

Analysis of the Application Value of the MEWS in Neurological Patients and Its Prognostic Influencing Factors

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Abstract: *Objective:* To evaluate the predictive value of Modified Early Warning Score (MEWS) for neurological disease prognosis and identify prognostic factors. *Methods:* This retrospective study analyzed 768 neurological patients with MEWS ≥ 4 (June 2022–June 2024). Patients were stratified by outcomes (favorable/unfavorable). Multivariable logistic regression and ROC analysis were performed. *Results:* 108 cases (13.1%) had unfavorable outcomes. Significant prognostic factors included: age, TBI history, onset-to-admission time, PT, MEWS score, and MEWS ≥ 4 frequency (all $P < 0.05$). MEWS showed AUC = 0.749 (sensitivity 62.0%, specificity 77.4%). *Conclusion:* MEWS demonstrates moderate predictive value (AUC = 0.749) for neurological outcomes. Consciousness assessment limitations (56.5% impaired cases) may affect sensitivity. A specialized model incorporating pupillary reflexes and GCS is recommended for improved early warning.

Keywords: Modified early warning score; Neurological diseases; Predict prognosis; Risk factors; ROC

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1. Introduction

Neurological diseases encompass stroke, traumatic brain injury, intracranial infections, and others, characterized by high incidence, high prevalence, high disability rates, and high mortality rates^[1]. The 30-day mortality rate after intracerebral hemorrhage reaches as high as 35%–52%, with 80% of patients at risk of disability^[2]. In China, the annual incidence of traumatic brain injury ranges from 55 to 64 per 100,000 people, resulting in nearly 100,000 deaths annually and imposing a heavy burden on families and society^[3].

The Modified Early Warning Score (MEWS), proposed by Subbe et al. in 2001, is a scoring system used to monitor patients' vital signs^[4]. It is characterized by its convenience in clinical observation and simple operation^[5]. MEWS has shown favorable application effects in pre-hospital emergency care, emergency departments, ICUs, and other critical care settings. However, research on its application in neurological patients is relatively limited. An MEWS

score of ≥ 4 often serves as a threshold for poor prognosis, used for clinical risk stratification, indicating a worse prognosis for such patients. Therefore, this study will focus on neurological patients with a MEWS score of ≥ 4 , exploring the predictive efficacy of MEWS for the prognosis of neurological patients and screening for factors influencing their prognosis. The aim is to provide evidence-based support for establishing a neurology-specific early warning scoring system.

2. Materials and methods

2.1. General information

A retrospective study was conducted, selecting 768 patients from the neurology and neurosurgery wards of a tertiary hospital in Zhenjiang between June 2022 and June 2024 as the research subjects. The study was approved by the hospital's ethics committee (K-2025039-W).

The inclusion criteria are as follows:

- (1) Age ≥ 18 years old;
- (2) MEWS score ≥ 4 points.

The exclusion criteria are as follows:

- (1) Patients whose family members have abandoned treatment;
- (2) Patients with incomplete clinical data.

2.2. Research methods

The questionnaire is designed by the researchers themselves, it includes:

- (1) General patient information, including age, gender, smoking history, alcohol consumption history, NRS2002 nutritional score, pre-admission self-care ability score (Barthel score), BMI (based on the first measurement upon admission), thrombotic risk (clinical judgment method), and comorbidities (whether the patient has hypertension, diabetes, coronary heart disease, or hyperlipidemia);
- (2) Information related to neurological diseases, including GCS score (based on the first admission), clinical symptoms (dizziness, headache), cranial CT examination, MEWS score (based on the first admission), and frequency of MEWS scores ≥ 4 points;
- (3) Other laboratory tests (based on the first measurement within 24 hours of admission), including total bilirubin, blood glucose, prothrombin time (PT), etc.

2.3. Data collection methods

After obtaining approval from the hospital administration, data was collected using the hospital's medical record management information system.

2.4. Statistical methods

SPSS 27.0 software was used for analysis. MEWS scores, as continuous data that did not conform to a normal distribution, were represented by medians (quartiles). Intergroup comparisons were made using analysis of variance or t-tests. Count data were represented by frequencies and percentages (%), and intergroup comparisons were made using chi-square tests or rank-sum tests. The significance level was set at $\alpha = 0.05$. A statistically significant difference was considered when $P < 0.05$.

