Cross-sectional Study

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SOFA and APACHE II scoring systems for predicting outcome of neurological patients admitted in a tertiary hospital intensive care unit

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Background: The field of neurology encompasses the study and treatment of disorders that affect the nervous system, and patients with neurological conditions often require specialized care, particularly in the ICU. Predictive scoring systems are measures of disease severity used to predict patient outcomes. The aim of this study was to compare the discriminative power of commonly used scoring systems, namely the sequential organ failure assessment (SOFA) and acute physiology and chronic health evaluation II (APACHE II) in the ICU of a tertiary care hospital.

Methods: This retrospective study included patients with neurological disorders in the ICUs of Tribhuvan University Teaching Hospital from 1 January 2022 to 31 December 2022.

Results: A total of 153 patients were included. The mean age of the patients was 54.76 ± 17.32 years with higher male predominance (60.78%). Ischaemic stroke was the most common neurological disorder. There were 58 patients (37.9%) who required mechanical ventilation and all-cause mortality was 20.9%. The mean SOFA score was significantly higher ($P = 0.002$) in survivors, whereas the mean APACHE II did not show a significant difference ($P = 0.238$). Receiver operating characteristic (ROC) analysis showed the area of curve (AUC) of SOFA score was 0.765 and of APACHE II was 0.722.

Conclusions: SOFA score had comparatively higher discriminative power than APACHE II. Assessment of the performance of scoring systems in a specific ICU setting improves the sensitivity and applicability of the model to these settings.

Keywords: APACHE II, neurological outcome, SOFA

Introduction

Neurological patients admitted to the ICU have manifestations and complications that are diffuse, and variable leading to considerable heterogeneity among patients. The outcomes of neurology patients in the ICU are of paramount importance, as they directly influence the quality of life and long-term prognosis for these individuals. Initially, outcome prediction in critical illness was based on the subjective judgment of the physicians. The rapid development of ICUs created the need for quantitative and clinically relevant outcome measures like a quantitative scoring system to evaluate the effectiveness of treatment practices. This has necessitated an evaluation of the effectiveness of treatment practices and the effect of disease severity on the outcome.

The acute physiology and chronic health evaluation II (APACHE II) is a widely used prognostic tool for predicting in-hospital mortality[1]. Although sequential organ failure assessment (SOFA) is useful for describing the degree of organ dysfunction and morbidity in septic patients, it is also applicable in non-septic patients[2]. SOFA and APACHE II are useful in assessing prognosis or predicting mortality in subsets of patients

HIGHLIGHTS

- Neurological patients admitted to ICUs present unique challenges due to the intricate nature of their conditions.
- Sequential organ failure assessment and acute physiology and chronic health evaluation II are commonly used objective scoring systems to assess the outcomes of patients admitted to ICUs.
- Evaluating the performance of the scoring systems in specific subspecialty populations will improve the applicability of the model to these contexts.
- Sequential organ failure assessment had higher discriminative power (area under the receiver operating characteristics curve 0.765) than acute physiology and chronic health evaluation II (area under the receiver operating characteristics curve 0.722) in predicting survival in neurological patients.

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Table 1

Baseline characteristics of patients with neurological diagnosis admitted to ICUs during the study period

Characteristics	Total ($n=153$)	Survivor ($n=121$)	Non-survivor ($n=32$)	*P*
Mean age (± standard deviation)	54.76 (± 17.32)	53.42 (±17.589)	59.81 (±15.482)	0.443
Male sex	93	73	20	0.823
Presence of co-morbid conditions	78	56	22	0.024
SOFA score	5.6536 (± 3.564)	4.9421 (±3.218)	8.3438 (± 3.57)	0.002
APACHE II score	13.7124 (± 6.9)	12.5289 (± 6.3)	18.1875 (±7.328)	0.238
Use of vasoactive therapy	18	11	7	0.097
Mechanical ventilation	58	37	21	< 0.01

APACHE II, acute physiology and chronic health evaluation II; SOFA, sequential organ failure assessment.

in different subspecialties. In the context of neurological disorders, SOFA and APACHE II have shown utility in determining mortality in status epilepticus[3]. The study aimed to evaluate the performance of SOFA and APACHE II in predicting the outcome of neurological patients admitted to intensive care units.

