

Application of Modified Early Warning Score System (MEWS) in the Assessment of Disease Condition and Prognosis of Patients After Neurosurgical Procedure or Intervention

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Objective: To evaluate the safety and clinical utility of the corrected Modified Early Warning Score (MEWS) system in predicting postoperative clinical deterioration and long-term prognosis in neurosurgical patients.

Methods: A prospective cohort study was conducted on 344 neurosurgical patients admitted between December 2021 and April 2022. Physiological parameters including axillary temperature, respiratory rate, heart rate, systolic blood pressure, arterial oxygen saturation, and consciousness level were systematically recorded. Patients were monitored for clinical deterioration and final outcomes over a 90-day postoperative period. Receiver operating characteristic (ROC) curve analysis was performed with 90-day mortality as the primary endpoint.

Results: The study demonstrated a significant correlation between elevated corrected MEWS scores and clinical severity ($p < 0.001$). ROC analysis revealed excellent predictive accuracy for 90-day mortality ($AUC = 0.944$), with an optimal cutoff value of 4.5 points demonstrating high sensitivity (92.9%) and specificity (82.0%). The maximum Youden's index of 0.749 further confirmed the robust discriminative capacity of this threshold.

Conclusion: The corrected MEWS scoring system shows strong predictive validity for postoperative clinical deterioration and long-term outcomes in neurosurgical patients.

Keywords: correction and improvement of early warning score, check MEWS, after neurosurgery, prognostic assessment

Introduction

Patients undergoing neurosurgery are susceptible to rapid postoperative deterioration due to multiple factors including underlying pathologies, anesthetic effects, and surgical trauma, with severe cases potentially progressing to life-threatening conditions.¹ The capacity of healthcare providers to accurately anticipate postoperative clinical trajectories is paramount for ensuring patient safety, minimizing emergent complications, and ultimately improving survival outcomes.^{2,3} This underscores the necessity for developing standardized, quantifiable objective assessment tools for patient evaluation.

Currently available clinical scoring systems for assessing illness severity include the Acute Physiology and Chronic Health Evaluation (APACHE), Early Warning Score (EWS), Modified Early Warning Score (MEWS), and Corrected Modified Early Warning Score (CM EWS).⁴ Among these, the Corrected MEWS has garnered increasing attention in clinical practice owing to its readily accessible parameters, operational simplicity, and reliable predictive validity.^{5,6}



While predominantly utilized in emergency, transport, and resuscitation settings, the application of Corrected MEWS in specialized clinical domains remains exploratory.^{7–9}

Notably, research specifically examining the utility of Corrected MEWS for postoperative neurosurgical assessment is limited, with no established consensus regarding optimal cutoff values in domestic clinical practice.^{10,11} This study therefore aims to systematically evaluate the predictive value of Corrected MEWS for clinical status and prognosis in post-neurosurgical patients.

Materials and Methods

Study Population and Ethical Considerations

This retrospective cohort study enrolled postoperative neurosurgical patients admitted to the Department of Neurosurgery at the Army Medical Center of the PLA between December 2021 and April 2022.

Inclusion criteria:

- Patients who were successfully transferred to the general ward following neurosurgical intervention.

Exclusion criteria:

- ICU admission within 72 hours postoperatively
- Perioperative mortality
- Treatment discontinuation or withdrawal of care
- Discharge due to full recovery
- Incomplete clinical datasets
- Loss to follow-up within 90 postoperative days
- COVID-19-related mortality within 90 postoperative days

Following rigorous screening per the predefined criteria, 281 eligible patients were included in the final analysis, with an age range of 14–87 years (mean \pm SD: 53.8 \pm 13.2 years).

The study protocol received approval from the Institutional Review Board of our medical center (Ethics Approval No. 2023-116), ensuring compliance with ethical standards for human subject research.

