ORIGINAL ARTICLE

Surgical Apgar Score in Predicting Post-operative Outcomes in Neurosurgical Patients - A Prospective Observational Study

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Abstract

Introduction: The Surgical Apgar Score (SAS) predicts postoperative outcomes in various surgical fields, but its utility in neurosurgery remains underexplored. This study evaluated SAS's effectiveness in predicting complications, mortality, and hospital stay in neurosurgical patients.

Methods: A prospective observational study was conducted on neurosurgical patients who underwent neurological surgery. SAS was calculated based on intraoperative blood loss, lowest heart rate, and lowest mean arterial pressure. Patients were categorized into three SAS groups (0 - 4, 5 - 7, and 8 - 10). Postoperative complications, mortality rates within 30 days, hospital stay and ICU stay durations were analyzed.

Results: Among 150 patients, 40 (26.7%) experienced significant postoperative complications, commonest being infections in 15 (10%), prolonged coma in 11 (7%), and reoperation in eight (5%). Mortality was observed in 10 patients (6.7%). The mean hospital stay was longer for patients with complications (15 days) compared to those without complications (Eight days), and ICU stays were also prolonged in patients with lower SAS. Patients with a low SAS (≤ 4) had a 40% complication rate, whereas those with a high SAS (≥ 8) had a 10% complication rate ($P < 0.05$). Lower SAS significantly predicted postoperative complications and mortality ($P < 0.001$).

Conclusions: SAS effectively predicts postoperative outcomes in neurosurgical patients. Its integration into perioperative decision-making may enhance patient care.

INTRODUCTION

Surgical outcomes are traditionally assessed using mortality and morbidity rates. Complex scoring systems like the Acute Physiology and Chronic Health Evaluation (APACHE) and Physiological and Operative Severity Score for the enumeration of mortality and morbidity (POSSUM) have been developed to predict outcomes but are often impractical for bedside use due to their complexity. In contrast, the Surgical Apgar Score (SAS), introduced by Gawande et al, provides a simpler and effective alternative by combining three intraoperative variables: estimated blood loss (EBL), lowest heart rate (HR), and lowest mean arterial pressure (MAP). Scores range from 0 to 10, with lower scores indicating higher risk of complications and mortality.[1,2]

SAS has been validated in various surgical specialties, including general, vascular, orthopedic, and gynecological surgeries.[3,4] In neurosurgery, Ziewacz et al demonstrated its predictive value, linking lower scores to increased complications and mortality, thus aiding in risk stratification and postoperative care prioritization.[5] Its integration into clinical workflows, including electronic health records, could support real-time decision-making and improve communication among healthcare teams.[6,7]

Given the rising volume of surgeries globally and the need for efficient, resource-friendly tools, this study has tried to evaluate the effectiveness of SAS in predicting postoperative outcomes in neurosurgical patients.

METHODS

This prospective study was conducted at Kathmandu Medical College and Teaching Hospital, Sinamangal, Kathmandu, Nepal from July 15, 2022, to July 14, 2023, involving 150 neurosurgical patients undergoing cranial surgeries. Ethical approval was obtained from the Institutional Review Board (Ref.: 13072022/06). Written informed consent was obtained, and procedures adhered to the Declaration of Helsinki (1975, as revised in 2000). Inclusion criteria were patients aged ≥ 18 years with complete intraoperative and postoperative data. Patients undergoing minor outpatient procedures or those unwilling to consent were excluded. The minimum sample size of 37 was calculated based on a 95% confidence interval, 80% power, and a standard deviation of 7, derived from prior SAS studies in neurosurgery.[1,5] Data was collected using a pre-designed proforma and included patient demographics, clinical diagnoses and types of surgery. Postoperative outcomes, including complications, ICU stay, hospital stay, and 30-day mortality, were recorded. SAS is calculated post operatively by summing points assigned to three intraoperative parameters.[1] These include EBL, MAP, and lowest HR. EBL is scored as follows: > 1000 mL (0 points), 601 - 1000 mL (1 point), and ≤ 600 mL (3 points). MAP values < 40 mm Hg receive 0 points, 40 - 54 mm Hg receive 1 point, and ≥ 55 mm Hg receive 3 points. HR is categorized as > 85 bpm (0 points), 76 - 85 bpm (1 point), and ≤ 75 bpm (3 points). The final score ranged from 0 to 10, with lower scores indicating increased risk for postoperative complications and mortality. Data analysis was performed using SPSS version 15.0. Descriptive statistics summarized patient characteristics, while chi-square tests and ANOVA were used to assess relationships between SAS and outcomes. Multivariate logistic regression, adjusting for confounders such as age and type of surgery, determined SAS's predictive value for postoperative complications. A P value < 0.05 was considered statistically significant.