Methods

This was a retrospective cross-sectional study including patients admitted to the ICU of TU Teaching Hospital with a neurological diagnosis from 1 January 2022 to 31 December 2022. This study uses data collected prospectively as part of the Nepal Intensive Care Research Foundation (NICRF) dataset. Details of the registry design and data management are published in detail on Wellcome Open Research. In brief, the NICRF registry has a modular dataset, where a core set of 33 data variables is captured within the first 24 h of admission to the ICU, and five variables are captured at discharge. Patient case mix and outcomes are reported using this core dataset[4]. If patients had been admitted more than once to the ICU during the study period, only the first admission was included. The de-identified data were entered and sorted to include only the neurology patients based on admission diagnosis and entered in IBM SPSS for analysis.

The admission to ICU were made on the clinical discretion of the on-duty doctor (residents in Internal Medicine or senior residents in Neurology) who were posted during the study duration. Any patients who were later shifted to other departments during the ICU stay were excluded from the study.

The ICU database contained information for all components of the APACHE II and SOFA score with physiological data collected for the age, sex, length of ICU, and hospital stay. Both SOFA and APACHE II were calculated from the admission data or if not available from the earliest data recorded after admission in ICUs. SOFA was calculated based on six different scores, one for each of the respiratory, cardiovascular, hepatic, coagulation, renal, and neurological systems each scored from 0 to 4 with an increasing score reflecting worsening organ dysfunction. APACHE II was introduced as a simplified modification of the original APACHE. APACHE II uses a point score based upon initial values of 12 routine physiologic measurements, age, and previous health status to provide a general measure of the severity of the disease. An increasing score (range 0–71) was closely correlated with the subsequent risk of hospital death. This work has been reported in line with the STROCSS criteria[5].

Statistical analysis

The outcome measure was ICU mortality (survivor vs non-survivor). Mortality during the ICU stay was considered as data

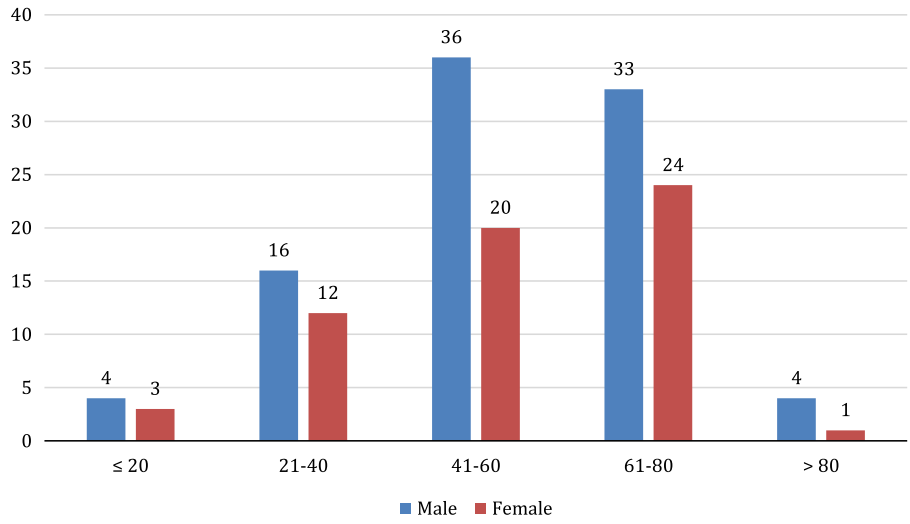

Figure 1. Gender distribution of patients in different age groups.