Research Methods

Corrected MEWS scores were calculated based on seven physiological parameters recorded within 3 days post-surgery: axillary temperature, respiratory rate, heart rate, systolic blood pressure, level of consciousness (using the AVPU scale), oxygen saturation, and age (see [Table 1](#) for scoring criteria). Each parameter was scored from 0 to 3 according to predefined thresholds, adapted from previously validated MEWS modifications.¹² Patients were categorized into three risk groups based on total corrected MEWS: Group I (0–3 points), Group II (4–6 points), and Group III (\geq 7 points). Clinical outcomes at 90 days were determined via medical record review or follow-up interviews and classified as

Table 1 Corrected MEWS Scoring Criteria

Parameter	3 Points	2 Points	1 Point	0 Points	Score Range
Respiratory Rate (/min)	\geq 30	21–29	15–20	9–14	0–3
Heart Rate (/min)	\geq 130	111–129	101–110	51–100	0–3
Systolic BP (mmHg)	\leq 70	71–80	81–100	$>$ 100	0–3
Temperature ($^{\circ}$ C)	\leq 35.0 or \geq 39.0	38.0–38.9	36.0–37.9	35.1–35.9	0–3
Consciousness (AVPU)	Unresponsive	Response to Pain	Response to Voice	Alert	0–3
Oxygen Saturation (%)	\leq 90	91–93	94–95	\geq 96	0–3
Age (years)	\geq 75	65–74	55–64	$<$ 55	0–3

improved, unchanged, worsened, or deceased, based on documented functional status and survival. ROC curve analysis was conducted using 90-day mortality as the outcome variable.

Clinical Outcomes

Clinical outcomes at 90 days postoperatively were categorized as follows. Improved: Functional status showed improvement compared to the preoperative baseline, with no new neurological deficits. This corresponds to a Glasgow Outcome Scale (GOS) score of ≥ 4 or a modified Rankin Scale (mRS) score of ≤ 2 . Unchanged: No significant clinical changes were observed, and the patient maintained a stable functional status. The GOS and mRS scores remained the same as at baseline. Deteriorated: The patient developed new or worsened neurological deficits or experienced increased functional dependence. This is reflected by a GOS score of ≤ 3 or an mRS score of ≥ 3 . Death: The patient experienced all-cause mortality within 90 days following surgery.

Statistical Methods

Statistical analysis was performed using SPSS version 22.0. Continuous data were expressed as $x \pm s$, while categorical data were presented as counts or percentages. The Chi-square test was used for comparisons. Predictive probabilities were utilized to generate the ROC curve, with χ^2 plotted on the x-axis and sensitivity on the y-axis. The area under the ROC curve (AUC) was calculated to assess predictive accuracy.

Results

Association Between Postoperative Corrected MEWS Scores and 90-Day Clinical Outcomes in Neurosurgical Patients

A significant positive correlation was observed between elevated Corrected MEWS scores within the first 72 postoperative hours and adverse clinical outcomes ($P < 0.001$). Higher scores demonstrated a strong predictive value for clinical deterioration and mortality, with pairwise comparisons across score strata revealing statistically significant differences in outcomes ($P < 0.001$, Table 2).

Predictive Performance of Corrected MEWS for 90-Day Mortality

ROC curve analysis was performed using 90-day mortality as the primary endpoint. The analysis yielded an AUC of 0.944, indicating excellent predictive accuracy. The optimal cutoff value was determined to be 4.5, demonstrating high sensitivity (92.9%) and specificity (82.0%). The maximum Youden's index of 0.749 further confirmed the robust discriminative ability of this threshold ($P < 0.001$, Figure 1).

These findings demonstrate that the Corrected MEWS scoring system serves as a highly significant prognostic tool (AUC > 0.9) for predicting 90-day mortality in post-neurosurgical patients.

The cutoff value of 4.5 for corrected MEWS demonstrates excellent discrimination for 90-day mortality. In clinical practice, this threshold could be considered as an early warning trigger for intensified monitoring or intervention post-neurosurgery, though prospective validation in broader cohorts is needed.

Table 2 Relationship Between Corrected MEWS Scores Within 3 Days Post-Surgery and Clinical Outcomes of Patients [n (%)]

Group	n	Improvement	Unchanged	Deterioration	Death
I	176	174 (98.9)	0	2 (1.1)	0
II	84	61 (72.6)	4 (4.8)	12 (14.3)	7 (8.3)
III	21	4 (19.0)	4 (19.0)	6 (28.6)	7 (33.4)

