ORIGINAL RESEARCH

Application of Modified Early Warning Score in Patients with Hypertensive Intracerebral Hemorrhage After Neurosurgery

Jing Zhao, BD; Qun Li, BD; Meng Gao, MM

ABSTRACT

Background • Hypertensive intracerebral hemorrhage (HICH) is one of serious complications of hypertension. Therefore, early identification of postoperative deterioration of patients and timely intervention measures are needed.

Objective •To evaluate the application of Modified Early Warning Score (MEWS) in HICH patients after neurosurgery.

Design • Retrospective study

Participants • 82 HICH patients admitted to the neurosurgery department of our hospital from July 2022 to January 2023 were enrolled as subjects.

Interventions • The MEWS score and the early warning score of postoperative deterioration of HICH patients were evaluated every hour. The respiratory rate, heart rate, systolic blood pressure, and blood oxygen saturation were monitored by a bedside multi-parameter monitor. The consciousness was evaluated by the Glasgow Coma Scale (GCS) score.

Primary Outcome Measures • The receiver operator characteristic (ROC) curve was drawn to compare the predictive effect of the early warning scale and the MEWS on the prognosis of postoperative deterioration in patients with HICH.

Results • The area under the ROC curve of early warning score predicted the postoperative deterioration of patients to be 0.9660, the best cutoff value was 3.9 points, the sensitivity was 98.35%, the specificity was 86.67%, and the Yoden index was 0.784. The area under the ROC curve of the MEWS for postoperative deterioration of HICH patients was 0.869, the best cutoff value was 3.9, the sensitivity was 83.33%, the specificity was 71.67%, and the Yoden index was 0.517. However, unlike early warning scoring scale, MEWS score was only used to evaluate vital signs with high frequency of clinical monitoring, and the threshold range of heart rate, systolic blood pressure and consciousness score set was not fully applicable to patients after HICH.

Conclusion • The early warning scoring scale for postoperative deterioration of HICH patients has good predictive efficacy and strong operability. (*Altern Ther Health Med.* [E-pub ahead of print.])

Jing Zhao, BD; **Qun Li**, BD, Department of Neurosurgery; Hainan Hospital of PLA General Hospital; Sanya; Hainan; China. **Meng Gao**, MM, Department of Cardiovascular; The Second Medical Center & National Clinical Research Center for Geriatric Diseases; Chinese PLA General Hospital; Beijing; China.

Corresponding author: Meng Gao, MM
E-mail: gz1208036@163.com

INTRODUCTION

Intracerebral hemorrhage (ICH), also known as hemorrhagic stroke, refers to abnormal bleeding of blood inside the brain tissue, usually caused by a rupture of a blood vessel, which may lead to damage to brain tissue and neurological dysfunction.[1] ICH is the second most common stroke subtype, accounting for about 10%-15% of all stroke incidences.[2] Compared to ischemic stroke, ICH has a higher mortality rate and is one of the primary causes of severe disability.[3] Hypertensive intracerebral hemorrhage (HICH) is the most common type of ICH in clinical practice, accounting for about 70%-80% of all ICH.[4] It is one of the most serious complications of hypertension with acute onset, rapid progression, and poor prognosis. The mortality rate can reach up to 38% ~ 43%. Hypertension often leads to pathological changes in the small arteries at the base of the brain. The prominent manifestations are hyaloid or fibrous degeneration and focal bleeding, ischemia, and necrosis in the wall of these small arteries, which weakens the strength of the blood vessel wall, leading to localized dilation, and the formation of micro-aneurysms.[5] The general onset of HICH is sudden severe headache, nausea, vomiting, and is often accompanied by restlessness, lethargy, or coma.[6] At present, surgical treatment is still the main strategy to effectively control the disease progression and reduce mortality of

patients with HICH. Craniotomy hematoma removal is the most widely used surgical method in clinical practice, which can reduce the mass effect, restore the function of compressed neurons, and avoid secondary brain injury,[7] but the trauma associated is large. Intraoperative stimulation and traction of the scalp and blood vessels are likely to aggravate brain tissue damage and cause rapid deterioration of the condition,[8] requiring immediate transfer to intensive care unit (ICU) for intensive care or reoperation, which will not only increase the difficulty of treatment but will also affect the recovery of nerve function and increase the economic burden of patients.

Condition observation is the key work of nurses. Timely and accurate assessment of the severity of the patient's condition after surgery, early identification, and prediction of deterioration of the condition in advance play a key role in reducing complications, improving prognosis, and improving the quality of perioperative care.[9] The load of nursing work associated with neurosurgery is high. As the main force of the clinical medical team, junior nurses undertake a large amount of nursing work. However, their work experience is limited, comprehensive ability and psychological quality are not good, and risk prevention awareness is weak. If the response to abnormal physiological changes is not timely enough, it is easy to delay the best treatment time, which affects the outcome of patients.[10] Given this apsect, it is necessary to establish a scientific and systematic assessment tool to help nurses identify potential critically ill patients early, inform and cooperate with doctors to ensure the adoption of appropriate and timely intervention measures.