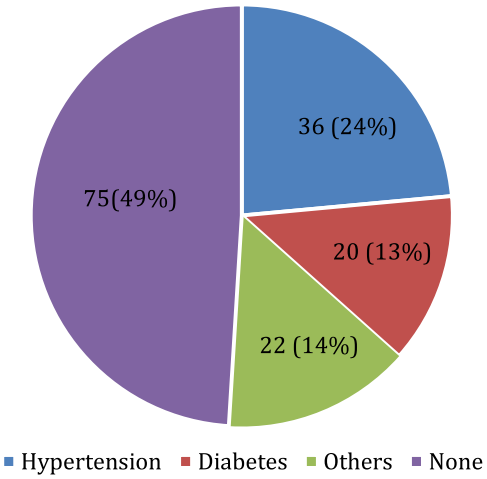

Figure 2. Presence of co-morbidities in study patients.

after discharge or transfer from ICU were not available in the database. Continuous variables were reported as mean ± standard deviation and compared using Student's *t*-test. Categorical variables were shown as the count and percentage and compared with the χ^2 test. Discrimination refers to the ability of a scoring model to distinguish between patients who survive for those who do not. The discriminative ability of the models for hospital mortality prediction was tested by the area under the receiver operating characteristics (AUROC) curve.

Result

The study included 221 patients admitted to ICU with a neurological diagnosis. After the exclusion of patients with missing data, 153 patients for whom both SOFA as well as APACHE II scores could be calculated were considered for analysis. The mean age of the patients was 54.76 ± 17.32 years with higher male predominance (60.78%) (Table 1). The gender distribution of patients in different age groups is shown in Fig. 1. Hypertension was present in 24% and diabetes in 13% of the study patients (Fig. 2). The most common neurological disorder was Ischaemic Stroke (Table 2). There were 58 patients (37.9%) who required mechanical ventilation during their hospital stay and 32 patients (20.9%) did not survive. The gender-wise distribution of

Table 2
Neurological diseases of study patients

Diagnosis	Frequency (number)	Percentage
Ischaemic stroke	57	37.26
CNS infection	48	31.37
Haemorrhagic stroke	14	9.15
Epilepsy	10	6.54
Myasthenia crisis	8	5.23
GBS	7	4.58
Degenerative disease	2	1.31
Tetanus	3	1.96
Autoimmune encephalitis	1	0.65
Neuroleptic malignant syndrome	1	0.65
Motor neuron disease	1	0.65
CNS demyelinating disease	1	0.65
Total	153	100%

CNS, central nervous system; GBS, guillain barre syndrome.

Table 3
Gender-wise distribution of SOFA score

SOFA Score	Female	Male	Total
0	5	4	9
1	4	5	9
2	2	8	10
3	5	15	20
4	5	10	15
5	10	7	17
6	6	8	14
7	6	13	19
8	3	6	9
9	4	7	11
10	3	3	6
11	2	1	3
12	1	2	3
13	1	1	2
14	1	1	2
15	2	2	4
Total	60	93	153

SOFA, sequential organ failure assessment.

Table 4
Gender-wise distribution of APACHE score

APACHE Score	Female	Male	Total
1	0	1	1
2	1	2	3
3	1	3	4
4	1	3	4
5	2	4	6
6	1	6	7
7	3	5	8
8	4	3	7
9	6	4	10
10	3	4	7
11	1	7	8
12	2	4	6
13	3	2	5
14	5	6	11
15	4	6	10
16	3	2	5
17	2	2	4
18	3	3	6
19	4	2	6
20	2	6	8
21	0	3	3
22	1	1	2
23	3	3	6
24	2	3	5
25	2	3	5
26	0	1	1
27	1	1	2
28	0	1	1
30	0	1	1
32	0	1	1
Total	60	93	153

APACHE II, acute physiology and chronic health evaluation II.

Table 5

Area under the curve for SOFA and APACHE II

Test result variable(s)	Area	Standard error
APACHE	0.722	0.053
SOFA	0.765	0.045

APACHE II, acute physiology and chronic health evaluation II; SOFA, sequential organ failure assessment.

