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Predictive value of Modified Early Warning Score (MEWS) and Revised Trauma Score (RTS) for the short-term prognosis of emergency trauma patients: a retrospective study

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ABSTRACT

Objectives This study aimed to assess the predictive value of the Modified Early Warning Score (MEWS) and Revised Trauma Score (RTS) for emergency trauma patients who died within 24 hours.

Design A retrospective, single-centred study.

Setting This study was conducted at a tertiary hospital in Southern China.

Participants A total of 1739 patients with acute trauma, aged 16 years or older who presented to the emergency department from 1 November 2016 to 30 November 2019, were included.

Interventions none None.

Outcome 24-hour mortality was the primary outcome of trauma.

Results 1739 patients were divided into the survival group (1709 patients,98.27%), and the non-survival group (30 patients,1.73%). Crude OR and adjusted OR of MEWS were 1.99, 95% CI (1.73 to 2.29), and 2.00, 95% CI (1.74 to 2.31), p<0.001, respectively. Crude OR and adjusted OR of RTS were 0.62, 95% CI (0.55 to 0.69) and 0.61, 95% CI (0.55 to 0.68), p<0.001, respectively. The area under the curve of MEWS was significantly higher than that of RTS (p=0.005): 0.927, 95% CI (0.914 to 0.939) vs 0.799, 95% CI (0.779 to 0.817).

Conclusions Both MEWS and RTS were independent predictors of the short-term prognosis in emergency trauma patients, MEWS had better predictive efficacy.

Strengths and limitations of this study

- To the best of our knowledge, no other study has done a statistical comparison of these two scoring systems in the field of early emergency trauma.
- Focus on early decision-making and rational use of trauma scoring system, to improve early triage efficiency.
- The retrospective nature of the study was a limitation, as it was not conducted in real-time and was limited by subjective differences in artificial statistical results and differences in recording time.
- The environment of emergency trauma may also affect the quality of vital signs recorded, leading to underestimation of the extent of the patient's physical disorders and deterioration.

INTRODUCTION

In most developed countries, a regional trauma system has been developed to triage and divert patients with traumatic injuries to appropriate trauma centres. Recent studies have shown a 25% reduction of mortality rate in traumatic injuries if the care was offered at trauma centres.[1] In China, multiple trauma is the fifth-leading cause of death. Each year, more than 400000 people die from motor vehicle accidents or industrial accidents, among which 1%–1.8% were multiorgan/multisystem injuries.[2] China's regional trauma system is not yet mature, and the management of trauma centres are facing great challenges. In all emergency rooms, especially in cases of overcrowding and understaffing, it is critical to rapidly screen large numbers of patients, identify the critically ill patients as quickly and appropriately as possible, assess the severity of their condition and assign appropriate treatment priorities, and transfer them towards or intensive care unit (ICU). Although risk stratification has been developed for selected emergency patient groups, few attempts have been made to develop a generic risk-adjusted score for emergency patients.[3 4]

In the last 30 years, different trauma scoring systems have been developed, most of which incorporate anatomical or physiological components or both.[5–9] However, these scores are either too complicated to calculate and have too many variables to meet the requirements of rapid risk stratification tools in the emergency environment, or they cannot be widely used due to the limitation of users and endotracheal intubation.[2 10–12] Perhaps the best-known indicators for assessing trauma severity and potential consequences are the Revised Trauma Score (RTS), Injury Severity Score (ISS) and Trauma Score-Injury Severity Scores (TRISS). Based on current research in the field of trauma, RTS remains the most widely used scoring system. RTS has been widely recognised for clinical decision making. Several articles have evaluated the performance of RTS in the emergency room as a triage and prediction tool. It can be used as an emergency department (ED) diagnostic tool to identify patients with severe trauma.[13–15] It is important to note that these scores are not warning scores, but severity indicators.[16]