Based on the sample size estimation method for multivariate logistic regression models and adhering to the principle of requiring 5–10 patients per independent variable, this study ultimately included 11 variables in the model. The incidence of poor patient prognosis in this study was 14%, and a 20% sample attrition rate was considered. Therefore, the minimum required sample size for the study was calculated to be approximately 491 cases using the formula $5 \times 11 \div 14\% \div (1 - 20\%)$, and ultimately, 768 cases were included in the study.

3. Results

3.1. General information of patients

A total of 768 patients were included in this study, comprising 297 males (38.7%) and 471 females (61.3%). After treatment, 660 patients (85.9%) had favorable outcomes, while 108 patients (14.1%) had unfavorable outcomes. **Table 1** presents the demographic and general information of the 768 patients with neurological diseases, with specific data provided in the table.

3.2. Univariate analysis of patient prognosis

From **Table 1**, it can be observed that age, BMI, number of underlying diseases, diabetes, history of cranial trauma, time from onset to medical consultation, NRS2002 score, prothrombin time (PT), ICU admission, MEWS score, and the frequency of MEWS ≥ 4 all showed statistically significant differences ($P < 0.05$).

Table 1. Univariate analysis of patient prognosis

Item	Total cases	Favorable outcome (n=660)	Unfavorable outcome (n=108)	Statistic	P value
Gender [n, %]				$\chi^2 = 0.644$	0.422
Male	297	259 (39.2)	38 (35.2)		
Female	471	401 (60.8)	70 (64.8)		
Age [years, n, %]				$\chi^2 = 23.417$	< 0.001
18–59	224	206 (31.2)	18 (16.7)		
60–90	524	443 (67.1)	81 (75.0)		
> 90	20	11 (1.7)	9 (8.3)		
Consciousness [n, %]				$\chi^2 = 2.534$	0.282
Alert	335	281 (83.9)	54 (16.1)		
Stupor	220	195 (88.6)	25 (11.4)		
Coma	213	184 (86.4)	29 (13.6)		
GCS Score [n, %]				$\chi^2 = 0.703$	0.704
3–8	230	201 (30.5)	29 (26.9)		
9–12	138	119 (18.0)	19 (17.6)		
13–15	400	340 (51.5)	60 (55.6)		
BMI [kg/m ² , n, %]				$\chi^2 = 4.066$	0.001
≤ 25	557	470 (71.2)	87 (28.8)		
> 25	211	190 (28.8)	21 (19.4)		

Table 1 (Continued)

Item	Total cases	Favorable outcome (n=660)	Unfavorable outcome (n=108)	Statistic	P value
Number of comorbidities [n, %]				$\chi^2 = 7.124$	0.008
< 2	493	436 (66.1)	57 (52.8)		
≥ 2	275	224 (33.9)	51 (47.2)		
Diabetes [n, %]				$\chi^2 = 8.158$	0.004
Yes	168	133 (20.2)	35 (32.4)		
No	600	527 (79.8)	73 (67.6)		
Hypertension [n, %]				$\chi^2 = 1.132$	0.287
Yes	528	449 (68.1)	79 (73.1)		
No	240	211 (32)	29 (26.9)		
Hyperlipidemia [n, %]				$\chi^2 = 1.826$	0.177
Yes	11	11 (1.7)	0 (0.0)		
No	757	649 (98.3)	108 (100.0)		
History of head trauma [n, %]				$\chi^2 = 7.043$	0.008
Yes	609	513 (77.7)	96 (88.9)		
No	159	137 (22.3)	12 (11.1)		
Meningeal signs [n, %]				$\chi^2 = 1.056$	0.304
Negative	658	562 (85.2)	96 (88.9)		
Positive	110	98 (13.8)	12 (11.1)		
Onset to admission time [n, %]				$\chi^2 = 11.815$	< 0.001
< 24h	572	506 (76.7)	66 (61.1)		
$\geq 24h$	196	154 (23.3)	42 (38.9)		
Barthel index [n, %]				$\chi^2 = 0.690$	0.406
≤ 40	384	334 (50.6)	50 (46.3)		
> 40	384	326 (49.4)	58 (53.7)		
NRS2002 ccore [n, %]				$\chi^2 = 11.742$	0.008
Normal (0 points)	47	35 (5.3)	12 (11.1)		
Mild (1 point)	49	39 (5.9)	10 (9.3)		
Moderate (2 points)	126	117 (17.7)	9 (8.3)		
Severe (≥ 3 points)	546	469 (71.1)	77 (71.3)		
Total bilirubin [$\mu\text{mol/L}$, n, %]				$\chi^2 = 1.690$	0.194
≤ 21	619	527 (79.8)	92 (85.2)		
> 21	151	133 (20.2)	16 (13.8)		
Prothrombin time [s, M (P25–P75)]				Z = 0.182	< 0.001
	11.5 (10.9, 12.2)	11.6 (10.4, 12.4)			

