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Comparison of the Effectiveness of Acute Physiology and Chronic Health Evaluation II and Modified Early Warning Score Scoring Systems in Predicting Mortality in Patients in the Intensive Care Unit

Yoğun Bakım Ünitesindeki Hastalarda Mortaliteyi Ön Görmede Akut Fizyoloji ve Kronik Sağlık Değerlendirme II ve Modifiye Erken Uyarı Skor Skorlama Sistemlerinin Etkinliklerinin Karşılaştırılması

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ABSTRACT

Aim: The relationship between various clinical scoring systems and clinical outcomes has been evaluated in the emergency department and intensive care unit. This study aimed to evaluate the capacity of the Acute Physiology and Chronic Health Evaluation (APACHE II) score and the Modified Early Warning Score (MEWS) in predicting the mortality of patients admitted to the intensive care unit.

Material and Methods: All patients (aged >18 years) admitted to the intensive care unit between September 1, 2017 and December 31, 2018 were included in this study. Laboratory data and vital signs at the time of hospitalization were used to calculate the MEWS and APACHE II scores. The primary goal of the study was to evaluate the relationship between these scoring systems and mortality.

Results: In total, 665 patients were included in the study. The mortality rate was 34.2%. The area under the receiver operating characteristic curve for the APACHE II score was 0.783, whereas that for the MEWS was 0.924 (95% confidence interval: 0.750–0.814 vs 0.901–0.943, respectively, p = 0.0001 for both). The APACHE II score cutoff value for mortality was 18, whereas that for the MEWS was 5 (sensitivity: 87.89% vs 88.99%, 95% confidence interval: 68.7–80.4 vs 84.2–92.7; specificity: 68.49% vs 83.33%, 95% confidence interval: 63.9–72.8 vs 79.5–86.7).

Conclusion: Although the MEWS was superior to the APACHE II score, both systems were significantly effective in predicting mortality.

Keywords: Intensive care unit, APACHE II, Mortality, Emergency

ÖZ

Amaç: Çeşitli klinik skorlama sistemlerinin acil serviste ve yoğun bakım ünitesinde (YBÜ) klinik sonuçlarla ilişkisi değerlendirilmiştir. Çalışmamızda YBÜ'ye yatan hastalarda ''Akut Fizyolojik ve Kronik Sağlık Değerlendirme" (APACHE II) ve "Modifiye Erken Uyarı Skor" (MEWS) skorlarının mortaliteyi değerlendirmedeki kapasitelerinin ortaya konması planlandı.

Gereç ve Yöntemler: Çalışmamıza 1 Eylül 2017 ile 31 Aralık 2018 tarihleri arasında YBÜ'ye yatan tüm hastalar (>18 yaş) dahil edildi. APACHE II ve MEWS skorlarını hesaplamak için yatış anında laboratuvar ve vital bulgular kullanıldı. Çalışmanın ana amacı skorlama sistemleri ile mortalite ilişkisinin değerlendirilmesiydi.

Bulgular: Çalışmaya 665 hasta dahil edildi. Yatan hastaların mortalitesi %34,2 olarak bulundu. APACHE II için ROC eğrisi altındaki alan 0,783'tü. (%95 güven aralığı (GA): 0,750–0,814, p = 0,0001). Mortalite için APACHE II skoru eşik değeri 18 (duyarlılık: %87,89, %95 GA: 68,7 – 80,4 ve özgüllük: %6849, %95 GA:63,9–72,8). MEWS skoru için ROC eğrisi altındaki alan 0,924'tü. (%95 GA =0,901–0,943, p = 0,0001). Mortalite için MEWS skoru eşik değeri 5 (duyarlılık: %88,99, %95 GA:84,2-92,7 ve özgüllük: %83,33, %95 GA:79,5-86,7) olarak bulundu.

Sonuç: Çalışmamızda MEWS skoru APACHE II skoruna daha üstün olmakla birlikte her ikisinin de mortalite tahmininde anlamlı olduğu tespit edildi.