Based on the need for a simple, fast and effective trauma classification tool, the Modified Early Warning Score (MEWS) is a qualified warning system. MEWS is a bedside assessment tool, and each of its variables can be easily and quickly calculated. MEWS, combining with vital signs and consciousness, covers the respiratory, circulatory and nervous systems, and reflects the overall situation of patients with the simplest and most direct score. MEWS has been developed for use in wards and ICU/high dependency units patients as an early warning system for adverse events in the hospital. It is also used to predict mortality and admissions to emergency rooms, but it is not a disease-specific score. Previous studies have shown that MEWS is a good predictor of the prognosis of emergency trauma patients,[17 18] yet other studies put this conclusion in controversy.[19] However, very few studies analysed patients with early trauma in the emergency room. Our study evaluated the predictive value of MEWS and RTS on 24-hour mortality among emergency trauma patients. Through retrospective chart review and data analysis, our study explored early triage indicators applicable to trauma patients in the emergency room.

METHODS

Study design

A retrospective, single-centred study was conducted in the ED of a comprehensive tertiary hospital in Suzhou, China to evaluate the predictive value of MEWS and RTS for the short-term prognosis of emergency trauma patients. Since the data collected are essential for the diagnosis and clinical follow-up of patients, it is not considered necessary to obtain informed consent from patients. Ensure patients' anonymity.

Setting and participants

We retrospectively analysed the clinical data of 1739 patients with acute trauma who were treated in the emergency room of The First Affiliated Hospital of Soochow University (a comprehensive tertiary adult hospital) from 1 November 2016 to 30 November 2019. The observation endpoint was death within 24 hours. Our study used an electronic medical record system to collect data for retrospective analysis. Our data were recorded by attending nurses and doctors at the time of patients' presentation to the ED. Because this was a short-term prognosis study, we did not conduct telephone follow-up on the patient's survival status. Figure 1 shows the flow diagram of the study. Inclusion criteria were: clear history of trauma, final diagnosis of acute injury examined by imaging; age not younger than 16 years; complete clinical and medical history. The following exclusion criteria were used: under 16 years of age;discharged from the ED before

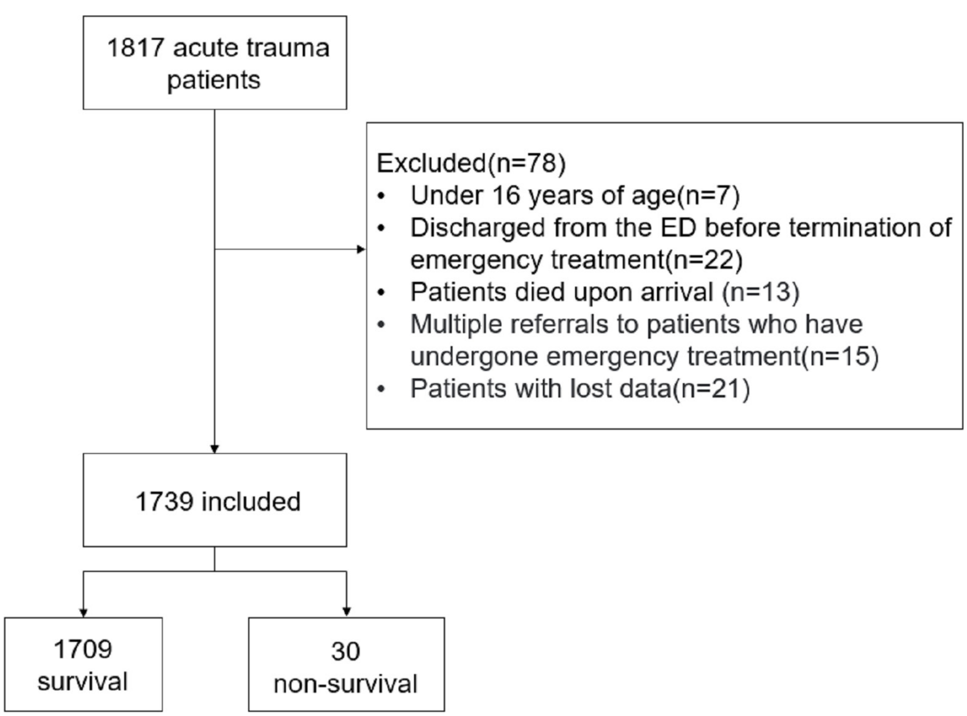

Figure 1 Flow chart of the study procedure. ED, emergency department.

