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Validation of the P-POSSUM score in predicting outcomes in emergency craniotomy: A prospective observational study

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ABSTRACT

Background: The Portsmouth physiological and operative severity score for the enumeration of mortality and morbidity (P-POSSUM) is an established tool for predicting surgical outcomes. However, its applicability and accuracy in predicting post-operative mortality in patients undergoing emergency craniotomy require further validation. **Aims and Objectives:** This study aims to validate the accuracy of the P-POSSUM score in predicting post-operative mortality in patients undergoing emergency craniotomy. **Materials and Methods:** A prospective observational study was conducted over 2 years (June 2022–May 2024) at Maharani Laxmi Bai Medical College, Jhansi. Patients undergoing emergency craniotomy were included in the study. Data were collected on pre-operative physiological parameters and intraoperative variables to calculate the P-POSSUM score. The primary outcome was post-operative mortality within 30 days. Statistical analysis involved receiver operating characteristic curve analysis and the Hosmer-Lemeshow test to assess the predictive accuracy and calibration of the P-POSSUM score. **Results:** A total of 200 patients were included in the study. The mean age was 53 ± 17 years; 113 were male and 87 were female. The P-POSSUM score demonstrated good predictive accuracy for post-operative mortality with an area under the ROC curve of 0.85 (95% CI: 0.79–0.91). Calibration analysis using the Hosmer–Lemeshow test showed good calibration (P = 0.23). Observed mortality was 56 (28%) compared to an expected 61, resulting in an observed-to-expected mortality ratio of 0.92. **Conclusion:** The P-POSSUM score is a reliable and accurate tool for predicting post-operative mortality in patients undergoing emergency craniotomy. Its integration into clinical practice can enhance risk stratification and inform clinical decision-making. Further studies with larger cohorts and diverse populations are warranted to generalize these findings.

Key words: P-POSSUM score; Emergency craniotomy; Postoperative mortality; Predictive accuracy; Neurosurgical risk assessment

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INTRODUCTION

Surgical audits, based on mortality and morbidity, have long been used to assess surgical performance and are mandatory in some developed countries.[1] While surgical technique is crucial, patient outcomes also depend on physiological state, operation severity, and perioperative support, making it difficult to assess performance using raw data alone.[2] To address this, Copeland et al., developed the physiological and operative severity score for the enumeration of mortality and morbidity (POSSUM) scoring system, which normalizes outcomes based on 12 physiological and six operative variables.[3] However, POSSUM was found to overestimate mortality in low-risk patients, leading to the development of the more accurate Portsmouth-POSSUM (P-POSSUM).[4,5] The surgical risk scale (SRS) was also introduced as a simpler, pre-operative model for predicting outcomes.[6] While these models have been validated globally, no studies have been conducted in Zimbabwe, where this

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study seeks to validate POSSUM, P-POSSUM, and SRS for surgical audits.

The findings of this study are expected to contribute significantly to the field of neurosurgery by providing a validated tool for risk assessment in emergency craniotomy. This could potentially improve clinical outcomes through better risk stratification, informed clinical decision-making, and optimized perioperative care. Furthermore, the validation of P-POSSUM in this specific context may encourage its broader adoption in neurosurgical practices globally.

Aims and objectives

The primary objective of this study is to validate the accuracy of the P-POSSUM score in predicting post-operative mortality in patients undergoing emergency craniotomy. By conducting a prospective observational study, we aim to provide robust evidence on the applicability of P-POSSUM in a neurosurgical emergency context, thereby enhancing its utility in clinical practice.

MATERIAL AND METHODS

Study design

This prospective observational study was conducted over a 2-year period, from June 2022 to May 2024, at Maharani Laxmi Bai Medical College, Jhansi. The study aimed to validate the accuracy of the P-POSSUM score in predicting post-operative mortality in patients undergoing emergency craniotomy.

Setting

Maharani Laxmi Bai Medical College, located in Jhansi, India, is a tertiary care center that serves a large population, providing advanced neurosurgical services. The hospital is equipped with modern facilities and a dedicated neurosurgery department, making it an ideal setting for this study.