Anahtar Kelimeler: Yoğun Bakım Ünitesi, APACHE II, Mortalite, Acil

Introduction

Patients in the intensive care unit (ICU) have different diagnoses and disease severities and exhibit various comorbidities. Because the intensive care process varies considerably depending on the clinic, it is essential for clinicians to measure the impact and effectiveness of their clinical practices. Mortality is a frequently used criterion because patients in the ICU usually have a severe clinical status and high mortality risk; therefore, mortality is a sensitive, significant, and appropriate parameter. However, because mortality is influenced by multiple factors, certain standardizations are necessary so that markers can be used to evaluate the results. To this end, several scoring systems have been developed for patients in the ICUs (1).

Scoring systems are helpful in monitoring the clinical status of patients admitted to the ICU, identifying disease severity, recording data, estimating mortality and morbidity risks, comparing ICUs, and improving clinical practice. Owing to these features, scoring systems can assist the monitoring of patients and implementation of treatment guidelines (2,3). For a scoring system to be ideal; it should be easily applicable, well standardized, and have a high level of sensitivity and specificity for different patients (2).

Studies have demonstrated the effectiveness of the Acute Physiology and Chronic Health Evaluation (APACHE II) scoring system used in ICUs (2). Additionally, the Modified Early Warning Score (MEWS) has been developed for the timely identification of clinical deterioration in hospitalized patients (4). Previous studies have focused on unplanned ICU transfers to measure the degree of deterioration that occurs shortly before admission to the ICU from emergency wards (3-5). Although clinical scoring systems are frequently used in ICU admissions, there is limited information on their simultaneous use and the advantages they have over each other. The aim of this study was to investigate the relationship of the MEWS and APACHE II score of patients admitted to the ICU with mortality.

Materials and Methods

Study Design and Patient Selection

The study retrospectively evaluated the file records of patients hospitalized in the Anesthesiology and Clinical Critical Care of the Health Sciences University, Ankara Numune Training and Research Hospital. All patients (>18 years) admitted to the ICU between September 1, 2017 and December 31, 2018 were included in the study. Approval was obtained from the local ethics committee (ethics committee approval number: E-19-2547), and the study was conducted in compliance with the principles of the Helsinki Declaration. The age of patients at the time of admission, their reason of admission (cardiovascular, neurological, respiratory, gastrointestinal, endocrine, urinary system, postoperative causes, infectious diseases, oncological and trauma patients, intoxications), their underlying diseases [yes (diabetes mellitus, hypertension, malignancy, etc.) or no], the ward from which they were admitted (emergency or other inpatient wards), their duration of hospitalization, mortality, and their MEWS and APACHE II score data were obtained from the file records. Laboratory data and vital signs at the time of hospitalization were used to calculate the MEWS and APACHE II scores.

APACHE II Score

The APACHE II score was obtained by summing the scores for 12 parameters: body temperature (°C), mean arterial pressure (mmHg), heart rate (pulse/min), respiratory rate (/min), oxygenation, fractional oxygen concentration, arterial pH, venous bicarbonate, sodium (mEq/L), potassium (mEq/L), serum creatinine (mg/dL), hematocrit, and leukocytes (/mm^3 × 1000).

Score = 15-Glasgow score

A: total acute physiology score (score of 12 parameters)

B: age score (years): <44 = 0 points, 45–54 = 2 points, 55–63 = 3 points, 65–74 = 5 points, and ≥75 = 6 points

C: chronic health score: previous severe organ system failure or immunodeficiency

a) Unoperated or emergency operated patient = 5 points,

b) Elective postoperative patient = 2 points

c) Total APACHE II score = A + B + C (6).

MEWS score

The MEWS was calculated based on five physiological parameters: systolic blood pressure (mmHg), heart rate (heartbeats/min), respiration rate (respiration/min), body temperature (°C), and response to stimulus (4).

Data Analysis

The recorded data was stored digitally. Statistical analyses were performed with the Statistical Package for Social Sciences (SPSS) version 16.0 for Windows (SPSS Inc., St. Louis, MO). $P < 0.05$ was considered as statistically significant. The t-test and/or Mann–Whitney's U-test were performed to compare nonparametric continuous variables in independent samples between the groups, and categorical variables were analyzed using the chi-square test or Fisher's exact test. Diagnostic screening tests to determine the cutoff value for the MEWS and APACHE II scores (sensitivity, specificity, positive predictive value, and negative predictive value) and the area under the receiver operating characteristic curve (ROC-AUC) analysis were performed. Spearman's correlation method was used to ascertain correlations between parameters. The results were stated as mean and standard deviation (SD) and/or median (minimum–maximum) for continuous variables. We used logistic regression to calculate the odds ratio (OR) ± 95% confidence interval (CI) for the association between mortality and events such as age, MEWS, and APACHE II score according to the corrected model for all available risk factors.