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RTS	Glasgow Coma Scale	Systolic blood pressure (mm Hg)	Respiratory rate (breaths/min)
4	13–15	>89	10–29
3	9–12	76–89	>29
2	6–8	50–75	6–9
1	4–5	1–49	1–5
0	3	0	0

Table 1 Coding of the Revised Trauma Score (RTS)

termination of emergency treatment; patients dead on arrival; multiple referrals for patients who have undergone emergency treatment and patients with incomplete data.

Data collection

All parameters were derived from medical records at admission to the emergency room. Gathered information included age, gender, trauma mechanism, vital signs (heart rate (HR), blood pressure, temperature (T), pulse oxygen saturation level SPO2, respiratory rate (RR)) and level of consciousness on presentation. We recorded the patient's retention time in the emergency room and the 24-hour survival status in the hospital, as well. The patients were followed throughout their ED stay and their outcome. 24-hour mortality was the primary outcome of trauma. If the patient died within 24 hours, the system would label the patient as non-survival, or else as survival. The MEWS and RTS were calculated for each subject based on the corresponding measured variables in their medical records. The medical records and calculated scores were saved to the database for further statistical analysis.

RTS and MEWS

Three parameters are considered for the RTS: systolic blood pressure (SBP, mm Hg), RR (cycles per minute), and Glasgow Coma Scale (GCS). The range of scores is 0–12, with lower scores corresponding to higher injury severity (table 1).[13] Table 1 shows the components of, and scores for, each individual aspect of the RTS.

The MEWS is widely used in the clinical setting as a quantified scoring system based on HR (beats per minute), SBP (mm Hg), RR(cycles per minute), T (°C) and Alert, responds to Voice, responds to Pain, Unresponsive (AVPU). As reported previously, the AVPU is estimated from the GCS as follows: A=14–15, V=9–13, p=4–8, U=3.[20–22] The corresponding score, ranging from 0 to 3, for each variable is shown in table 2. In contrast to RTS, a higher MEWS indicates a worse state of patients.

Statistical analysis

Shapiro-Wilk test was used to test the normality of continuous variables. All continuous variables not conforming to normality were expressed as median (IQR) and were compared by Mann Whitney test. The categorical variables were expressed as frequency and percentage and were compared using the probability ratio χ^2 test. The logistic regression model was used to calculate the OR of death variables. Gender and age were added into the multifactor model to adjust the variable OR value. The area under the curve (AUC) was analysed and calculated by the receiver operating characteristic curve (ROC curve). Statistical analysis and graphic rendering were performed using STATA V.15.0. Double-tailed p<0.05 was considered statistically significant.

Patient and public involvement

It was not appropriate or possible to involve patients or the public in the design, or conduct, or plans of our research.

RESULTS

Patient selection and characteristics

Figure 1 shows the flow diagram of the study. Medical records of 1817 patients with acute trauma were collocated. A total of 1739 were included in the analysis, among which 1272 (73.15%) were males, and the median age was 51 years. All patients arrived by ground means,

Table 2 Modified Early Warning Score

Variable	Score 0	1	2	3
Systolic blood pressure (mm Hg)	101–199	81–100	71–80 ≥200	≤70
Heart rate(/min)	51–100	41–50 101–110	≤40 111–129	≥130
Respiratory rate (/min)	9–14	15–20	<9 21–29	≥30
Temperature (°C)	35–38.4		<35 ≥38.5	
AVPU score	Alert	Reacting to voice	Reacting to pain	Unresponsive

AVPU, alert, responds to voice, responds to pain, unresponsive.