The purpose of this study is to combine the vital sign parameters in Modified Early Warning Score (MEWS) with the neurosurgery specialty indicators to construct an early warning score scale for postoperative deterioration of HICH patients.

Data and methods

General data

82 patients with HICH admitted to the neurosurgery department of our hospital from July 2022 to January 2023 were selected by convenient sampling method for disease evaluation.

Inclusion criteria: (1) Met the HICH diagnostic criteria defined by the 2020 edition of the Chinese Multidisciplinary Guidelines for the Diagnosis and Treatment of HICH; (2) Age >18 years old; (3) Patients hospitalized for HICH for the first time; (4) Underwent craniotomy for hematoma removal; (5) Transferred to NICU for continuous treatment after surgery; (6) The Glasgow Coma Scale (GCS) score at admission was 3-15.

Exclusion criteria: (1) Patients with severe mental disorders; (2) Patients who could not collect or record the monitoring indicators completely due to various reasons.

All patients signed informed consent forms.

Research tool

General Information Questionnaire. Name, gender, age, bleeding site, history of diabetes, history of coronary heart disease, history of cerebral infarction, emergency surgery, and admission Glasgow Coma Scale (GCS) score were included.

Early Warning score for postoperative deterioration in patients with HICH. Nine evaluation indexes including respiratory rate, heart rate, systolic blood pressure, consciousness, body temperature, intracranial pressure, pupil light reflex, blood oxygen saturation, and related symptoms were included. The respiratory rate, heart rate, systolic blood pressure, intracranial pressure, and related symptoms were assigned a score of 0-3, and the consciousness, body temperature, pupil light reflex, and blood oxygen saturation were assigned a score of 0-2, with a total score of 0-23. The larger the score, the higher the risk level of disease deterioration.

MEWS. MEWS[11] consisted of five evaluation indicators: body temperature, respiration, heart rate, systolic blood pressure, and consciousness (alert/verbal/painful/unresponsive (AVPU) score).[12] Each indicator was divided into several reference intervals, and each interval was assigned different scores. Except for body temperature, which was assigned 0 to 2 points, the other indicators were assigned 0 to 3 points, and the total score was 0 to 14 points. The higher the score, the more severe the condition. In this study, the GCS score was converted into the AVPU score. It has been pointed out in some studies that the AVPU score can be derived from the GCS score, and a GCS of 15 corresponds to A (Alert, awake); a GCS of 14 corresponds to V (Voice); a GCS of 13-9 corresponds to P (Pain); a GCS ≤8 corresponds to U (Unresponsive).

Data collection methods

The patients were transferred to NICU after surgery, used as the starting point of observation, and the observation end point was 72 hours after surgery. The MEWS score and the early warning score of postoperative deterioration of HICH patients were evaluated every hour, and scored at any time when the condition changed. The deterioration of the patient's condition was assessed based on the increase in the doctor's course records of "rescue," "death," "re-surgical treatment," "use of rapid intravenous injection of mannitol of 20% to reduce intracranial pressure" and "emergency tracheotomy." The respiratory rate, heart rate, systolic blood pressure, and blood oxygen saturation were monitored by a bedside multi-parameter monitor. The consciousness was evaluated by GCS score.[13] The pupil reflex to light was observed by pupil marker. Axillary body temperature was measured using a mercury thermometer, and each patient underwent invasive intracranial pressure (ICP) monitoring with an implanted intracranial pressure probe.

Quality control

(1) All the data were collected in the neurosurgery ICU of a tertiary general hospital in Shanxi Province. The subjects were screened in strict accordance with the inclusion and exclusion criteria to ensure the consistency of sample sources.

(2) Nurses with unified training were responsible for the evaluation and recording of the score table. In the process of evaluation, data were collected according to the actual situation of patients to ensure the accuracy and authenticity of the evaluation results.

(3) The members of the research team sorted out and filed the collected data every day, communicated with the raters in time for the incomplete assessment items, and entered the data into the Excel sheet after double-checking for accuracy.

Statistical analysis

The ROC curve was drawn using SPSS 25.0 software (IBM Corp., Armonk, NY, USA), and the optimal cut-off value was determined according to the Youden index. Sensitivity, specificity, and positive and negative predictive value were used to test the predictive efficacy of the scoring scale, and the test level was $\alpha = 0.05$.