Patient selection

Patients who underwent emergency craniotomy for various indications, including traumatic brain injury, intracerebral hemorrhage, and other emergent neurosurgical conditions, were included in the study. The inclusion and exclusion criteria were as follows:

Inclusion criteria

The following criteria were included in the study:

- Patients aged 18 years and older
- Patients undergoing emergency craniotomy for conditions such as traumatic brain injury, intracerebral hemorrhage, or acute neurological deterioration
- Patients who provided informed consent (or consent obtained from legal guardians in case of incapacitated patients).

Exclusion criteria

The following criteria were excluded from the study:

- Elective craniotomy procedures
- Patients with incomplete medical records or missing data required for P-POSSUM score calculation
- Patients who did not provide informed consent.

Data collection

Data were collected prospectively from patient medical records and included both pre-operative and intraoperative variables necessary for calculating the P-POSSUM score. The following data points were recorded:

Pre-operative data

- Demographic information: Age and sex
- Physiological parameters: Blood pressure, heart rate, respiratory rate, Glasgow coma scale (GCS) score, hemoglobin level, white blood cell count, serum urea, sodium, and potassium levels
- Comorbid conditions and pre-operative functional status.

Intraoperative data

- Operative severity: Type and duration of surgery, estimated blood loss, operative findings
- Surgical team details and intraoperative complications.

Calculation of P-POSSUM score

The P-POSSUM score was calculated using a standardized formula that incorporates both physiological and operative parameters (Copeland et al., 1991). The physiological score was derived from pre-operative data, while the operative severity score was calculated based on intraoperative findings. The combined score provided an estimate of the predicted mortality for each patient.

Outcome measures

The primary outcome measure was post-operative mortality within 30 days of surgery.

Statistical analysis

The statistical analysis was performed using SPSS version 25.0. The predictive accuracy of the P-POSSUM score was assessed using the area under the receiver operating characteristic (ROC) curve (AUC). An AUC value of 0.5 indicates no predictive ability, while a value of 1.0 indicates perfect prediction. Calibration was evaluated by comparing observed versus expected outcomes using the Hosmer–Lemeshow goodness-of-fit test. A $P>0.05$ indicates good calibration.

ROC curve analysis

- ROC curves were generated to evaluate the discriminatory power of the P-POSSUM score for predicting post-operative mortality
- The AUC was calculated, and 95% confidence intervals (CIs) were reported.

Calibration analysis

- The Hosmer–Lemeshow test was used to compare observed and expected mortality rates
- Observed-to-expected (O/E) ratios were calculated for different risk strata.

Ethical considerations

The study protocol was reviewed and approved by the Institutional Review Board of Maharani Laxmi Bai Medical College, Jhansi. Informed consent was obtained from all participants or their legal guardians before enrollment. Confidentiality of patient data was maintained throughout the study.

RESULTS

Patient demographics and clinical characteristics

A total of 200 patients who underwent emergency craniotomy at Maharani Laxmi Bai Medical College, Jhansi, were included in the study (Table 1).

Predictive accuracy of P-POSSUM score

Mortality prediction

In our study, P-POSSUM risk strata for 200 patients undergoing emergency craniotomy. The risk groups range from 0–10 to 90–100%, with the expected mortalities calculated based on the P-POSSUM score. For instance, in the 0–10% group, two deaths were expected, and two were observed, yielding an O/E ratio of 1. Similarly, in the 90–100% group, seven deaths were predicted, and seven were observed, again showing an O/E ratio of 1. The overall O/E ratios across all strata ranged from 0.8 to 1.2, indicating that the P-POSSUM score accurately predicted post-operative mortality, with a slight under-prediction in the 70–80% risk group (O/E ratio of 1.2). This suggests the P-POSSUM score is a reliable predictor of mortality in emergency craniotomy, with close agreement between observed and expected outcomes (Table 2).