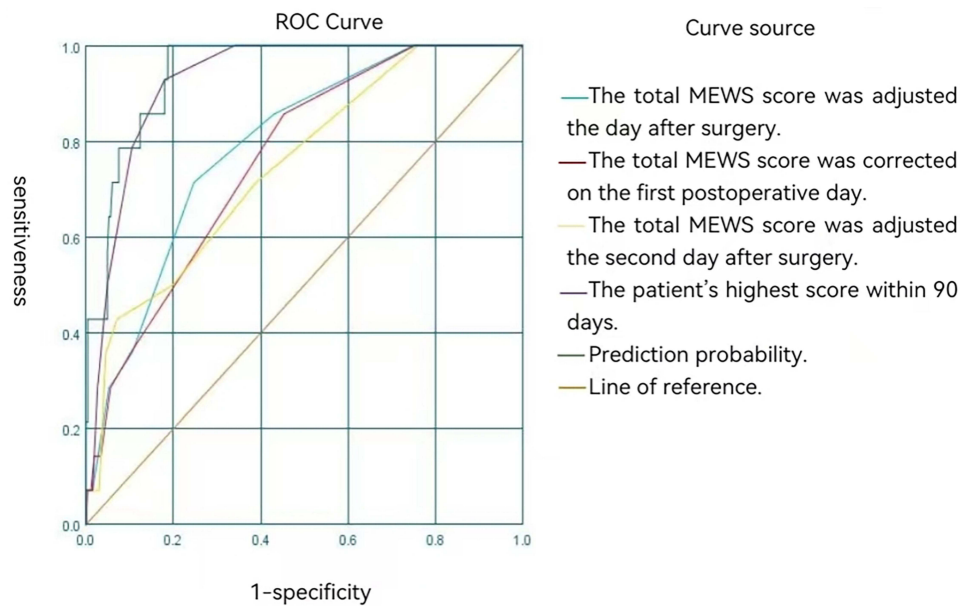


Figure 1 ROC curve of MEWS score correction within 3 days post-neurosurgery predicting 90-day outcomes in neurosurgical patients.

Discussion

Patient safety remains a paramount priority in healthcare delivery worldwide. Clinical evidence demonstrates that adverse events are frequently preceded by measurable physiological derangements that serve as critical warning signs.¹³ This recognition has driven the global medical community to develop and implement various early warning scoring systems, aiming to facilitate timely, efficient, and precise identification of at-risk patients.

The evolution of these scoring systems began with Morgan et al's pioneering work on the EWS.¹⁰ While this system offered advantages in terms of rapid parameter acquisition and operational simplicity, its clinical implementation demonstrated significant inter-hospital variability. Subsequent refinements by Subbe led to the development of the Modified Early Warning Score (MEWS), which gained widespread clinical adoption due to its enhanced user-friendliness.^{14–16} However, comparative analyses have revealed limitations in MEWS's diagnostic performance. Specifically, it demonstrates inferior sensitivity compared to established intensive care scoring systems (APACHE II and SAPS II) in detecting potentially critical illness.^{17,18}

Furthermore, the system's parameter selection lacks comprehensive coverage of critical physiological indicators and suffers from insufficient specificity for certain clinical scenarios.¹⁹ To improve specificity and sensitivity, Tang et al⁵ incorporated oxygen saturation into MEWS, forming the Corrected MEWS, which is now applied in emergency and critical care. Recent multicenter studies have extensively validated early warning systems in respiratory emergencies. A Spanish prospective study of 902 emergency department patients with acute respiratory distress found that while Modified Sequential Organ Failure Assessment (mSOFA) showed the best predictive performance for 2-day mortality (AUROC 0.911), MEWS still maintained clinical utility with an AUROC of 0.82–0.87 across different respiratory conditions.¹⁹ This suggests that although specialized scores may outperform MEWS in specific scenarios, its balanced performance across diverse conditions supports its use as a general screening tool. In diabetic emergencies, comparative studies suggest more nuanced performance differences among scoring systems. A retrospective analysis of diabetic patients presenting with sepsis found that while SOFA score showed superior predictive value for septic shock onset (AUROC 0.866 at 48 hours), MEWS still demonstrated clinically useful performance (AUROC 0.79) and maintained advantages in rapid assessment due to its simpler parameters.⁴ This highlights the importance of selecting scoring systems based on both predictive accuracy and clinical practicality. However, the system's performance varies significantly by pathology. In toxic alcohol poisoning cases, a seven-year retrospective study demonstrated that while APACHE II and SOFA scores showed superior predictive value for adverse outcomes (AUC 0.97 and 0.94 respectively), MEWS exhibited limited discriminative ability (AUC=0.68) compared to these specialized scoring systems.¹⁷ This underscores

the importance of using pathology-specific scoring tools for certain toxicological emergencies. Our findings align with this refinement: Corrected MEWS scores calculated within three days post-neurosurgery showed strong correlation with 90-day clinical outcomes. Specifically, patients with scores ≥ 7 had a mortality rate of 33.4%, compared to 0% in those with scores ≤ 3 , demonstrating a clear predictive gradient.