RESULTS

Total of 150 patients were included in the study. The median age of the patients was 45 years (Range: 18 - 80 years), with a slight male predominance 90 (60%). Baseline characteristics of the patients are shown in Table 1. SAS scores of the study population is represented in Figure 1. Patients with a low SAS (≤ 4) were more likely to have undergone emergency surgery. Post- operative complications of the study patients are shown in Table 2. The relationship between SAS and postoperative complications was statistically significant (P < 0.05). The data demonstrates a statistically significant association (P < 0.05) between lower SAS and increased complication rates, reinforcing the predictive value of the SAS.

Table 1: Baseline characteristics of the study participants

Category	N (%)
Age (median; range)	45; 18 - 80
Male patients (%)	90 (60%)
Emergency surgeries (%)	98 (65%)
Elective surgeries (%)	98 (35%)
Hypertension (%)	45 (30%)
Diabetes (%)	75 (15%)
Cardiovascular disease (%)	15 (10%)

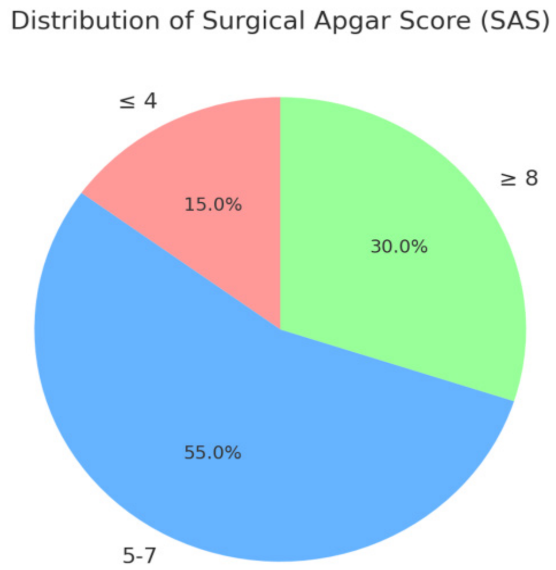

Fig 1: The pie chart visualizes the distribution of Surgical Apgar Scores (SAS)

Table 2: Postoperative complications in the study population

Complications	N (%)
Infection	15 (10)
Prolonged coma	11 (7)
Reoperation	8 (5)
No complication	116 (78)

Overall, 10 patients (6.7%) died within 30 days of surgery.

All of these patients had an SAS of 5 or lower. The average length of hospital stay was significantly longer in patients with complications (mean 15 days) compared to those without complications (mean 8 days). Patients with a low SAS (≤ 4) had a longer average ICU stay (mean 10 days) compared to those with higher SAS scores (mean 4 days); 15% of patients stayed in the ICU for more than 10 days, and 20% had a hospital stay of more than 14 days.

The SAS was found to be a significant predictor of postoperative complications and 30-day mortality (Table 3). The multivariate logistic regression analysis showed that patients with an SAS of 4 or lower had an increased odds ratio (OR) for complications (OR 3.5, 95% CI: 2.1-5.8, P < 0.01) and mortality (OR 4.2, 95% CI: 2.5-6.9, P < 0.01) compared to those with an SAS of 8 or higher (Table 3).

Table 3: SAS with complication rate and mortality rate

SAS	Complications rate (%)	Mortality rate (%)
0 - 2	60	30
3 - 4	45	20
5 - 6	30	10
7 - 8	15	5
9 - 10	5	1

The bivariate chi-square test confirmed the association between lower SAS and higher rates of complications (P = 0.03). ANOVA analysis also showed a statistically significant difference in hospital stay based on the SAS (P < 0.05), with lower scores associated with longer stays. Forest plot below demonstrates the varying risk levels associated with different SAS ranges, with a reference line at OR = 1 for comparison.

Patients with the lowest SAS (0-2) had the highest odds ratio (OR) for postoperative complications (OR 12.5, 95% CI: 5.2-30.1, P < 0.001), indicating a strong predictive value for poor outcomes. Patients with SAS 3-4 and 5-6 also demonstrated elevated ORs for complications (8.4 and 4.2 respectively) compared to those with SAS 9-10, emphasizing the association of lower SAS with increased risk. Table 4 provides the results of logistic regression analysis assessing the predictive value of the SAS in neurosurgical patients. ICU and hospital stay durations showed significant associations with SAS, with ORs of 1.8 and 2.4, respectively. Figure 2 also illustrates the forest plot summarizing the odds ratios and 95% confidence intervals (CIs) for various SAS ranges in predicting postoperative complications.

