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Original Article

Modified early warning score in assessing disease conditions and prognosis of 10,517 pre-hospital emergency cases

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Abstract: Objectives: To study the values and feasibility of modified early warning score (MEWS) in the disease condition assessment and death prediction in pre-hospital emergency cases (PHECs). Methods: 10,517 PHECs were collected as the study subjects, the data were collected on the scene for MEWS; 90-day was set as the end point and the patient's outcome was set as the observation indicators. The counting data were expressed as percentage and performed the χ^2 test; the measurement data were expressed as mean ± standard deviation ($\bar{x} \pm s$) and performed the group t test, with $P < 0.05$ considered as statistically significant. The corresponding predictors of the area under curve (AUC) of the MEWS characteristic curve were then calculated. Results: MEWS of the dead patients was significantly higher than the patients survived ($P < 0.05$), with the sensitivity as 88.45%, specificity as 71.28%, accuracy as 87.13%, Youden index as 0.5973, and AUC as 0.883. MEWS ≥ 4 points was the cut-off point to distinguish the critical conditions and predict the risk of death. Conclusions: MEWS had certain distinguishing abilities towards the disease condition assessment and death prediction in PHECs, and could be used as an effective tool to manage PHECs.

Keywords: Modified early warning score, pre-hospital emergency care, disease assessment, intervention, management, program

Introduction

With the social and economic developments and the improvements of people's requirements towards medical emergency aid, pre-hospital emergency care (PHEC) has been greatly developed all over the world [1]. In 2014, Chinese "Management of pre-hospital medical emergency care" was promulgated and implemented, which standardized the behavior and pushed forward the cause of PHEC. The quality of PHEC was related to the safety of patients [2]; therefore, the efficient scientific assessments of the PHEC patients' conditions as well as timely and effective treatment and intervention would be essential [3]. The evaluation system towards the conditions of critically ill patients could not only objectively evaluate the risks of death or serious complications facing in front of the critically ill patients but also be widely used to evaluate the treatment measures, resource utilization, or quality control [4]. For example, acute physiology and chronic health evaluation II (APACHEII) and III scoring system, SPASII scoring system, and ISS scoring system, etc. [5-7], were widely used in clinics, thus playing great roles for the rapid medical developments. However, it needs a long period to get the above parameters; therefore, it would affect the timely assessment towards the patients; furthermore, most parameters could not be obtained on the scene or in primary-level hospitals, so it would be unrealistic to apply them into assessing the conditions of PHEC. Currently, the determination of disease conditions by PHEC doctors mainly relies on their clinical experience, and an accurate, objective, and credible quantitative indicator was still lacking [8]. How to fast and correctly assess disease conditions and adopt effective interventions is a very real problem faced by clinicians. We used modified early warning score

Table 1. MEWS indicators and their weights

Item	Score						
	3	2	1	0	1	2	3
Heart rate (beats/min)		≤ 40	41-50	51-100	101-110	111-130	≥ 130
SBP (mmHg)	≤ 70	71-80	81-100	101-199		≥ 200	
Breathing frequency (beats/min)		< 9		9-14	15-20	21-29	≥ 30
Body temperature (°C)		< 35.0		35.0-38.4		≥ 38.5	
Consciousness				Clear	Responded to sound	Responded to pain	No respond

Table 2. Comparison of survival and death frequency distribution between the patients with different MEWS (4893 PHECs) (cases)

Group	Cases	MEWS (points)												
		0	1	2	3	4	5	6	7	8	9	10	11	12	13
Survival group	9709	60	3668	2714	1261	885	424	291	147	115	89	33	22	0	0
Death group	808	0	28	56	80	68	56	52	49	50	103	79	106	73	8

Table 3. Basic information and clinic feature between survival and death

Group	Cases	Aged	Males	Females	Internal medical diseases	Trauma	Others
Survival group	9709	44.2±15.7	6228	3720	943	437	350
Death group	808	55.6±18.3	348	221	5343	2920	524

(MEWS) to assess the conditions of PHECs, achieved certain initial results, and reported below.

Materials and methods

Clinical data

A total of 10,517 patients visited and treated by the PHEC staff of our hospital on the scene from January 2013 to December 2014 were selected; all the patients were at least 15 years old, and those with poor compliance or did not cooperate the diagnosis and treatment were excluded. This study was conducted in accordance with the declaration of Helsinki. This study was conducted with approval from the Ethics Committee of Guangxi Medical University. Written informed consent was obtained from all participants.