RESULTS

General data

A total of 82 subjects were included in this study, with an average age of 45.30 ± 10.92 years (ranging from 38 to 76 years). While 44 patients were male, 38 were female. Their history of diseases and GCS score on admission have been summarized in Table 1. A total of 16 patients had deterioration of the disease, including 5 patients with unplanned secondary surgery, 4 patients with emergency tracheotomy, 2 patients with postoperative death, and 5 patients with rescue. 66 patients did not suffer from disease deterioration (Table 1).

Research results

The area under the ROC curve of early warning score for predicting postoperative deterioration was 0.9660, the best cut-off value was 3.9, the sensitivity was 98.35%, the specificity was 86.67%, the Youden index was 0.784, the positive predictive value was 0.55, and the negative predictive value was 0.98. The area under the ROC curve of the MEWS score for postoperative deterioration of HICH patients was 0.869, the best cut-off value was 3.9, the sensitivity was 83.33%, the specificity was 71.67%, the Youden index was 0.517, the positive predictive value was 0.45, and the negative predictive value was 0.86. The results are displayed in Figure 1, Table 2, and Table 3.

Among the 82 patients with postoperative HICH, 16 patients experienced deterioration, and the early warning score of postoperative deterioration in HICH patients was greater than or equal to 5 points as the best cut-off value, and 13 patients with worsening disease were predicted. The Kappa value of 0.62 was tested for consistency, indicating there was a moderate consistency between the predicted outcome of disease deterioration of early warning score scale and the actual outcome of disease deterioration.

DISCUSSION

The 2018 edition of "Notice on Further Strengthening Patient Safety Management" issued by the National Health

Table 1. General Data of Patients

Items	n	Constituent ratio (%)
Gender		
Male	44	53.66
Female	38	46.34
Age		
<60	25	30.49
≥60	57	69.51
History of diabetes		
Yes	18	21.95
No	64	78.05
History of coronary heart disease		
Yes	14	17.07
No	68	82.93
History of cerebral infarction		
Yes	22	26.83
No	60	73.17
Position of bleeding		
Basal ganglia hemorrhage	47	57.32
Thalamic hemorrhage	11	13.41
Lobar hemorrhage	11	13.41
Brainstem hemorrhage	4	4.88
Cerebellar hemorrhage	9	10.98
Emergency operation		
Yes	63	76.83
No	19	23.17
GCS score on admission		
13-15	11	13.41
9-12	29	35.37
3-8	42	51.22
Deterioration of the disease		
Unplanned secondary surgery	5	6.09
Emergency tracheotomy	4	4.88
Postoperative death	2	2.44
Rescue	5	6.09
No	66	80.50

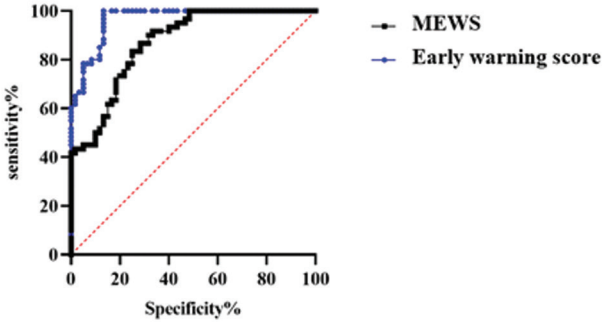
Table 2. Sensitivity and Specificity Values on the ROC Curve of the MEWS Score for Postoperative Deterioration of HICH Patients

Threshold value	Sensitivity	Specificity	Youden index
0.9	1.0000	0.0155	0.015
1.9	1.0000	0.2093	0.209
2.9	0.8991	0.5075	0.445
3.9	0.8333	0.7167	0.517
4.9	0.8134	0.8514	0.414
5.9	0.5005	0.9556	0.334
6.9	0.4448	0.9857	0.298

Table 3. Sensitivity and Specificity Values of the ROC Curves of the early warning score for Postoperative Deterioration of HICH Patients

Threshold value	Sensitivity	Specificity	Youden index
0.9	1.0000	0.0151	0.0155
1.9	1.0000	0.1342	0.1340
2.9	0.6888	0.5674	0.2252
3.9	0.9835	0.8667	0.7842
4.9	0.2505	0.9253	0.1756
5.9	0.2501	1.0000	0.2500
6.9	0.1250	1.0000	0.1251

Figure 1. Analysis of the ROC Curve of Early Warning Score and MEWS score for Postoperative Deterioration in HICH Patients



Commission points out that ensuring patient safety and reducing avoidable harm are the basic requirements of health services. It is necessary to further increase the emphasis on patient safety management and encourage evidence-based research on patient safety.[14] It has been reported that the average risk of perioperative death in patients undergoing neurosurgery is more than twice that of all patients,[15] and the mortality rate of HICH patients after craniotomy hematoma removal can reach up to 12.8% - 88.9%. For HICH patients with unstable postoperative conditions and at risk of deterioration at any time, providing scientific and reasonable clinical observation is the key to ensuring perioperative safety and improving the quality of care.