Table 3 Baseline characteristics

Variables	Survival 1709 (98.27)	Non-survival 30 (1.73)	P value
Sex			0.204
Female (%)	462 (27.03)	5 (16.67)	
Male (%)	1247 (72.97)	25 (83.33)	
Age (year)	51 (25)	52 (23)	0.936
MAP (mm Hg)	99 (23)	53 (77)	<0.001
HR (n/min)	85 (23)	60 (107)	0.008
SBP (mm Hg)	133 (34)	78 (110)	<0.001
GCS	15 (5)	4 (7)	<0.001
T (℃)	36.9 (0.8)	35.6 (2.4)	<0.001
RR (n/min)	20 (4)	14 (23)	0.007
SpO_2 (%[*])	98 (5)	71 (91)	<0.001
RTS	12 (0)	9 (8)	<0.001
MEWS	2 (2)	8 (5)	<0.001
HER (hour)	4 (13)	4 (12)	0.851

Continuous variables were expressed as median (IQR); categorical variables were expressed as n/percentage; p values were calculated by Mann-Whitney test or χ^2 test as appropriate. Except for gender, p values calculated by the Mann-Whitney test.
GCS, Glasgow Coma Scale; HER, hours in the emergency room; HR, heart rate; MAP, mean arterial pressure; MEWS, Modified Early Warning Score; RR, respiratory rate; RTS, Revised Trauma Score; SBP, systolic blood pressure; SpO_2, pulse oxygen saturation; T, body temperature.

mostly by ambulance. The majority of trauma patients were male, mainly traffic injuries and blunt contusions, more than half were multiple injuries, which were related to the rapid development of our city and the types of local job composition.

Comparison of baseline and clinical characteristics between survivors and non-survivors

To investigate the early mortality outcome, 1739 patients were divided into the survival group (1709 patients,98.27%) and the non-survival group (30 patients, 1.73%). The total 24-hour mortality rate was 1.73%. Table 3 shows the characteristics of the survival and the non-survival groups of the study population. There were no significant differences in gender and age between the two groups. The survival group and the non-survival group had statistical significance in the following factors (p<0.05), expressed respectively as median (IQR): mean arterial pressure (MAP) 99 (23) vs 53(77); SPO_2 98 (5) vs 71 (91); HR 85 (23) vs 60 (107); SBP 133 (34) vs 78 (110); GCS:15 (5) vs 4 (7); T 36.9 (0.8) vs 35.6 (2.4); RR 20(4) vs 14(23). There was no significant difference in hours in the emergency room (HER) between the two groups (p=0.851). The mean RTS (IQR) of the survival and non-survival groups was 12 (0) vs 9 (8) (p<0.001), respectively. The mean MEWS (IQR) for the survival and non-survival groups was 2 (2) vs 8 (5) (p<0.001), respectively.

Association between the RTS, MEWS and mortality

Table 4 summarises the relationship between RTS, MEWS, and mortality. MEWS crude OR and adjusted OR were 1.99, 95% CI (1.73 to 2.29) and 2.00, 95% CI (1.74 to 2.31), p<0.001, respectively. The RTS crude OR and adjusted OR were 0.62, 95% CI (0.55 to 0.69) and 0.61, 95% CI (0.55 to 0.68), p<0.001, respectively.

Prognostic performance of the RTS and MEWS in terms of mortality

Figure 2 shows the ROC curve for RTS and MEWS in terms of mortality. The AUCs of MEWS and RTS were 0.927, 95% CI (0.914 to 0.939) and 0.799, 95% CI (0.779 to 0.817), p=0.005, respectively, indicating that both MEWS and RTS were good predictors of short-term (24 hours) mortality, whereas MEWS had better predictive efficacy than RTS. MEWS was a high priority for the triage of emergency trauma patients.

