Comparative research on the prognostic ability of improved early warning and APACHE II evaluation for hospitalized patients in the emergency department

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ABSTRACT

Objective: To compare the feasibility and applicability of predicting the prognosis of patients using the Early Warning Score (MEWS) system and the Acute Physiology and Chronic Health Evaluation (APACHE II) system in the Emergency Department.

Methods: Using a prospective study method, the APACHE II and MEWS data for 640 patients hospitalized in the Emergency Internal Medicine Department were collected. The prognoses, two scores to predict the corresponding prediction index of sensitivity, specificity and positive predictive value for the prognosis, the negative predictive value and the ROC curve for predicting the prognosis were analyzed for all patients.

Results: In the prediction of the risk of mortality, the MEWS system had a high resolution. The MEWS area under the ROC curve was 0.93. The area under the ROC curve for the APACHE score was 0.79, and the difference was statistically significant (Z = 4.348, P < 0.01).

Conclusions: Both the MEWS and APACHE II systems can be used to determine the severity of emergency patients and have a certain predictive value for the patient's mortality risk. However, the MEWS system is simple and quick to operate, making it a useful supplement for APACHE II score.

Keywords: MEWS, APACHE II, Prognosis, Predictive ability, Area under ROC curve, Emergency patients

1. Introduction

At present, the most widely used and authoritative evaluation method is the Acute Physiology and Chronic Health Evaluation system (APACHE II). However, the clinical data acquisition using this system is time-consuming, complicated, and costly; therefore, the lack of medical resources in the region has limited the use of APACHE II. The Modified Early Warning Score (MEWS) is a new scoring method for patient assessment and risk stratification and is used in emergency departments or before admission. The system is simple, easy to operate, and was developed in emergency departments and intensive care units (ICUs) of the UK and other developed countries. The APACHE II system helps nurses assess patient conditions according to objective physiological indicators and enhances health care personnel awareness to assess the severity of the patient's condition. Use of the MEWS system by domestic healthcare workers has received increasing attention, but at present, the relevant research on the MEWS system in the Xinjiang Uygur Autonomous Region is sparse. The purpose of this study was to investigate the feasibility and applicability of MEWS and APACHE II systems in predicting the prognosis of hospitalized patients in the Emergency Internal Medicine Department in the Xinjiang Uygur Autonomous Region.

2. Objects and methods

2.1. Selection of participants

This study selected patients from January to March in 2014 from the Emergency Department of the Xinjiang Uygur Autonomous Region from a grade three general hospital. The inclusion criteria were as follows: (1) a patient who is hospitalized in the emergency internal medicine; (2) 18 years of age or older (the APACHE score is

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designed for patients over 18 years of age); (3) hospitalization time of at least 24 h; and (4) documented APACHE II score. The exclusion criteria were as follows: cannot continue treatment for other reasons (such as refusing treatment and referral, etc.). A total of 640 patients were investigated; among these patients, 354 cases were male (55.31%), and 286 cases were female (44.69%); the patient age range was 19–92 years (61.34 ± 16.79); 283 cases were of Han descent (44.22%); and 357 cases were ethnic minorities (55.78%). A total of 574 patients (89.69%) survived, and 66 died (10.31%).

2.2. Survey method

All of the study subjects who met the inclusion criteria were examined using the APACHE II and MEWS systems at 24 h following admission. Using the patient visit as the observation point, nurses assessed the patient’s vital signs, consciousness and MEWS every 4–6 h after the initial assessment. Nurses complete the death MEWS assessment according to the last recorded data regarding the patient’s vital signs and consciousness.

According to the APACHE II requirements, the worst physiological and biochemical indexes were evaluated and recorded after the patients were admitted to the emergency department at 24 h. Following the patient’s prognosis and admission to the hospital (whether the patient was admitted to the Emergency Internal Medicine Department of the ICU), the death and survival conditions at the time of discharge was the end point of the observation period.