SOFA and APACHE II score are shown in Table 3 and Table 4 respectively.

SOFA scoring system had higher discriminative power (AUROC 0.765) than APACHE II (AUROC 0.722) in predicting survival in neurological patients (Table 5). In the SOFA scoring system the cut-off score of 4.5 had a sensitivity of 93.8% and a specificity of 50.41% whereas, for the APACHE II scoring system, the cut-off score of 18.5 had a sensitivity of 56.3% and a specificity of 81% (Fig. 3).

Discussion

The present study aimed to assess the utility of the sequential organ failure assessment (SOFA) and acute physiology and chronic health evaluation II (APACHE II) scoring systems in predicting the outcome of neurological patients admitted to a tertiary hospital ICU. The findings provide valuable insights into the prognostic utility of these scoring systems for this specific patient population.

The demographic characteristics of the patient revealed a mean age of 54.76 years, which aligns with the prevalence of neurological disorders in middle-aged and older individuals[6]. The mean age of patients admitted to the ICU is similar in our neighbouring countries[7,8]. There was no association of age with mortality in this study which was similar to the study by Leong and Tai *et al*[9]. The higher proportion of males (60.78%) may reflect underlying epidemiological trends in neurological diseases[6]. The predominance of Ischaemic stroke as the most common diagnosis concurs with established patterns in neurological diagnosis in the hospital[10].

A substantial portion of patients (37.9%) required mechanical ventilation. This highlights the severity of the neurological conditions being managed in the ICU and underscores the critical nature of the study population. Additionally, the all-cause mortality rate of 20.9% underscores the importance of accurate prognostic tools for identifying patients at higher risk of adverse outcomes.

The requirement for mechanical ventilation as a predictor of mortality is consistent with the severity of illness and organ dysfunction observed in critically ill neurological patients. Mechanical ventilation often indicates a compromised respiratory status, which can be a harbinger of poor prognosis. In the presence of co-morbid conditions and the use of mechanical ventilation, the mortality was higher ($P < 0.05$). These findings have been similar to studies conducted in other countries[11,12]. The study's findings, combined with existing literature, underscore the value of assessing mechanical ventilation as a prognostic factor in neurological ICU patients.

Despite initially being used for evaluating organ dysfunction in septic function, SOFA score had higher discriminative power