Table 1 (Continued)

Item	Total cases	Favorable outcome (n=660)	Unfavorable outcome (n=108)	Statistic	P value
ICU Admission [n, %]				$\chi^2 = 5.104$	0.024
Yes	395	352 (53.3)	43 (39.8)		
No	373	308 (46.7)	65 (60.2)		
MEWS [points, M (P25, P75)]				$Z = -9.013$	< 0.001
	4 (4, 5)	6 (5, 10)			
Frequency of MEWS ≥ 4 [n, %]				$\chi^2 = 45.840$	< 0.001
< 5 times	572	520 (78.8)	52 (48.1)		
≥ 5 times	196	130 (21.2)	56 (51.9)		

3.3. Multivariate analysis of patient prognosis

Using the outcome status as the dependent variable (unfavorable = 0, favorable = 1), 11 statistically significant variables from the univariate analysis were included in the logistic regression model. **Table 2** presents the assignment of independent variables. With $\alpha_{\text{entering}} = 0.05$ and $\alpha_{\text{exiting}} = 0.1$, the forward conditional method was employed to identify risk factors. The Hosmer-Lemeshow test yielded $\chi^2 = 5.997$, $P = 0.540$.

Table 2. Description and coding of independent variables

Variable	Assignment
Age	18–59 years = 1, 60–90 years = 2, > 90 years = 3
BMI	$\leq 25 \text{ kg/m}^2 = 1$, $> 25 \text{ kg/m}^2 = 2$
Number of comorbidities	$\geq 2 = 1$, $< 2 = 2$
History of diabetes	No = 0, Yes = 1
Onset to admission time	$< 24 \text{ h} = 1$, $\geq 24 \text{ h} = 2$
NRS2002 score	0 points = 0, 1 point = 1, 2 points = 2, ≥ 3 points = 3
Prothrombin time	$< 13.3 \text{ s} = 1$, $\geq 13.3 \text{ s} = 2$
ICU admission	No = 0, Yes = 1
MEWS score	≤ 5 points = 1, > 5 points = 2
Frequency of MEWS ≥ 4	< 5 times = 1, ≥ 5 times = 2
History of head trauma	No = 0, Yes = 1

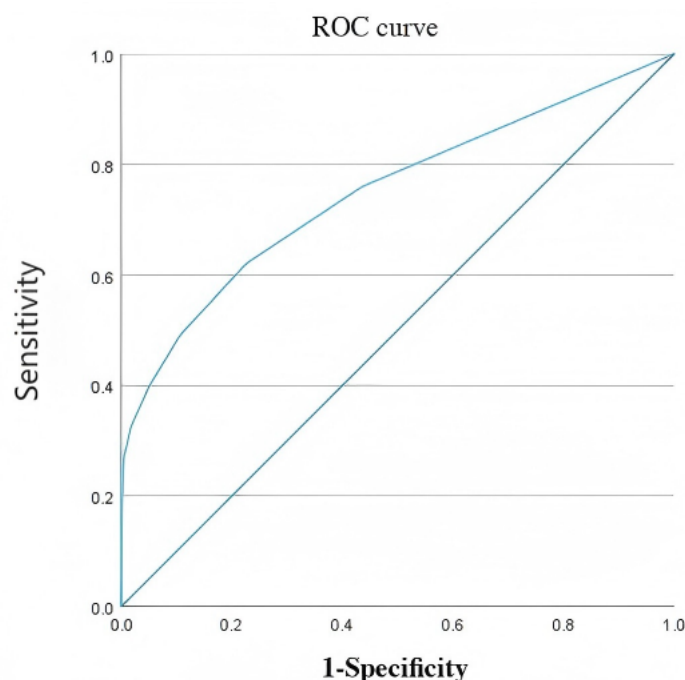
The Omnibus test of model coefficients showed $\chi^2 = 163.070$, $P < 0.001$, indicating a good fit. The data in **Table 3** reveal that age, history of cranial trauma, time from onset to medical consultation, prothrombin time, and the frequency of MEWS score ≥ 4 are independent risk factors for the prognosis of patients with neurological diseases.