Moreover, the ROC curve analysis yielded an AUC of 0.944, with a cutoff of 4.5, 92.9% sensitivity, and 82.0% specificity, supporting its strong prognostic accuracy. These findings are consistent with previous studies,^{5,9,20} suggesting that Corrected MEWS is a robust early warning tool for postoperative neurosurgical patients.

Validation of MEWS in Uganda and Cape Town supports its global feasibility: in Uganda, MEWS ≥ 5 predicted 7-day mortality with OR = 5.82 (95% CI 2.42–13.99) and a Cape Town consensus refined cutoffs for resource-limited wards.²¹ In Cape Town, experts used a Delphi process to tailor a MEWS chart for general wards. They reached $\geq 70\%$ consensus on seven vital sign thresholds—including respiratory and heart rates, systolic BP, temperature, and consciousness/SpO₂ cutoffs.²²

Compared to APACHE II or NEWS, Corrected MEWS offers advantages in terms of ease of calculation, faster parameter acquisition, and minimal data requirements, making it well-suited for resource-limited or high-turnover settings such as neurosurgical wards or emergency units. Age-specific limitations warrant particular attention. A comprehensive systematic review of 21 studies (n=11,183) evaluating early warning systems found that while these scores showed strong predictive value for 48-hour mortality (AUROC 0.88–0.93) and cardiac arrest (AUROC 0.74–0.86) in adult populations, the evidence regarding their impact on clinical outcomes and resource utilization remains inconclusive due to methodological limitations in most studies.²³ This suggests that while MEWS demonstrates good predictive validity, its clinical implementation requires careful consideration of patient populations and local care protocols. In emergency department triage settings, a multicenter prospective study of 798 patients found that while MEWS showed utility in risk stratification, clinical judgment by physicians demonstrated superior accuracy for predicting hospital admission (sensitivity 91.9% vs 44.0% for MEWS ≥ 3 , $p < 0.001$), suggesting that scoring systems should complement rather than replace clinician assessment.²⁴ However, APACHE II provides greater granularity for ICU-level decision-making, and NEWS may offer better discrimination in respiratory or septic cases. Thus, the choice of scoring system should be tailored to the clinical context.

Study Limitations and Future Directions

This study has limitations, including its single-center design, limited sample size, and lack of a comparison group using alternative scoring systems. These factors may limit generalizability. To address this, we propose a prospective, multi-center study comparing Corrected MEWS, NEWS, and APACHE II in neurosurgical populations. Such research could assess not only predictive performance but also operational feasibility (eg, time to calculate, training needs, inter-rater reliability) to inform clinical adoption.

Conclusion

In summary, the corrected MEWS demonstrated strong predictive value for 90-day prognosis in neurosurgical patients, with an AUC of 0.944, sensitivity of 92.9%, and specificity of 82.0% at the optimal cutoff of 4.5. Clinical outcomes were significantly stratified by MEWS scores: Group I (score 0–3) had a 0% mortality and only 1.1% deterioration rate, while Group III (score ≥ 7) exhibited a mortality rate of 33.4% and a deterioration rate of 28.6%. These findings suggest that corrected MEWS can serve as an effective early warning tool for identifying clinical deterioration and guiding timely interventions in the neurosurgical postoperative setting.

However, this study has limitations, including a relatively small sample size, its single-center design, and the lack of a control or comparator group. Further multicenter prospective studies are needed to validate these findings and explore the generalizability of corrected MEWS across broader clinical contexts.

Data Sharing Statement

All data generated or analysed during this study are included in this article. Further enquiries can be directed to the corresponding author.

Ethics Approval and Consent to Participate

This study was conducted with approval from the Ethics Committee of Chinese People's Liberation Army Special Medical Center [Medical research ethics (2023)-116]. This study was conducted in accordance with the declaration of Helsinki. Written informed consent was obtained from all participants.

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Disclosure

The authors declare that they have no competing interests in this work.

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