of trauma severity [15]. The SBP is also often the only measurement of blood pressure recorded in trauma registries. Finally, as the mechanism of injury, blunt or penetrating, has been included in field triage tools, this study looked at the effect of incorporating mechanism of injury into the score [16].

Validation of mREMS

The validation of the mREMS score utilized a retrospective analysis of data from level I–IV trauma centers that contributed to the U.S. National Trauma Data Bank (NTDB), a nationwide registry managed by the American College of Surgeons (ACS) [17]. The databank used for this validation step did not include the data used for the development of the mREMS score. Data were provided by 758 U.S. hospitals from the calendar year 2012. The study included all patients 16 years and older who were treated with blunt and/or penetrating injuries. The only exclusions were patients with missing data necessary to calculate an mREMS score, those who were transferred from another facility, and burn and/or drowning victims. The analysis included 429,711 patients (Fig. 1).

The data collected from each patient included age, gender, race, systolic blood pressure (SBP), respiratory rate (RR), heart rate (HR), peripheral oxygen saturation, Glasgow Coma Scale (GCS), temperature, length of stay time, mechanism of injury, in-hospital mortality, and state trauma level designation. The ISS score was included in the NTDB database; all other scores were calculated during the data analysis phase. The study and design was reviewed and approved by the site Institutional Review Board.

Measurements

The mREMS score is composed of patient age, and the routinely acquired vital signs SBP, HR, RR, peripheral oxygen saturation, and GCS. The mREMS score is calculated with each variable being assigned a scoring range of 0–4 with the exception of GCS, which has a range of 0–6, with an overall maximum mREMS score of 26 (Table 1).

In the preliminary score modification, odds ratios of age, GCS score assignments, and injury type (blunt or penetrating) were calculated against mortality outcomes. Using odds ratios and the area under the receiver operating characteristic (ROC) curve models, age and GCS point assignments were adjusted by modifying the score cutoffs by lowering the overall impact of a high age value and increasing the overall impact of a low GCS value. Odds ratios were also used to evaluate the benefit of adding mechanism of injury to the score. Clinical judgment was used to devise multiple scoring models in order to replace MAP values with SBP. The SBP models were compared to the current MAP model using the Spearman method. Odds ratios and the area under the receiver operating characteristic (ROC) curve were used to identify the SBP scoring method that best predicted mortality.

The modified score, mREMS, was then validated using a national database and its performance compared to currently utilized trauma scoring systems to determine which scoring method best predicts in-hospital mortality. We compared mREMS to the most frequently used scoring systems to predict in-hospital mortality, such as RTS, ISS, MGAP and SI.

Statistical analyses

For this study, patients were divided into two groups, those who survived and those who died in-hospital. The NTDB database contains all necessary data to calculate each of the scores for this comparison. The ISS score for each patient was already provided and each other score was calculated using their respective formula.

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