Table 3. Multivariate analysis of prognostic factors in patients with neurological disorders

Variable	β	SE	Wald	P-value	OR	95% CI
Age	0.922	0.283	10.603	0.001	2.514	1.443–4.378
History of head trauma	-0.869	0.392	4.914	0.027	0.419	0.195–0.904
Onset to admission time	0.802	0.278	8.334	0.004	2.230	1.294 - 3.843
Prothrombin time	1.801	0.330	29.860	< 0.0001	6.057	3.175–11.558
MEWS score	1.981	0.255	60.165	< 0.0001	7.251	4.395–11.961
Frequency of MEWS ≥ 4	1.345	0.251	28.682	< 0.0001	3.839	2.346–6.280
Constant	-9.167	0.998	84.384	< 0.0001	< 0.0001	-9.167

3.4. Predictive effect of MEWS score on the prognosis of patients with neurological diseases

Figure 1 depicts the ROC curve drawn with the state variable value set to 1 (i.e., unfavorable outcome). The area under the ROC curve for the MEWS score was 0.749 [95% CI 0.692, 0.807], $P < 0.001$, with an optimal cutoff value of 6, a Youden index of 0.394, a sensitivity of 62.00%, and a specificity of 77.40%.

**Figure 1.** ROC curve of the modified early warning score (MEWS).

4. Discussion

4.1. Analysis of the effectiveness of MEWS scores in patients with neurological disorders

Figure 1 indicates that MEWS exhibits moderate predictive efficacy for the prognosis of patients with neurological disorders (AUC = 0.749, sensitivity 62.00%, specificity 77.40%), which is slightly lower than that reported in previous studies ^[6,7]. This discrepancy may be attributed to the relatively broad range of neurological diseases included in this study, suggesting limitations in the application of the MEWS system in specific populations.

Notably, 56.5% of cases exhibited impaired consciousness, leading to an imbalance in the weighting of the AVPU score and an elevated overall MEWS score. This resulted in insufficient sensitivity to pathological changes specific to neurological disorders.

Studies have shown that a MEWS score of ≥ 4 has predictive value for intensive care needs [8–11]. A foreign study indicated that the AVPU dimension does not fully reflect neurological specificity [12]. It is recommended to optimize the implementation of MEWS scoring system and incorporate specialized neurological indicators to construct a neurology-specific assessment model, aiming to enhance the accuracy of nursing teams in identifying neurological critical conditions.

4.2. Factors influencing the prognosis of neurological patients with MEWS scores ≥ 4

4.2.1. Age

The results in **Table 3** indicate that age is a significant factor influencing the prognosis of neurological patients ($P < 0.05$). As age increases, patient prognosis tends to worsen, consistent with findings from related studies [13–15]. The potential reasons for this are as follows:

- (1) With the progression of aging, the incidence of various comorbidities gradually rises, affecting patient prognosis [14];
- (2) Decline in physiological functions among elderly patients can lead to discrepancies between disease progression and clinical manifestations, making early disease changes easily overlooked and thereby delaying treatment and affecting prognosis.

In clinical practice, nursing staff should conduct comprehensive specialist nursing assessments for patients of different age groups and implement targeted measures based on the patient's condition. In the event of any changes in the patient's condition, a rapid response system should be immediately activated to improve patient prognosis.

4.2.2. History of cranial trauma

Table 3 reveals that a history of cranial trauma is a protective factor for the prognosis of neurological patients ($P < 0.05$), with patients having a lower risk of poor prognosis. The findings of this study differ from those of previous studies [16,17]. The reasons for these discrepancies may include:

- (1) Patients with cranial trauma, due to the severity of their condition, tend to receive greater attention from healthcare professionals, leading to earlier and more proactive interventions;
- (2) This study also included patients from the neurology department, which may introduce some bias into the results.