GCS is a commonly used clinical tool to evaluate patients' consciousness level, including eye-opening reactions, speech reactions, and limb movement. The total score is 3-15, and the lower the score, the more serious the coma.[16] Several studies have shown that there is a significant correlation between lower GCS score and worse prognosis of patients in craniocerebral injury and other neurological diseases.[17] However, GCS score has some limitations, such as insufficient accuracy of consciousness assessment for patients with tracheal intubation, orbital swelling, aphasia, sedation treatment, paralysis, and fewer assessment items which exclude pupil size, light reflex, and other brain stem reflex characteristics.[18] It is not comprehensive and reliable to use GCS alone to assess the severity of patients' disease. The reduced light reflex of the new pupil, bilateral pupil asymmetry, and bilateral mydriasis are important signs of HICH aggravation.[19] As an important examination of the nervous system, pupillary light reflex refers to the constriction of the pupil after light stimulation, which is the "window" for clinical judgment of the severity of cerebral hemorrhage, reflecting the functional damage of the central nervous system, early detection of brain hernia, and predicting the prognosis of patients.[20] Monitoring vital signs, including respiration, heart rate, body temperature, blood pressure, and blood oxygen saturation, is an important aspect of assessing the condition of hospitalized patients. Vital signs are the most direct, easy to obtain, and the most objective data, and also one of the main contents of nursing evaluation.[21] Vital signs have important clinical value in accurately judging the deterioration of a patient's condition. Many previous studies have pointed out that some physiological parameters may be disturbed hours or days before serious adverse events such as cardiac arrest, unplanned ICU transfer, or life-threatening organ failure.[22] Outliers with 3 or more vital signs are strong predictors of high mortality.[23] In this study, GCS score, vital signs, pupillary light reflex, and intracranial pressure were used as early warning indicators for the deterioration of HICH patients, which made up for the defects of using GCS score alone, and helped clinical nurses to comprehensively evaluate the condition and find potential risk factors in time.

ROC curve is also known as the receiver operating characteristic curve, which is drawn with sensitivity as the ordinate and (1-specificity), namely misdiagnosis rate, as the abscissa.[24] The area under the ROC curve (AUC) reflects the accuracy of the diagnostic test. The larger the AUC (the closer to 1.0), the higher the accuracy of the diagnosis. Generally, AUC >0.8 is considered to have a moderate diagnostic value.[25] The results of this study showed that the AUC of the modified early warning score for postoperative deterioration of HICH patients was 0.966, which was higher than the AUC of MEWS, and the sensitivity and specificity of the best critical value of 3.9 for early warning scores were higher than that of the best critical value of 3.9 for MEWS. Sensitivity is the index to evaluate the correct identification of patients with deterioration, and specificity is the index to measure the correct identification of patients without deterioration. The prediction efficacy of the early warning score for postoperative deterioration in HICH patients was better than that of the MEWS score. This may be compared with the self-made early warning score table, which includes GCS score, pupil, intracranial pressure, related symptoms, and other neurosurgical specialized indicators. Compared to MEWS, the early warning score is more targeted to predict the change in the critical condition of HICH patients after surgery. MEWS score only evaluates vital signs with high clinical monitoring frequency, and the set critical value ranges of heart rate, systolic blood pressure, and consciousness score are not fully applicable to patients after HICH, since there may be no obvious disease symptoms and abnormal vital signs at the beginning of the disease change. When the body's ability to regulate the normal functioning of various tissues and organs is significantly damaged and beyond its compensation ability, hemodynamic instability and abnormal vital signs can occur. At this time, the condition has deteriorated significantly, and the best opportunity for intervention may be missed. Meanwhile, pupillary light reflex and intracranial pressure often have changed before significant changes in vital signs, which have important early warning value for the evaluation of neurosurgery patients. Consistently, many studies have indicated that early warning score is a useful tool for predicting in-hospital mortality in critically ill patients.[26,27]

This study has several limitations. First, it was a retrospective, single-center study. Second, the sample size was relatively small. These limitations may reduce the generalizability of the results. Hence, multicenter studies are needed for further validation and to remove selection bias.

CONCLUSION

In summary, the early warning score scale for postoperative deterioration of HICH patients has good predictive efficiency and strong operability, which provides an objective basis for clinical nurses to predict the risk of patient's condition deterioration, and provides auxiliary tools and reference for high-quality cooperation between doctors and nurses.

AUTHOR DISCLOSURE STATEMENT

The authors declare that they have no competing interests.

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