2.3. Survey tool

2.3.1. MEWS score

There are several versions of the MEWS system. This study adopted the MEWS used in Queens Hospital and the Burton Hospital in the UK.5 Respiratory rate, heart rate (atrial fibrillation and the ventricular rate), systolic blood pressure, consciousness and body temperature (axillary temperature) comprise the 5 physiological parameters of the assessment and are assigned 0–2 points. Pulse, systolic blood pressure, respiratory frequency and mental state are assigned 0–3 points, and the combined score is added to obtain the MEWS. The lowest possible score is 0 points, the highest possible score is 14 points, and the higher the score, the more serious the patient’s condition. The normal values of systolic blood pressure are 90–140 mmHg (1 mmHg = 0.133 kPa), and if the patient blood pressure clearly differed from the normal value, calculated according to the basic blood pressure procedure, patient awareness was assessed using the AVPU assessment method. This system includes alert (A), response to voice (V), response to pain (P) and unresponsive (U) scoring. The nurses assessed patients for the first time when before physician evaluation, and the treatment measures were decided according to the patient’s condition and the score. According to the related literature, from initial inspection of the patient to the end of the assessment in the Emergency Department, the MEWS score took only 10 min.

2.3.2. APACHE II score

The APACHE II scoring system is a comprehensive assessment of the age, acute physiology, pathological changes and chronic health status of the patients with severity measured by the doctor. The total APACHE II score consists of 3 parts, with the score ranging from 0 to 71 points.6 The higher the score, the more serious the patient’s condition and the higher the mortality rate.

According to APACHE II requirements, the worst physiological and biochemical indexes were evaluated and recorded, and the patients were admitted to the Emergency Department at 24 h. An APACHE II score of 20 points is the cut-off point for severity.8 According to the literature, the patient must be admitted and hospitalized for 24 h in order to obtain all of the parameters.1 Acute physiology and pathology scores, including body temperature, average blood pressure, heart rate, respiratory rate, oxygen saturation, blood pH value or bicarbonate (not recommended for blood gas analysis), serum sodium, serum potassium, serum creatinine, hematocrit and leukocyte count, Glasgow coma score as measured once per hour (score = 15) body temperature, blood pressure and heart rate, respiratory rate, oxygen saturation, average blood pressure, and the remaining 11 physiological parameters were obtained 24 h after admission. Each parameter is scored as 0–4 points with a total score of 0–60 points. The age score is responsible for 0–6 points and the chronic health status score for 2–5 points, which indicates the chronic health conditions for organ dysfunction or immune function suppression.9

2.4. Evaluation indicators

2.4.1. Correlation between MEWS and APACHE II score

The correlation analysis was performed between the measured MEWS and APACHE.

2.4.2. Prediction of patient outcome (ROC curve)

According to the area under the ROC curve (the area under the receiver operating characteristic curve, AUROCC, denoted as Az), which indicates the resolution of the scoring system, the higher the resolution, the better the effectiveness of the evaluation system.

The area under the ROC curve of the value is Az = 0.5–1, and when the area under the ROC curve is less than 0.7, the resolution is relatively low; from 0.7 to 0.9, the resolution is moderate; and more than 0.9, the resolution is high. At present, the ROC curve is regarded as the best method for measuring the quality of diagnostic information and decision-making.10

2.4.3. Prognosis predictions (sensitivity and specificity)

The percentage of patients with positive MEWS who were positive patients was evaluated along with the percentage of negative patients who were correctly identified by the MEWS.

2.4.4. Prediction of outcome (positive predictive value, negative predictive value)

The positive predictive value refers to the proportion of truly positive patients (positive) according to the screening test results; the negative predictive value refers to the proportion of truly negative patients according to the screening tests.

2.5. Statistical analysis

Using SPSS17.0 statistical software for statistical analysis, the measurement data are described by mean and the standard deviation (M ± SD). The analysis of variance was used for statistical inference. Categorical data are expressed as a percentage, and the χ² test was used for statistical inference; the overall accuracy of two score measure with ROC area under the curve, test level a = 0.05, P < 0.05 for the difference was statistically significant.