Future research could further expand the sample size, include a wider range of patient types, and analyze the impact of different interventions on prognosis to more comprehensively explore the relationship between a history of cranial trauma and patient prognosis.

4.2.3. Time from onset to hospital visit

The time from symptom onset to medical consultation is a risk factor affecting the prognosis of patients with neurological disorders ($P < 0.05$). Patients with symptom duration ≤ 24 hours exhibit better prognoses, with specific data presented in **Table 3**. Zheng's team confirmed that delayed medical consultation is a key factor influencing patient prognosis (OR = 1.050) through logistic regression analysis, although its effect size is slightly lower than that observed in this study [18]. Hu et al. argued that a time from symptom onset to medical consultation

exceeding 3.5 hours is an independent risk factor for poor prognosis in severe cerebral infarction (OR = 3.643), showing significant consistency with the findings of this study^[19]. Delayed medical consultation may result in missing the golden window for treatment, leading to irreversible patient damage. It is recommended to conduct community health education during the pre-hospital phase to enhance the public's ability to recognize early symptoms and to conduct prospective, detailed analyses of the relationship between medical consultation time and patient prognosis.

4.2.4. Prothrombin time

Prolonged PT is a predictor of poor prognosis ($P < 0.001$). Patients with neurological disorders who have a PT < 13.3 seconds exhibit relatively better prognoses, consistent with the findings of related studies, with specific data presented in **Table 3**^[20,21]. The results of a retrospective study conducted by scholars such as Li indicate that the use of antithrombotic drugs is a key risk factor affecting the prognosis of elderly patients with intracranial hemorrhage, a finding similar to that of this study^[22]. PT is an important indicator for assessing a patient's coagulation function, primarily reflecting the status of the exogenous coagulation system. Abnormalities in the quantity or quality of coagulation factors, as well as the presence of anticoagulant substances in the blood, can lead to prolonged PT^[23]. Prolonged PT may further trigger multiple organ failure, causing irreversible harm, and can lead to poor prognosis or even death in patients^[24]. Therefore, monitoring PT is crucial for early identification of coagulation dysfunction and prevention of poor prognosis. It is recommended that nursing staff monitor and assess patients' coagulation function as early as possible, promptly identify coagulation abnormalities, and implement targeted interventions at an early stage to reduce the risk of poor patient prognosis.

4.2.5. MEWS score and frequency of MEWS ≥ 4

The study results indicated that the MEWS score was a significant influencing factor on patient prognosis ($P < 0.001$), with specific data presented in **Table 3**. A higher MEWS score was associated with a worse patient prognosis. MEWS demonstrated good efficacy in predicting in-hospital mortality among TBI patients and could also predict patient prognosis^[6,14,25]. The MEWS score aids healthcare professionals in identifying potentially critically ill patients. Our study results revealed that the frequency of MEWS scores ≥ 4 was a risk factor affecting patient prognosis ($P < 0.001$), with a higher frequency of MEWS scores ≥ 4 correlating with an increased risk of poor patient prognosis. Currently, research on the frequency of MEWS scores and their association with prognosis is relatively scarce. We recommend conducting prospective studies in the future to explore the relationship between the frequency of MEWS scores ≥ 4 and prognosis.

5. Conclusion

The MEWS demonstrated moderate efficacy (AUC = 0.749) in predicting the prognosis of patients with neurological diseases. The high incidence of impaired consciousness (56.5%) led to an imbalance in the AVPU scale's weighting, with its sensitivity (62.00%) and specificity (72.40%) showing potential for improvement. Studies have shown that compared to other illness assessment systems, the MEWS score offers higher accuracy in predicting the risk of patient condition changes. By integrating factors such as age, time from onset to medical consultation, coagulation function, and pupillary reflex, MEWS could potentially construct a specialized early warning model that breaks through the bottleneck of traditional scoring systems in neurological applications.

The study's limitations include its single-center retrospective design, which may introduce selection bias, and the potential for errors in manual data entry. We recommend conducting multi-center prospective studies in the future, utilizing standardized electronic medical record systems for data collection, and developing specialized neurological scores to provide evidence-based support for establishing a localized early warning system.

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