DISCUSSION

The study was conducted at a trauma centre in a general hospital situated in a low/middle-income country. The proportion of severe trauma patients we treated was larger than that in other peripheral hospitals, and the population we studied was the emergency trauma population after entering the emergency room. The specific time from the trauma to the emergency room was not recorded, so there was a certain bias in terms of hospital level and patient selection. Low-income and middle-income countries bear a greater burden of trauma and have less access to quality care than high-income countries. Compared with developed countries, trauma centres in low/middle-income countries are relatively immature and need to learn from experience while exploring and improving their own protocols and programmes.[23]

The emergency room has a heavy clinical workload and lacks resource allocation. Doctors who can make effective clinical judgments are often responsible for the daily work of a large number of patients. However, emergency trauma patients need to make a judgement within a short time and achieve the best triage and treatment. In our study, we compared the predictive efficacy of RTS and MEWS in early mortality among trauma patients at ER. By comparing AUC (0.927 and 0.799 for MEWS and RTS, respectively), we found that MEWs performed statistically superior to RTS. To our knowledge, no other study has done a statistical comparison of these two scores in the field of early emergency trauma. MEWS should serve as a high priority indicator for the triage of emergency trauma patients. MEWS is a high priority for the triage of emergency trauma patients. We also found that in addition to the vital signs covered by the two scores, MAP, SPO2 and T may also be worthy of attention in triaging trauma severities.

Some authors believe that calculating MEWS at several points during a patient's hospitalisation can help healthcare providers assess the effectiveness of interventions

Table 4 ORs calculated by the logistic regression model

Variables	Crude OR	95% CI	P value	Adjusted OR	95% CI	P value
MEWS	1.99	1.73 to 2.29	<0.001	2.00	1.74 to 2.31	<0.001
RTS	0.62	0.55 to 0.69	<0.001	0.61	0.55 to 0.68	<0.001

Adjustment variables: sex and age.
MEWS, Modified Early Warning Score; RTS, Revised Trauma Score.

offered to critically ill patients.[24] We chose to record the patient's vital signs at the time of emergency room entrance and calculate the RTS and MEWS, instead of trending serial RTS and MEWS. This is because our focus is on rapid decision making, which warrants using all immediately available patient data as a starting point for decisions, instead of waiting for the condition to deteriorate. The patient's worst vital signs (or worst RTS or MEWS) can only be identified retrospectively; not prospectively.[25] The efficiency of rapid decision making and triaging often determines the outcome of trauma patients. Early Warning Scores can help doctors and nurses understand patients' conditions more quickly and effectively, and help them make early decisions.

RTS is a well-established predictor of mortality in traumatised populations, but there is no clear evidence to support its use as a primary categorising tool and as a predictor of outcomes other than mortality.[26 27] However, the components constituting RTS are not stable and can be affected by prehospital care. Therefore, the RTS values obtained in the emergency room may be obtained when

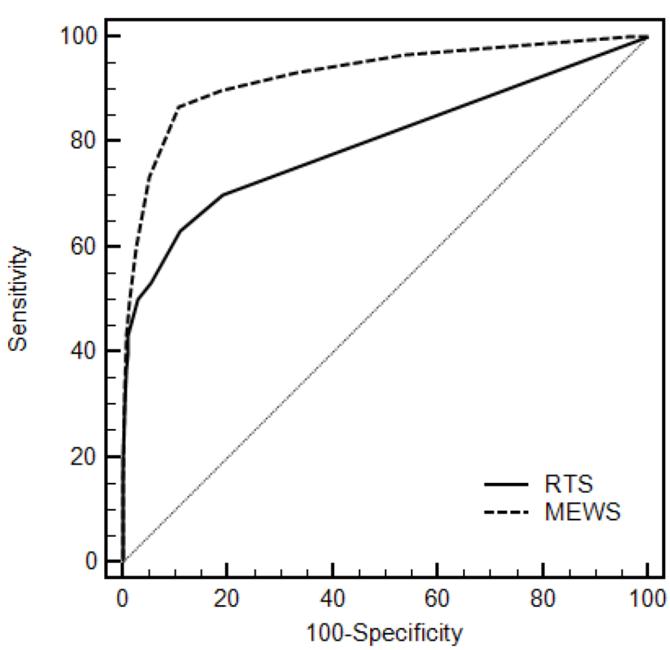

Figure 2 Receiver operating characteristic (ROC) curve of the study population. The solid line is the ROC curve of RTS 24-hour in-hospital mortality prediction. The dashed line is the ROC curve of MEWS 24-hour in-hospital mortality prediction. The grey line is the reference line. MEWS, Modified Early Warning Score; RTS, Revised Trauma Score.