3. Results

3.1. Correlation between MEWS and APACHE II scores

The overall MEWS score of the patients was 3.92 ± 2.58, and the APACHE II score was 14.29 ± 6.51. The MEWS and APACHE II scores were positively correlated, and the correlation coefficient was (r) = 0.63, P < 0.01.
3.2. ROC curve for predicting the prognosis resolution

3.2.1. Area under the ROC curve of the MEWS score and APACHE II score predicted the patient's prognosis

The area under the ROC curve for the MEWS system was $A_A = 0.93$ (95% CI = 0.900–0.969); the best cutoff value for predicting the death of the patient was 7, and the MEWS was used to determine the patient’s prognosis; $P < 0.01$. The sensitivity was 76.92%, the specificity was 91.70%, the positive predictive value was 51.02%, and the negative predictive value was 97.23% (Fig. 1).

The area under the ROC curve in the APACHE score was $A_A = 0.93$ (95% CI = 0.736–0.849); the APACHE score was statistically significant for judging the prognosis of the patients ($P < 0.01$). The sensitivity was 83.08%, the specificity was 62.80%, the positive predictive value was 20.15%, and the negative predictive value was 97.04% (Fig. 2).

3.2.2. MEWS and APACHE II scores predicted the area under the ROC curve for the patients

The area under ROC curve for the MEWS system was $A_E = 0.65$ (95% CI = 0.606–0.691), the best cut-off value to predict a patient was 4 points, and the MEWS was used to determine whether the patient parameters were statistically significant ($P < 0.01$). The sensitivity was 56.47%, the specificity was 70.76%, the positive predictive value was 71.68%, and the negative predictive value was 55.38%. A MEWS score of more than 4 points increased the risk of patient admission to the ICU (Fig. 3).

The area under ROC curve for the APACHE score was $A_A = 0.68$ (95% CI = 0.638–0.721), and the use of the APACHE score to determine the patient position on the curve was statistically significant ($P < 0.01$). The sensitivity was 61.16%, the specificity was 66.79%, the positive predictive value was 61.16%, and the negative predictive value was 66.79% (Fig. 4).

3.2.3. Comparison of MEWS and APACHE II scores for the prognosis of patients in the emergency internal medicine

The area under the ROC curve for the MEWS system was greater than that of the APACHE II score, as shown in Fig. 5.

The difference in the area under the ROC curve between the MEWS and APACHE II scores in predicting the prognosis of the patients was statistically significant ($Z = 4.348, P < 0.01$) (Table 1).
Fig. 5. MEWS score and APACHE II score in predicting the prognosis of patients with the ROC curve.

Table 1

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Number of cases</th>
<th>Area under the ROC curve</th>
<th>Z</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICU</td>
<td>363</td>
<td>0.65</td>
<td>0.68</td>
<td>1.352</td>
</tr>
<tr>
<td>Death</td>
<td>66</td>
<td>0.91</td>
<td>0.79</td>
<td>4.348</td>
</tr>
</tbody>
</table>

Note: Modified Early Warning Score; APACHE II: Acute Physiology and Chronic Health Evaluation II.

3.2.4. Comparison of MEWS and APACHE II scores in the identification ability of inpatients in the Emergency Internal Medicine Department

In the identification of patients who should be admitted to the ICU, the MEWS and APACHE II score were used (Fig. 6). There was no significant difference in area under the ROC curve (Z = 1.352, P > 0.05).

3.2.5. Comparison of the MEWS and APACHE II scores in predicting the authenticity and benefits of patient outcomes

Two types of scoring systems were used to assess the specificity and the positive predictive value and the prognosis of patients, and these methods were significantly different (χ² = 136.207, χ² = 33.621, P < 0.05). The specificity and the positive predictive value of the MEWS system was higher than that of the APACHE II score. The predictive value of each system for the sensitivity of negative scores was not different (χ² = 0.769, χ² = 0.029, P > 0.05) (Table 2).