Results

A total of 665 patients admitted to the ICU during the study period were assessed. The mortality rate was 34.2%. The mean age (± SD) of the patients was 68 ± 11 years, mean duration of hospitalization was 11.1 ± 10.5 days, median MEWS was 5 (minimum–maximum: 1–11), and median APACHE II score was 16 (minimum–maximum: 5–47).

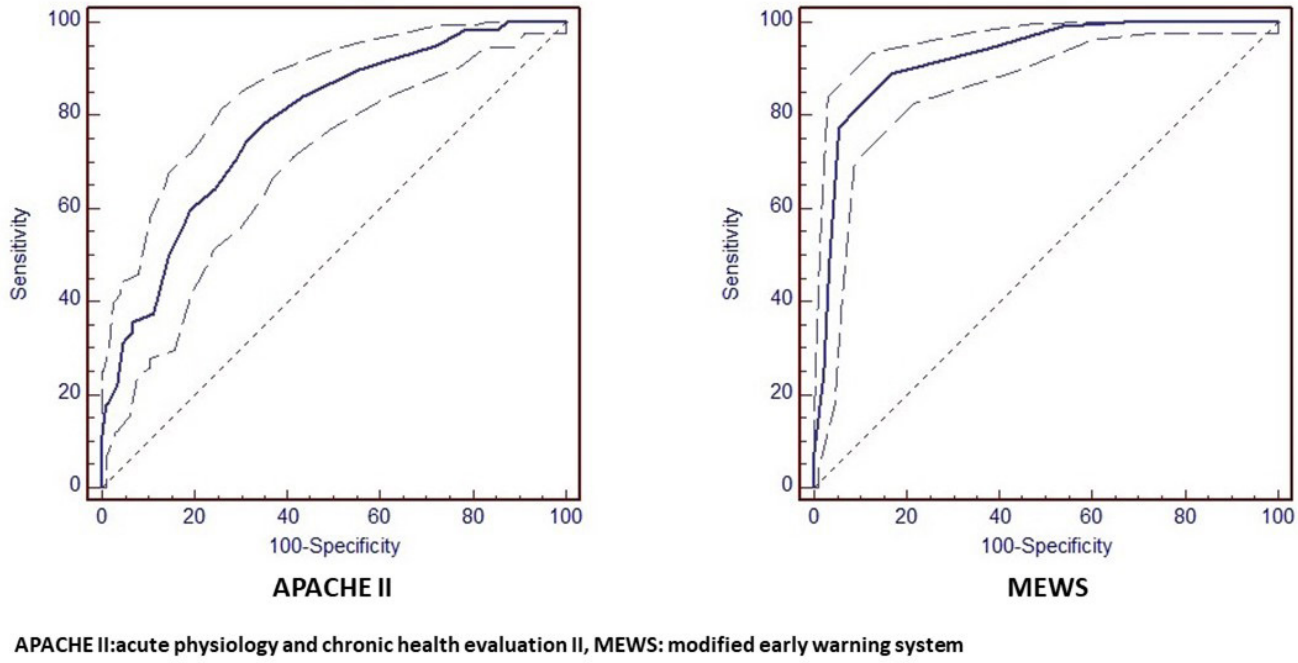

Figure 1. Receiver operating characteristics curves for APACHE II and MEWS scores in predicting mortality

Table 1. Relationships among mortality, disease, the ward to which the patient was admitted, and the MEWS/APACHE II scores

		Mortality			Comorbid diseases			Admitted Department		
Variables	All patients	Yes (n:227)	No (n:438)	P value	Yes (n:595)	No (n:70)	P value	ED (n:335)	Other services (n:330)	p value
Age (Years)[a]	68±15	67±17	69±14	0.186	70±14	57±19	<0.001*	66±18	71±12	<0.001*
ICU stay [a]	11.1±10.5	10.6±8.3	11.5±11	0.291	11.5±10.8	8.1±6.1	0.010*	12.4±11.6	9.9±9.1	0.003*
MEWS scores [b]	5 (1-11)	7 (3-11)	4 (1-9)	<0.001*	5 (1-11)	5 (1-9)	0.845	5 (1-11)	5 (1-10)	0.074
APACHE II scores [b]	16 (5-47)	24 (10-47)	15 (5-32)	<0.001*	17 (5-47)	15 (7-29)	0.008	17 (6-32)	16 (5-47)	0.062

