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Comparison of modified Kampala trauma score with trauma mortality prediction model and trauma-injury severity score: A National Trauma Data Bank Study☆

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ABSTRACT

Background: Mortality prediction of trauma patients relies on anatomical, physiological or combined scores. The purpose of this study is to compare the diagnostic accuracy of the modified Kampala Trauma Score (M-KTS) with the Trauma Mortality Prediction Model (TMPM), and Trauma-Injury Severity Score (TRISS) using data from a large dataset from a developed registry, the National Trauma Data Bank (NTDB).
Methods: Using 2011 and 2012 data from NTDB, patient based trauma scores (M-KTS, TMPM, and TRISS) were calculated and predictive ability of M-KTS for mortality was compared with other trauma scores using receiver operating characteristics (ROC) curves.
Results: A total of 841 089 patients were included in the study. TRISS outperformed other scores (AUC = 0.922, %95 CI 0.920–0.924) with M-KTS as the second best score (AUC = 0.901, %95 CI 0.899–0.903) followed by TMPM (AUC = 0.887, 95% CI 0.844–0.889). For blunt trauma, TRISS (AUC = 0.917, 95% CI 0.915–0.919) performed better than M-KTS (AUC = 0.891, %95 CI 0.889–0.893) and TMPM (AUC = 0.874, 95% CI 0.871–0.877). For penetrating trauma, M-KTS (AUC = 0.956, 95% CI 0.954–0.959) and TMPM (AUC = 0.955, 95% CI 0.951–0.958) had similar performance after TRISS (AUC = 0.969, 95% CI 0.967–0.971).
Conclusion: M-KTS performed worse than TRISS although its' main advantage is simple use in resource-limited settings.

Introduction

Injury severity is one of the key interests in trauma-related research, and mortality is the outcome of these studies. Use of injury severity scoring systems is essential in evaluating and benchmarking outcomes and for objective comparison of trauma systems. Complex formulas requiring computational power may limit their daily clinical benefits. Trauma scores were developed to identify the impact of injury and quantitate the severity of injuries. Trauma registries have been used to develop and evaluate these trauma scores. They include hospital administrative datasets and regional or national trauma registries, as well as the National Trauma Data Bank (NTDB®), the largest trauma registry available.

Trauma scores can be categorized as anatomic, physiologic, and combined scores based on the method of calculation. The most commonly used trauma score is the Injury Severity Score (ISS). As an anatomic scoring system, ISS is composed of the sum the square of the three highest Abbreviated Injury Scale (AIS) scores for the three most injured ISS regions [1]. Because of ISS's imprecise ability to perfectly predict mortality, several other anatomically based scoring systems were developed, but they failed to replace ISS [2,3]. To overcome this problem, Glance et al. developed Trauma Mortality Prediction Model (TMPM) for anatomically based trauma assessment, and codes were developed to predict mortality after trauma and published in the International Classification of Diseases, Ninth Edition (ICD-9-CM) [4,5].

The Revised Trauma Score (RTS) is a physiologic scoring system developed using a logistic regression method. It comprises three physiologic values [Glasgow Coma Scale (GCS) score, systolic blood pressure (SBP), and respiratory rate (RR)] [6]. Lack of anatomic scores and under-performance limited its' common use. The Trauma and Injury Severity Score (TRISS) is a combined trauma score based on the use of coefficients derived from the Major Trauma Outcome Study. It uses the RTS, ISS, and age index [7].

KTS is a combined trauma score and was created by Kobusingye and Lett [8]. The Injury Surveillance System in Uganda (ICC) validated KTS for local use and as an alternative to other trauma scores, while researchers in several studies recommended it to be used as a predictor of mortality in resource-poor settings [8-10]. KTS is calculated with

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five categorical components: age, SBP, RR, neurologic status [alert, responsive to verbal stimulus, responsive to painful stimulus, unresponsive (AVPU)], and number of serious injuries.

This study aims to compare the accuracy M-KTS to more established trauma scoring system using a large dataset from a developed world registry. In the present study, we compared M-KTS with more established trauma scoring systems (TMPM), as well as with a combined score (TRISS), using a database derived from a population compiled in a developed database world registry (NTDB®), and we evaluated M-KTS's prognostic accuracy. We hypothesized that M-KTS could serve as a valuable predictor of mortality compared with other trauma scores and sought to compare the diagnostic accuracy of M-KTS using the largest available database of trauma patients.

Patients and methods

This study included patients in NTDB® registry of 2011 and 2012. Analysis of NTDB® was approved by the American College of Surgeons NTDB® committee. NTDB® is defined as the largest aggregated U.S. trauma registry ever assembled. The dataset included 1 620 156 patients hospitalized after trauma over a 2-year period. Data used in the study and calculation of trauma scores included demographic characteristics, type and mechanism of injury (based on ICD-9-CM codes), vital signs, GCS values, AIS and ISS codes, and patient outcomes (defined as survival to hospital discharge). Patients without AIS and ISS codes, those with burns or non-traumatic injuries (e.g., poisoning, drowning, and suffocation), patients with missing or invalid data (data missing on age, gender, outcome), and patients younger than 1 year were excluded. Patients with missing values or with incalculable scores for any of the five categories because of missing components (age, SBP, RR, AIS and ISS scores, and GCS) were excluded. Patients who were dead on arrival to the emergency department (ED), transferred to another hospital, or left against medical advice were also excluded. We also included patients treated at trauma centers with a caseload of at least 500 patients per year to robust patient care with trauma registry systems. ICD-9-CM codes used for injury type define injuries as either blunt or penetrating trauma and according to mechanism of injury (pedestrian, bicycle, motorcycle, motor vehicle collision, fall, stabbing, and gunshot wounds). The final dataset included patients with all valid trauma scores and outcomes.