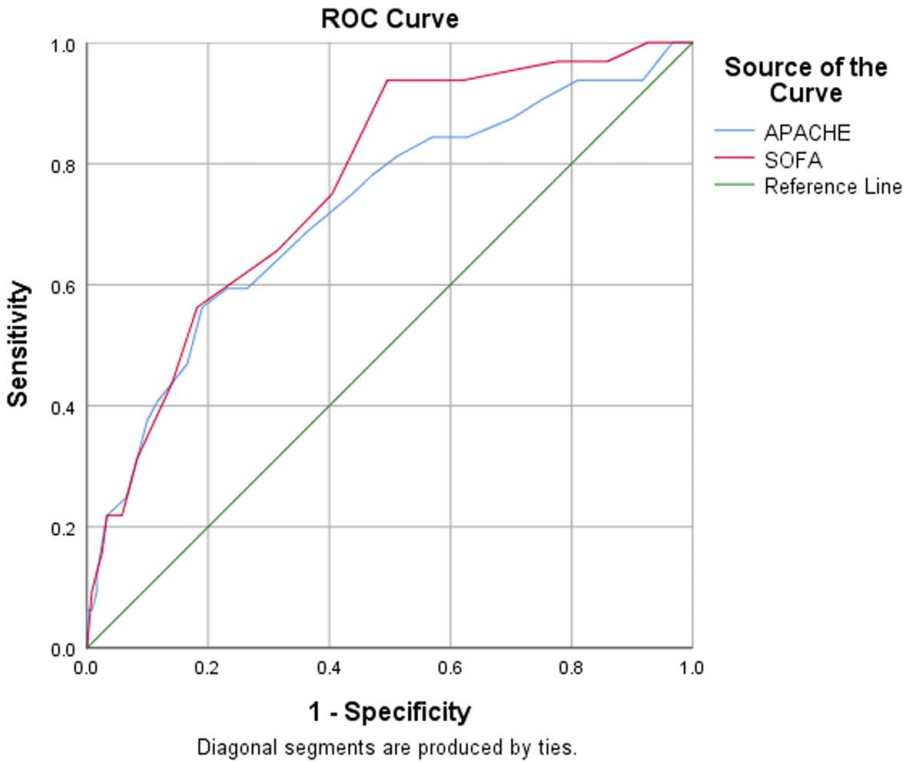

Figure 3. Combined area under the receiver operating characteristics curve of SOFA and APACHE II. APACHE II, acute physiology and chronic health evaluation II; ROC, receiver operating characteristic; SOFA, sequential organ failure assessment.

than APACHE II. Similar findings have been described in other subspecialties besides neurology[13,14,15]. In status epilepsy, SOFA and APACHE II are useful in determining survivors. In this study, the mean SOFA and APACHE II scores were lower in survivors and demonstrated a moderate to good discriminatory power of both systems in distinguishing between survivors and non-survivors. These results indicate that both SOFA and APACHE II scores have acceptable utility in prognosticating the outcomes of neurological patients in the ICU[16].

Furthermore, the statistically significant relationship between SOFA score, the presence of co-morbid conditions, mechanical ventilation, and mortality underscores the clinical relevance of these factors in predicting patient outcomes. The association between higher SOFA scores and increased mortality aligns with the established concept that greater organ dysfunction is often linked to worse clinical outcomes. Similarly, the impact of co-morbid conditions on mortality emphasizes the importance of considering patients' overall health status when assessing prognosis.

This study has several limitations. Being a single-centre study, the results may not be generalizable to a broader context. Missing data affecting the scoring system (SOFA and APACHE II) could distort the analytical parameters. Patients discharged on request or left against medical advice did not represent the true outcome measures.

Conclusion

SOFA score had comparatively higher discriminative power than APACHE II. Overall mortality was comparatively higher in the presence of co-morbid conditions, higher SOFA score, and use of mechanical ventilation. These factors can be used to stratify patients according to their prognosis and adjust the treatment plan accordingly. Patients with these factors may require more intensive monitoring and support than patients without them. Assessment of the performance of scoring systems in specific populations and more defined ICU patients improves the sensitivity and applicability of the model to a particular setting which can guide the appropriate level of care and intervention.

Ethical approval

Ethical approval has been given by Institutional Review Committee of Tribhuvan University and Teaching Hospital, the reference number being 468 (6-11) and the approval sheet is uploaded alongside.

Consent

The data were obtained from the database maintained by the hospital ICUs as part of real time data capturing. The database was set up in collaboration with Nepal Health Research Council which is the primary research regulating body to conduct research in various fields related to health and permits secondary use of collected data. A general consent is signed by the patient or guardian prior to admission. As the data are de-identified or anonymized, it is not possible to trace or recontact the patients. Prior permission from the hospital department, hospital director and Institutional Review Committee was taken for use of collected data.

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The study did not have any sponsor.

Author contribution

S.S. contributed to writing the manuscript, the collection of case information, and manuscript revision. B.P.G., H.P. and R.O. contributed to writing the manuscript and collection of data. B.P.G., H.P. and R.O. contributed to the literature review and interpretation of results. B.P.G., R.K., R.O., and R.R. were involved in the patient care team and contributed to the collection of case information.

Conflicts of interest disclosure

There are no conflicts of interest.

Research registration unique identifying number (UIN)

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Data availability statement

This study uses data collected prospectively as part of the Nepal Intensive Care Research Foundation (NICRF) dataset. Details of the registry design and data management are published in detail on Wellcome Open Research.

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