APACHE II: acute physiology and chronic health evaluation, MEWS: modified early warning score, ICU: intensive care unit, ED: emergency department.
*Values of P<0.05 were considered significant.
[a] Mean ± standard deviation
[b] Median (minimum-maximum)

The MEWS and APACHE II scores were significantly higher in patients who died ($p < 0.001$ and $p < 0.001$, respectively). There were no significant differences between patients with and without mortality in terms of age and duration of hospitalization ($p > 0.05$). The MEWS remained similar in terms of diagnosis at hospitalization and concomitant diseases ($p > 0.05$), whereas age, duration of hospitalization and APACHE II scores were found to be statistically significantly higher in the presence of concomitant disease ($p < 0.001$, $p = 0.010$ and $p = 0.008$, respectively). Age was significantly lower in the patients admitted from the emergency department, whereas duration of hospitalization was significantly longer ($p < 0.001$, $p = 0.003$, respectively). The MEWS and APACHE II scores of patients admitted from the emergency department and other wards were similar ($p > 0.05$) (Table 1).

Logistic regression analysis was performed by considering mortality as the dependent variable and other factors such as age and MEWS and APACHE II scores as independent variables. MEWS and APACHE II scores were found to affect the occurrence of mortality, whereas age was found to have no effect on mortality ($p < 0.001$, $p = 0.001$, $p = 0.168$, respectively) (Table 2).

ROC analysis was performed to determine the predictive diagnostic value of MEWS and APACHE II scores in terms of mortality. The area under the ROC curve for the APACHE II score was 0.783. (95% Cl = 0.750–0.814, p = 0.0001), whereas the APACHE II score cutoff value for mortality was 18 (sensitivity: 87.89%, 95% CI: 68.7–80.4; specificity: 68.49%, 95% CI: 63.9–72.8). The area under the ROC curve for the MEWS was 0.924. (95% Cl = 0.901–0.943, p = 0.0001), whereas the MEWS cutoff value for mortality was 5 (sensitivity: 88.99%, 95% CI: 84.2–92.7; specificity: 83.33%, 95% CI: 79.5–86.7). The ROC curve is shown in Figure 1.

Table 2. Relationships among mortality, age, and MEWS/APACHE II scores

	Mortality	
Variables	OR (%95 CI)	p value
Age (Years)	0.993(0.983-1.003)	0.168
MEWS scores	3.025(2.556-3.581)	<0.001*
APACHE II scores	1.173(1.140-1.207)	<0.001*

* Values of P<0.05 were considered significant.
CI: confidence interval, OR: odds ratio, APACHE II: acute physiology and chronic health evaluation, MEWS: modified early warning score.

Discussion

In this study, the MEWS and APACHE II scores were higher in patients who eventually died, whereas age, duration of hospitalization, and APACHE II scores were higher in patients with concomitant diseases. Furthermore, the age of patients admitted to the ICU from inpatient wards was higher. At the time of admission, the MEWS (area under the ROC curve = 0.924) was superior to the APACHE II score (area under the ROC curve = 0.783) in predicting mortality.

In the previous decade, as the survival rate improved in many conditions requiring critical care, more attention was given to prognostic scores to determine the probability of mortality (7). The APACHE II score is a classification system for disease severity that is applied within 24 h of admission to the ICU. High scores indicate more severe disease, acute physiological dysfunction, and high mortality risk due to acute disease. However, the use of the APACHE II scoring system involves extremely complex calculations (8). The APACHE II score is calculated as an integer score between 0 and 71 (7,9); it is widely accepted as a measure of disease severity and has been shown to accurately classify the mortality risk in a variety of disease states and in different clinical settings (9). Higher scores correspond to more severe diseases and higher mortality (7,9). The first APACHE II model was developed by Knaus et al. (6).