AIS is an anatomic scoring system developed by the Association for the Advancement of Automotive Medicine to classify and describe injuries. Since its introduction in 1969, seven major updates have been published. Beside its extensive use for classification, AIS severity is assessed by assigning scores ranging from 1 for minor injury to 6 for maximum (fatal) injury for one of six body regions. Because AIS is a measurement system for single injuries and lacks an aggregation function, Baker et al. developed an AIS-derived ISS for use as an overall score to describe the severity of multiple injuries [11]. ISS comprises the sum of the square of the highest AIS in three regions of the five regions (head-neck, face, thorax, abdomen-pelvic contents, extremities-–pelvic girdle and external). If any of the scores of the six sub-regions is 6, the ISS score is set to 75.

The NTDB® contains a precalculated ISS along with ICD-9 codes with AIS 1998 revision (AIS 98). Precalculated ISS scores were supplied by the contributing trauma centers, and they were used in this study. AIS codes were globally mapped to AIS 98. If the hospital did not submit a corresponding AIS code, the ISS was based on the AIS derived using ICDMAP-90 software. Four types of ISS were in the NTDB®; and the precalculated ISS submitted by the trauma center to NTDB® was used in this study. The other three methods of ISS calculation—ISS derived from the AIS score submitted by the hospital, ISS derived from mapping of existing AIS codes to AIS 98, and ISS derived from AIS score calculated using ISS/AIS mapping—were excluded.

TMPM based on ICD-9 (TMPM-ICD-9) was calculated by using the method described by Glance et al. [4]. The five worst injuries of patients are taken into consideration, and the probability of death is calculated with a two-stage approach. STATA routine (Tmpm.ado) was provided by its developers and is available on the Internet. TMPM-ICD-9 matches injuries to one of six precalculated model-averaged regression coefficients (MARC), and probability of death is a product of the cumulative inverse normal function of the sum of the five highest MARC values multiplied by the model coefficients [4]. To achieve consistency of trauma scoring, TMPM-ICD-9 was calculated by using the AIS codes of each trauma patient submitted by the corresponding trauma center.

M-KTS was calculated by using the method described by Kobusingye and used the original formula [8]. We used categorical components for calculating an overall score: age, SBP, respiratory change, neurologic status, and number of serious injuries (AIS score greater than or equal to 3). The neurologic status components of the AVPU score are alert, responsive to verbal stimulus, responsive to painful stimulus, and unresponsive; however, since NTDB® registry records report patients' more commonly accepted GCS for neurologic status, we converted NTDB® registry GCS records to corresponding AVPU scores using a stepwise method described in a recent study by Weeks et al. [12]. Patient with a motor response score of 6 (obeys commands) and an eye response score of 4 (spontaneously opens eyes) was considered "alert." An eye response score of 3 (opens eyes to verbal commands) was considered "responds to verbal stimulus." A motor response from 2 to 5 (extension to painful stimulus = 2, localized painful stimulus = 5) or an eye response score of 2 (opens eyes in response to painful stimulus) was considered "responds to painful stimulus." Motor and eye responses of 1 (no motor or eye response to painful stimulus) were considered "unresponsive." The total M-KTS score ranges from 0 to 10.

The TRISS is a combined trauma score that uses different coefficients for blunt or penetrating trauma derived from the Major Trauma Outcome Study [7]. It uses RTS, ISS, and age index (which uses categorized age values) to predict Ps with the equation $Ps = 1/(1 + e^{-b})$, where b is calculated using $b = b0 + b1\ (RTS) + b2\ (ISS) + b3\ (age\ index)$. The RTS was calculated by using the function $RTS = (0.9368 \times GCS) + (0.7326 \times SBP) + (0.2908 \times RR)$ [6].

Probability of death using TRISS, TMPM, and M-KTS was assessed by using the receiver operating characteristic (ROC) method to evaluate how each score discriminates between survivors and non-survivors. An ROC curve plots the false-positive rate (100-specificity) on the x-axis and the true-positive rate (sensitivity) on the y-axis. A random guess would lie on the line drawn from the left lower corner to the right upper corner, and a perfect discrimination passes through the upper left corner [13].

Patients were categorized further by race and/or ethnicity (Caucasian, African-American, Asian, American Indian, Pacific Islander, or other) and by insurance status as privately insured (Blue Cross/Blue Shield, other commercial insurance), publicly insured (Medicaid, Medicare, other government insurance), uninsured (including self-pay), and other forms. The mechanism of injury was classified as blunt, penetran, or other form according to the International Classification of External Causes of Injury published by the World Health Organization as part of its Family of International Classifications [14]. Mortality was the primary outcome, and patients who had "survival to discharge" were included in this study. Mortality was reported with a separate ROC curve, and area under curve (AUC) calculations were performed for the overall population; by injury type (blunt or penetrating); according to ISS severity (minor = 1–8, moderate = 9–15, severe = 16–24, and very severe = 25 or higher); and by age group, defined as children (1–17 years), young (18–64 years), and elder (≥65 years). This severity classification was commonly used in previous studies [5].

Results

After all exclusion criteria were applied, among the 1 620 156 patients reported by 840 trauma centers, 841 089 (51.9%) met the study inclusion criteria, and the total dataset included patients with 3 051 342 instances of complete injury scoring data and mortality.

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