4. Discussion

4.1. Value of MEWS score in predicting the prognosis of hospitalized patients in the Emergency Internal Medicine Department

This study showed that the MEWS system predicted the patient's prognosis with high resolution. In 66 cases of death, 29 had MEWS of 7 points and above, accounting for 43.94%. In 363 ICU patients, the MEWS were 4 points and above, accounting for 56.47%. Thus, the MEWS system can be used to predict patient prognosis, and MEWS values of 7 points and above have significantly increased risk of death and need to enter ICU monitoring. Consistent with the results of studies reported by Chen and Erol,[11,12] Emergency Department nurses apply MEWS score to assess the severity of the patient, and the results should be promptly reported to the doctor. In addition, the frequency of monitoring should be increased to prepare for emergency treatment.

4.2. Value of the APACHE II score in predicting the prognosis of hospitalized patients in the Emergency Internal Medicine Department

The APACHE II score is currently the domestic clinical application for critical illness scoring methods for patients admitted to the ICU. The APACHE II score considers more than 20 physiological and biochemical parameters measured over 24 h, making the data acquisition time-consuming and laborious. Due to hardware limitations, many biochemical parameters are not conducive to rapid assessment in the case of an emergency, and therefore, the use of this system is limited. This study also showed that the APACHE II score predicts the patient's prognosis with a moderate degree of resolution: in 66 cases of death, 34 cases had APACHE II scores 20 points and above, accounting for 51.52%. The APACHE II score can be used to predict the prognosis of patients, but its ability to distinguish among patients is moderate.

4.3. Advantages of clinical application of the MEWS

Through research and related literature reports, the MEWS system can be used to predict the prognosis of patients and to help emergency department nurses complete scientific patient assessments. The MEWS uses five life signs to calculate the value of the assignment, does not increase the extra burden of nurses, does not require special equipment, has no site constraints, has a simple operation and calculation, and on average takes 10 min to complete. Scientific evaluation of patients increases the scientific nature of nursing work and allows doctors and nurses to work

Table 2

<table>
<thead>
<tr>
<th>Marking system</th>
<th>Number of cases</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Positive predictive</th>
<th>Negative predictive</th>
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</thead>
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<tr>
<td>MEWS</td>
<td>640</td>
<td>76.92</td>
<td>91.7</td>
<td>51.02</td>
<td>97.23</td>
</tr>
<tr>
<td>APACHE II</td>
<td>640</td>
<td>83.08</td>
<td>62.8</td>
<td>20.15</td>
<td>97.04</td>
</tr>
<tr>
<td>χ²</td>
<td>0.769</td>
<td>136.207</td>
<td>33.621</td>
<td>0.000</td>
<td>0.029</td>
</tr>
<tr>
<td>P</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.866</td>
</tr>
</tbody>
</table>

Fig. 6. MEWS and APACHE II scores to assess the patient's position on the ROC curve.
together to complete the assessment of the patient. Strong repeatability and timely assessment of critically ill patients can aid in their early diagnosis and treatment.

5. Conclusions

This study compared the abilities of the MEWS and APACHE II scores to predict patient prognoses, and the results indicated that the MEWS system can be used to predict the prognosis of patients in the Emergency Internal Medicine Department. The MEWS value can be an effective tool to help emergency nurses scientifically assess patients.

When the patient’s MEWS value is seven points or more in an Emergency Internal Medicine Department, and show a poor prognosis, these patients should be further examined. Because the MEWS system is simple and rapid, it can be used as a tool to assess the patient’s condition in the Emergency Internal Medicine Department, and it can be used in clinical departments. However, it is worth noting for researchers that there are multiple versions of the MEWS system, and when choosing the MEWS system, early clinical observation and optimal cut-off values for clinical evaluation must be chosen to ensure the best results.

Conflicts of interest

All contributing authors declare no conflicts of interest.

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