The APACHE II score was found to be useful in predicting mortality in patients with intoxication, urosepsis, and ICU admission (2,8,10,11). Furthermore, high APACHE II scores were found to be associated with prolonged ICU hospitalization (9). Similar to these studies, the APACHE II score was associated with increased mortality in this study. For an APACHE II score with a low threshold (≥5), the sensitivity and specificity in predicting mortality was 75% and 86%, respectively. In contrast, for an APACHE II score with a high threshold value (≥10), significantly higher sensitivity (84%) and specificity (88%) values were reported (11). Özbilgin et al. reported that the sensitivity and specificity of an APACHE II score >13.5 in predicting mortality was 77.5% and 70.9%, respectively (3). According to the results of this study, the APACHE II score cutoff value was 18 (sensitivity, 87.89%; specificity, 68.49%) for mortality. The relationship between the APACHE II score and mortality appears to vary, which was also the case in the present study. Although the APACHE II score calculated at initial hospitalization appears to be effective in determining the mortality rate in intensive care patients, this effectiveness may differ between general intensive care clinics (2). The obtained values may have varied because of differences in the diagnosis of patients included in the study and as a result of the treatments before admission to the ICU. Therefore, the use of these systems in critical decision-making processes, such as the selection of patients who will be admitted to intensive care or the management and termination of treatments, is ethically and scientifically disputable (7,12).

The MEWS is a useful bedside monitoring tool owing to its low cost and shorter scoring times (13). The MEWS is frequently used in emergency services when there is limited time, and a higher score indicates a more critical patient and a higher rate of ICU admission (14,15). It was also found that the mortality risk is higher in patients with a MEWS ≥3 (13). Köksal et al. found that the MEWS for mortality in the emergency department was 5 and that the MEWS was effective in predicting mortality (16). Subbe et al. also reported the same results (4). Gok et al. found that in patients admitted to the ICU from the emergency department, mortality increased significantly if the MEWS was ≥5 (17). In their study on geriatric patients, Cei et al. suggested that the MEWS was simple and useful in predicting clinical deterioration, even with a single measurement (18). High MEWS were shown to be closely associated with mortality rates in patients in the ICU (19). Similarly, in this study it was found that a high MEWS increased mortality. Based on the findings, a MEWS >5 increased the risk of mortality (sensitivity: 88.99%; specificity: 83.33%).

A study was evaluated the MEWS and APACHE II scores together; this study reported that neither can predict early clinical deterioration (5). Additionally, the APACHE II score was found to be superior to the MEWS in determining prognosis for patients with septic shock in the emergency department (20). Based on the results of the present study, it was concluded that the MEWS was superior to the APACHE II score in predicting mortality at the time of ICU admission. In studies evaluating these two scoring systems, differences were observed in terms of cutoff values and the superiority in predicting mortality, which can be explained by the differences between the clinics where the patients were evaluated, as well as the differences in the patients' diagnoses. Based on the results of this study, it was concluded that the MEWS scoring system is more practical at the time of ICU admission and that the MEWS is superior to the APACHE II score. Its advantages includes that the MEWS score parameters are low and are calculated in a short time. Despite the frequent use of the MEWS score outside the ICU, ICU physicians can provide important insights for mortality.

This study had some limitations because of its retrospective nature. It was not possible to analyze scoring changes over time

or conduct comparisons with other scoring systems. Because this study was performed at a single center and because of diagnostic differences between clinics, it is possible that the results cannot be generalized to other clinics.

Conclusion

Scoring systems are useful for predicting prognosis in the initial evaluation of patients admitted to the ICU. Clinicians can use scoring systems to assess and determine patient management more easily during ICU admission. In addition, scoring systems can provide other clinicians with an idea about the clinical severity of the patient. Although the MEWS was more effective at the time of admission in this study, MEWS and APACHE II scoring systems were both found to be significantly effective in predicting mortality. However, large-scale, multi-center studies comparing a greater number of scoring systems with multiple patient groups are necessary to develop scoring systems with easily applicable criteria that provide more accurate results.

Conflict of Interest Statement

The content of this paper has not been influenced directly or indirectly by any actual or potential conflict of interest. The authors have no conflicts of interest relevant to this article.

AUTHOR CONTRIBUTIONS:

Concept: EC; **Design:** EC, ES; **Supervision:** AB, AC; **Materials:** EC, ES; **Data Collection and/or Processing:** EC, AC; **Analysis and/or Interpretation**: AB, AC; **Literature Search:** EC, ES; **Writing Manuscript**: EC; **Critical Review:** IOT.

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