patients are more physiologically stable. Therefore, it is doubtful whether the RTS obtained in the emergency room can be properly used as the value of in-hospital triage.[27] It has been suggested that the sensitivity and specificity of RTS for prehospital use of trauma patients are not as good as expected.[28] And for some injury types, RTS is a relatively moderate predictor of death, with no advantage over other scoring systems.[11 12]

Few studies have analysed the early prognosis of emergency patients. Based on the review of the existing literature, we found that the predictive power of the scoring systems varied with the endpoint of the study. Kondo *et al*[29] analysed the correlation between long-term mortality and short-term mortality of RTS, T-RTS, TRISS, MGAP (mechanism, GCS, age and arterial pressure) score and GAP (GCS,age and arterial pressure) score. They found that T-RTS was better at predicting short-term mortality than long-term mortality. What Lee *et al*[5] did was the correlation analysis of late death in ICU. They found that after excluding patients who died within 72 hours of entering the ICU, the APACHE II score and Sequential Organ Failure Assessment score were of high predictive value. TRISS, RTS, ISS, and other scores were more suitable for early prognostication. Different studies can get different results with the same scoring system due to the choice of periods.[5 30] Several studies have examined the relationship between emergency MEWS and mortality, but little has been done on prehospitalisation and early MEWS. The application of MEWS in inpatients has been well-validated, most studies have found that MEWS collected in the emergency room is a good predictor of patient hospitalisation rate and in-hospital mortality. It is recommended to use MEWS ≥3–4 as the node of intervention. However, most of their study endpoints were longer than 30 days.[20 25 31–38] Besides, two other studies found that the predictive power of MEWS was moderate.[3 39] Fullerton *et al* and Leung *et al* discussed the relationship between emergency MEWS and early prognosis,[40 41] the endpoint they chose was also 24 hours, but unlike us, Fullerton *et al* chose heart-related patients,[40] and Leung *et al* discussed non-traumatic emergency patients.[41] Few studies have been done on early outcomes of trauma. In the population of trauma patients, Jiang *et al*, Rocha *et al* and Salottolo *et al* also suggested that MEWS was a good predictor of long-term mortality in hospitals,[2 17 18] while Patel *et al* showed no significant statistical difference.[19] The difference was that the patients selected by the first three were various types of trauma, while the patients selected by Patel *et al* were bone trauma patients.[19] It can be inferred that the predictive effect of different scores is related not only to the selected study endpoint but also to the type of injuries. Our study included patients with all types of trauma with 24-hour mortality as the study endpoint and found that MEWS had a better predictive value than RTS.

Limitations and implications for future research

However, our study is not without its limitations. This retrospective study was limited to a small sample. Although there was no difference in prehospital treatment, the analysis may be biased due to different hospital transfer times and other factors. Also, the retrospective nature of the study is a limitation, as it was not conducted in real-time and was limited by subjective differences in artificial statistical results and differences in recording time. The environment of emergency trauma may also affect the quality of vital signs recorded, leading to underestimation of the extent of the patient's physical disorders and deterioration. The size of the population is also a limiting factor since the data was obtained from a single hospital. Larger samples from multiple hospitals are needed to confirm our findings. We plan to further explore the prediction value of the two scores for different severity of trauma by collecting additional data. To further explore a more mature early warning system, a combination of laboratory indicators, biomarkers, complex algorithms and electronic medical records will be introduced, using process-based automated computing rather than a simple scoring system.

CONCLUSION

Both MEWS and RTS were independent predictors of the short-term prognosis in emergency trauma patients, MEWS had better predictive efficacy. It should be a priority for trauma patient evaluation in the emergency room and will facilitate rapid emergency response decisions.

Contributors ZY and DC conceived the study. FX and DC designed the study. DC performed the statistical analysis and drafted the manuscript. FX was involved in data selection and data collection. ZY and DC contributed substantially to its revision. DC took responsibility for the manuscript as a whole.

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Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

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