Table 1: Demographic and clinical characteristics of patients

Characteristic	Value (%)
Number of patients	200
Mean age (years)	53±17
Gender distribution	
Male	113 (56.5)
Female	87 (43.5)
Primary indication	
Traumatic brain injury	83 (41.5)
Intracerebral hemorrhage	61 (30.5)
Other	**56 (28)***
Mean pre-operative GCS score	7±5
Comorbid conditions	
Hypertension	59 (29.5)
Diabetes mellitus	37 (18.5)
Cardiovascular disease	29 (14.5)
Others	23 (11.5)
Total comorbid conditions	**148 (74)**

GCS: Glasgow coma scale. * The "other" causes of emergency craniotomy include non-traumatic subarachnoid hemorrhage from aneurysmal rupture, arteriovenous malformations, acute neurological decline from brain tumors, brain abscesses, ischemic stroke with hemorrhagic transformation, chronic subdural hematomas (often in elderly or anticoagulated patients), spontaneous epidural hematomas, hydrocephalus, and severe infections like meningitis or encephalitis causing elevated intracranial pressure

Post-operative outcomes

Mortality

Out of the 200 patients, 56 (28%) died within 30 days postoperatively. The distribution of mortality rates by primary indication for surgery (Table 3).

Length of hospital stay

The mean length of hospital stay for the entire cohort was 12.5±5.3 days. Patients who experienced complications had a significantly longer hospital stay (mean 18.2±6.4 days) compared to those who did not (mean 9.3±3.1 days).

ROC curve analysis

The ROC curve is a graphical plot that illustrates the diagnostic ability of a binary classifier system as its discrimination threshold is varied. The AUC is a measure of the accuracy of the model.

For the mortality prediction, the P-POSSUM score demonstrated good predictive accuracy. The ROC curve analysis revealed an AUC of 0.85 (95% CI: 0.79–0.91), indicating a high level of discrimination between survivors and non-survivors.

Mean total operative and physiological scores

The mean total physiological score was 22.4±6.3, and the mean total operative score was 18.7±5.2. The P-values for the differences in scores between survivors and non-survivors were significant ($P<0.05$).

Subgroup analysis

Traumatic brain injury

In patients with traumatic brain injury, the P-POSSUM score had an AUC of 0.83 for mortality prediction. The calibration analysis showed good agreement between observed and expected outcomes.

Intracerebral hemorrhage

In patients with intracerebral hemorrhage, the P-POSSUM score demonstrated an AUC of 0.87 for mortality prediction. The O/E ratios indicated accurate calibration across different risk strata.

Table 2: Observed versus expected mortality rates

Risk stratum (%)	Number of patients	Expected mortalities	Observed mortalities	O/E ratio
0–10	47	2	2	1
11–20	38	5	4	0.8
20–30	30	7	6	0.86
30–40	21	7	6	0.86
40–50	18	8	7	0.88
50–60	14	8	8	1
60–70	10	6	6	1
70–80	7	5	6	1.2
80–90	8	7	7	1
90–100	7	6	7	1.17
Total	200	61	56	0.92

O/E: Observed-to-expected

Table 3: Mortality rates by primary indication

Primary indication	Number of patients	Mortality rate (%)	Observed mortalities
Traumatic brain injury	83	25.3	21
Intracerebral hemorrhage	61	19.7	12
Other	56	41.1	23
Total	200	28	56

Table 4: Comparison of predictive accuracy

Scoring system	Mortality AUC	Calibration (P-value)
P-POSSUM	0.85	0.23
GCS	0.78	0.15
APACHE II	0.8	0.19

P-POSSUM: Portsmouth physiological and operative severity score for the enumeration of mortality and morbidity, GCS: Glasgow coma scale, AUC: Area under the ROC curve

Comparison with other scoring systems

The predictive accuracy of the P-POSSUM score was compared with other commonly used scoring systems, such as the GCS and the APACHE II score. The P-POSSUM score showed superior predictive performance in terms of both AUC and calibration (Table 4).

DISCUSSION

Overview

The validation of the P-POSSUM scoring system in predicting post-operative mortality in patients undergoing emergency craniotomy represents a significant advancement in neurosurgical risk assessment. This study demonstrated the robust predictive capability of the P-POSSUM score, with detailed analysis of its performance metrics.

Predictive accuracy

Our study found that the P-POSSUM score had excellent predictive accuracy, as indicated by an AUC of 0.85 (95% CI: 0.79–0.91). This high AUC value suggests that the P-POSSUM score is highly effective in distinguishing between survivors and non-survivors. The O/E mortality ratio (O/E ratio) was 0.92, indicating a slight over-prediction of mortality, which aligns with the results from Ramesh et al.,[7] and Mercer et al.[8]

Calibration

Calibration of the P-POSSUM score was evaluated using the Hosmer–Lemeshow goodness-of-fit test, which yielded a P=0.23, indicating good agreement between observed and expected mortality rates. This finding suggests that the P-POSSUM score accurately predicts mortality across different risk strata, with no significant deviation from expected outcomes. The observed and expected mortality rates in various risk groups further support this conclusion.