Rescue process

When the PHEC staff arrived the scene, the necessary PHEC measures were performed, such as oxygen supply, transfusion or medicine, maintaining airway patency, or even cardiopulmonary resuscitation, etc.); meanwhile, MEWS was immediately implemented towards the patient (the scoring indicators and weights were shown in **Table 1**) [9]. As for the critically ill patients, the on-the-spot rescue was firstly performed, and then took the patients back to the hospital for further treatment. According to their disease conditions, the patients were performed emergency treatment in the outpatient, or admitted into the observation room, the special ward, or the intensive care unit.

Data collection

Such clinical data as the patient's name, sex, age, living address, telephone number, clinical diagnosis, on-the-spot MEWS were recorded and registered into the scene-visiting registration form; certain special staff was assigned to track and observe the patients' prognosis, and to calculate the survival or mortality rate of the patients 90 days later; calculated area under curve (AUC) of the MEWS characteristic curve, found the cut-off point, and analyzed and summarized the results.

Statistical methods

SPSS20.0 statistical software was used: first, listed the death frequency distributions of the patients in different segments, drew the patients' receiver operating characteristic (ROC)

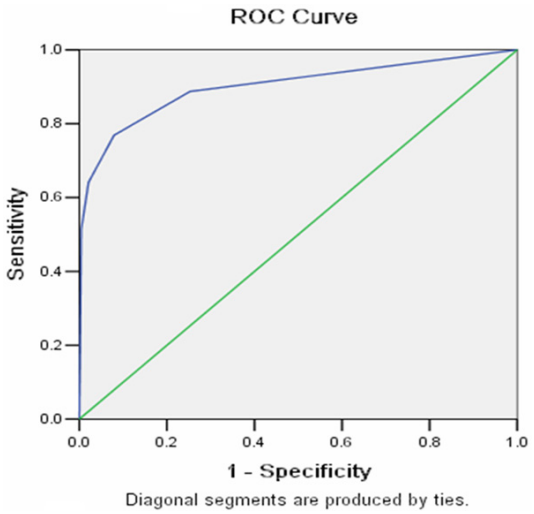

Figure 1. MEWS characteristic ROC curves of PHECs.

curves, calculated AUC, found the cut-off point, and calculated the corresponding predictors of the patients. The counting data were expressed as percentage; the data were compared using the χ^2 test; the measurement data were expressed as $\bar{x}\pm s$ and performed the t test, with $P < 0.05$ considered as statistically significant.

Results

Age, sex, and disease categories of PHECs

A total of 10,507 PHECs were enrolled, aged (52.9±20.6) years old, including 6576 males and 3941 females (M/F=1.67:1). Among the 10517 PHECs, 6286 cases were of internal medical diseases, accounting for 59.77%; 3357 cases were of such surgical diseases as trauma and others, accounting for 31.92%; 874 cases were of other medical diseases, accounting for 8.31%. The systems involved in the internal medical diseases were in the order of the nervous system, cardiovascular system, and digestive system; divided according to the sites, the patients' traumas mainly occurred on the four limbs or body's unspecified parts, accounting for the first place, followed by cranial trauma. The basic information and clinic feature between survival and death in **Table 3**.

Comparison of MEWS

Among the 10,517 PHECs, 9709 survived, MEWS score (2.43±1.80) points; 808 died, MEWS score (7.24±3.43) points. The comparison of MEWS between the patients with different outcomes showed statistically significant difference (t=-66.546, $P < 0.05$).

Comparison of survival and death frequency

Set MEWS 4 points as the cut-off point, the mortality rate of the MEWS ≥ 4 points group was 24.30% (644/2650), and that of the MEWS < 4 points group was 2.08% (164/7867). There was statistically significant difference between these two groups (χ^2=1379.56, $P < 0.01$) (**Table 2**).

AUC and corresponding predictors of the MEWS characteristic ROC curve

AUC of the ROC curve was 0.883, so the best cutoff point for determining the critically illness degrees of PHECs was ≥ 4 points (**Figure 1**; **Table 4**).

Discussion

It is very important for the successful completion of clinical rescue to objectively and accurately assess the disease conditions and critical degrees of PHECs, especially the effective assessment and accurate prediction towards the potential risk of death [10-13]. Although some scholars believed that the mortality probability model (MPM) scoring and the acute physiology and chronic health evaluation II (APACHEII) scoring could effectively predict the disease conditions and death risk of critically ill cases, the MPM scoring existed the shortage of poor operability, and the APACHEII scoring had such disadvantages as long period for data collection, multifarious test items, costly, and tedious calculations, etc., which were not conducive for the early assessment toward patient's conditions; therefore, their applications in PHEC were limited [12]. MEWS was a new scoring tool rising abroad in recent years; composed by conventional vital signs, this scoring tool would not be limited by equipment, personnel, or working space, so its operability was strong, and had been widely used in intensive care unit (ICU) and emergency first aid [14, 15]. Some Chinese scholars applied MEWS towards the patients with emergency first aid and believed that MEWS was applicable and feasible for evaluating the disease conditions and predicting the prognosis of the patients, and could reduce the occurrence of misdiagnosis and mistreatment in clinical work, thus preventing and reducing the potential medical treatment disputes [11]. In order to explore the val-