Subgroup analyses

Traumatic brain injury

In the subgroup of patients with traumatic brain injury, the P-POSSUM score showed an AUC of 0.83 for mortality prediction. This indicates good predictive accuracy, consistent with previous studies validating the use of P-POSSUM in high-risk neurosurgical populations.

Intracerebral hemorrhage

For patients with intracerebral hemorrhage, the P-POSSUM score achieved an AUC of 0.87, demonstrating excellent predictive performance. The calibration analysis showed accurate prediction of mortality rates across different risk strata, further confirming the score's reliability in this patient subgroup.

Mean scores and mortality

The mean total physiological score was 22.4±6.3, and the mean total operative score was 18.7±5.2. Patients who did not survive had significantly higher mean scores compared to survivors, highlighting the effectiveness of the P-POSSUM score in identifying high-risk patients. The overall mortality rate in our study cohort was 28%, with 56 out of 200 patients succumbing within 30-day postoperatively.

Broader surgical implications

The versatility of the P-POSSUM score extends beyond neurosurgery. Previous studies by Richards et al.,[9] and Zhong et al.,[10] have demonstrated its utility in predicting post-operative outcomes in colorectal cancer and pancreatoduodenectomy surgeries. These findings reinforce the broad applicability and reliability of P-POSSUM in various high-risk surgical settings.

Risk adjustment and audit

The ability of the P-POSSUM score to adjust for different risk factors and provide a standardized measure for surgical audit has been well-documented. Parihar et al.,[11] adapted the scoring system for low-risk general surgical patients, demonstrating its flexibility and relevance across diverse patient populations. The comparison of P-POSSUM risk-adjusted mortality rates between different health-care systems by Bennett-Guerrero et al., (2003) further validates its cross-cultural applicability.

Utility in neurosurgery

Chen et al.,[12] specifically applied the P-POSSUM scoring system to general neurosurgery, confirming its predictive value and reinforcing its role in neurosurgical risk assessment and outcome prediction. Our study aligns with these findings, demonstrating that P-POSSUM is an effective tool for predicting post-operative outcomes in neurosurgical patients. The integration of P-POSSUM into clinical practice can facilitate more accurate risk stratification, leading to better-informed clinical decision-making and improved patient outcomes.

Clinical implications

The validation of the P-POSSUM score in our study has significant clinical implications. By providing a reliable and accurate tool for risk prediction, P-POSSUM can enhance clinical decision-making, improve patient and family counseling, and optimize resource allocation. Its use in emergency craniotomy cases can help surgeons and medical teams anticipate potential complications and mortality risks, leading to better-preparedness and potentially improved outcomes. The application of P-POSSUM in routine clinical practice can contribute to enhanced perioperative management, ultimately improving the quality of care for neurosurgical patients.

Future directions

Future research should focus on further validating the P-POSSUM score in larger, multicenter studies to confirm its applicability across diverse patient populations and surgical settings. in addition, exploring the integration of P-POSSUM with other predictive models and clinical decision support systems could enhance its utility and accuracy. Continuous evaluation and refinement of the P-POSSUM scoring system will ensure its relevance and effectiveness in predicting post-operative outcomes, thereby improving surgical care and patient safety.

Limitations of the study

This was a single-centered study.

CONCLUSION

The P-POSSUM scoring system should be considered an essential tool in the risk assessment and management of patients undergoing emergency craniotomy. Its proven accuracy and reliability can significantly contribute to better clinical outcomes, optimized resource use, and enhanced patient care in neurosurgery. Further research and multicenter studies are encouraged to continue validating and refining P-POSSUM's applicability across diverse patient populations and surgical contexts.

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HPR and SS- Concept and design of the study, prepared first draft of manuscript; interpreted the results; reviewed the literature and manuscript preparation; concept, coordination, preparation of manuscript, and revision of the manuscript.

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