Table 4. Predictors of MEWS for the risk of death in PHECs

Score	Sen (%)	Spe (%)	Acc (%)	+pv (%)	-pv (%)	α (%)	β (%)	YI	+LR	-LR	AUC	cutoff value	P
MEWS	88.45	71.28	87.13	97.36	33.94	10.1	22.5	0.5973	3.08	0.162	0.883	≥ 4 points	P < .05

Note: Sen: sensitivity, Spe: specificity, ACC: accuracy, +PV: positive predictive value, -PV: negative predictive value, α: false positive, β: false negative, YI: Youden index, +LR: positive likelihood ratio, -LR: negative likelihood ratio, U: test value of AUC.

ues of MEWS in the disease condition assessment and risk prediction of PHECs, we applied it to assess the conditions and predict the death risk of PHECs. AUC is an important indicator to evaluate the good and bad points of one system, and the greater AUC, the higher the resolution of this evaluation system, the better the evaluation performance, and the greater the application values. According to the criteria of Swets [16]: AUC < 0.5 meant no diagnostic value; AUC 0.5-0.7 meant low accuracy; AUC 0.7-0.9 meant certain accuracy; AUC > 0.9 indicated high accuracy. In this study, AUC of the MEWS characteristic curve was 0.883, with the sensitivity as 88.45%, specificity as 71.28%, accuracy as 87.13%, Youden index as 0.5973, indicating that MEWS had certain accuracy in assessing the conditions and predicting the risk of death in PHECs. The patient with promptly-screened high mortality rate should be actively performed certain prevention measures and intensive care, and these actions would have positive clinical significance to improve the success rate, similar to the literatures [10, 11, 13]. The results of this study showed that MEWS could be used as a valid determining tool for assessing the conditions and predicting the mortality of PHECs, had better roles for the pre-hospital condition assessment and the potential death risk prediction; its operability, simplicity, and practicality made it worthy of the applications towards PHECs.

In this study, we initially developed and implemented the following pre-hospital medical intervention programs, and the results proved them to be effective. PHECs needed to be monitor the five vital signs during PHEC and transportation period, namely the heart rate, blood pressure, breathing frequency, body temperature, and consciousness, to understand MEWS, which was the basis to judge and assess the disease conditions; as a basic requirement, it was required by the further management, and should focus on emergency first aid rather than transportation. PHECs with MEWS ≥ 2 points should generally be performed the necessary interventions on the scene, such as further ECG, rapid blood sugar screening, as well as oxygen supply, oral medication, establishing intravenous access, and symptomatic treatment if necessary. PHECs with MEWS ≥ 4 points generally had potential critical disease conditions, and should be monitored ECG, blood pressure, oxygen, and breathing dynamics on the scene and in an ambulance based on the above second item; meanwhile, prepared the defibrillator, tracheal cannula, and simple breathing machine for real-time rescue. PHECs with MEWS ≥ 6 points should be rescued on the scene, and transported after the conditions became stable. Certain special PHECs, such as with acute coronary syndrome, particularly with acute myocardial infarction, malignant arrhythmias, or severe failure, even if their MEWS were low, the above second or third item could be directly performed. When treating special PHECs with cardiopulmonary resuscitation, acute myocardial infarction, suspected cerebral infarction, or severe trauma, the hospital should be contacted on the treatment field or on the road, thus to start the early warning and response system. The admission hospital should prepare in advance, establish the green channel for cardiovascular diseases and stroke; the relevant departments should prepare for the admission and establish the seamless connections between PHEC and after hospital admission. As for emergent public events, MEWS might be high or low; the hospital should start the early warning and response system and the protocols for these emergent public events. In principle, seriously ill PHECs with MEWS ≥ 4 points should be admitted into the wards, special care unit, or ICU. Dynamic management should be performed according to the changes of MEWS, when the score increased, the interventions should also be increased, vice versa. MEWS could be used as the tool to evaluate and manage the quality of PHEC, and the reduction of MEWS from PHEC to hospital admission could be regarded as a PHEC behavior with quality. The implementation of MEWS

increased the patients' satisfaction, improved the success rate of rescue and diagnostic accuracy; meanwhile, the quality and safety awareness among medical staff were enhanced, and the disputes and complaints between doctors and patients were greatly reduced [17]. Therefore, MEWS could be used as an effective tool to manage PHEC [18], and this program still needed to be further perfected and improved continuously.

Disclosure of conflict of interest

None.

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