Table 4: Statistical analysis of SAS predictive value

Variables	Odds ratio	95% Confidence interval	P - value
SAS (0 - 2 vs 9 - 10)	12.5	5.2 - 30.1	< 0.001
SAS (3 - 4 vs 9 - 10)	8.4	3.1 - 22.7	< 0.001
SAS (5 - 6 vs 9 - 10)	4.2	1.9 - 9.3	0.002
SAS (7 - 8 vs 9 - 10)	2.5	1.1 - 5.6	0.03
ICU Length of stay (Days)	1.8	1.4 - 2.3	< 0.001
Hospital stay (Days)	2.4	1.9 - 3.1	< 0.001

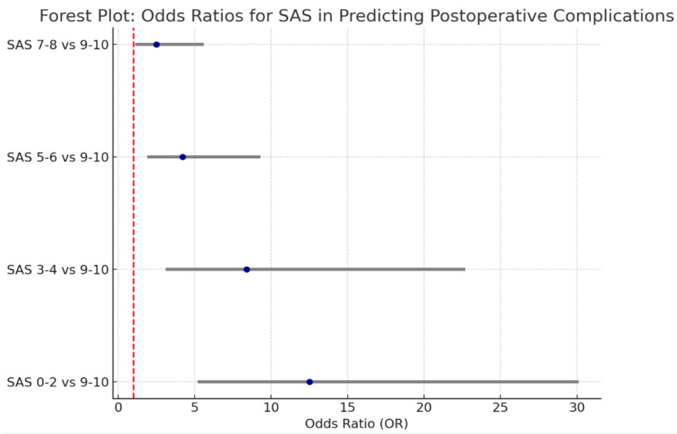

Fig 2: The forest plot showing the odds ratios and confidence intervals for each SAS range in predicting postoperative complications

DISCUSSION

The results of our study demonstrate that the SAS is a valuable tool for predicting postoperative outcomes in neurosurgical patients. This finding is consistent with previous studies across various surgical disciplines, which have also highlighted the predictive value of SAS for complications and mortality.[1,2] The predictive strength of SAS in neurosurgery, as reflected in our study, underscores its utility for clinical decision-making in this specialized field.

The present research demonstrated that patients with lower SAS (0-4) had significantly higher rates of postoperative complications compared to those with higher SAS (8-10). Similar trends have been observed in general surgery, vascular surgery, and gynecological procedures, highlighting SAS's broad applicability. This correlation is especially relevant in neurosurgery, where complications often have critical consequences on patient outcomes. By recognizing these patients early, clinicians may adjust perioperative care strategies to mitigate risks and improve recovery.

Mortality rates also correlated with SAS in the present study. Patients with SAS in the 0-4 range experienced a mortality rate of 25%, while those in the 8-10 range had a significantly lower mortality rate of 5%. This supports the findings from similar studies in general surgery and vascular surgery, where lower SAS has consistently been linked with higher mortality rates.[3,4] This finding is in congruence to a research by Reynolds et al, who reported similar mortality trends in their multicenter study of 4,119 patients.[9] Sobol et al also found comparable patterns in neurosurgical outcomes, though they reported slightly lower overall mortality rates.[10] The ability of SAS to predict mortality risk in neurosurgical patients allows for better stratification of patients, which could help clinicians identify those who would benefit from more intensive postoperative monitoring and care.

The length of hospital stay also showed a clear relationship with SAS. Patients with a low SAS (0-4) had an average hospital stay of 12 days, whereas those with a higher SAS (8-10) stayed for an average of five days. Prolonged hospital stays are typically associated with higher complication rates and greater healthcare resource utilization.[11] In our neurosurgical cohort, a lower SAS appears to serve as a reliable predictor for prolonged hospitalization, reinforcing the importance of SAS as a practical tool not only for patient prognosis but also for planning healthcare resource allocation. These findings parallel those reported by Urrutia et al in their analysis of surgical outcomes.[12]

Logistic regression analysis confirmed that SAS is an independent predictor of postoperative complications, mortality, and length of stay. The odds of experiencing postoperative complications increased by 2.5 times for each decrement in SAS, with a confidence interval of 1.6 - 3.9. This finding is in accordance to previous studies that have validated SAS as a robust predictor of adverse outcomes.[13] The ease with which SAS can be calculated intraoperatively makes it an attractive metric for real-time risk assessment, allowing for timely interventions. This progressive increase in risk with decreasing SAS values supports findings by other researches in the past.[14]

Despite its apparent utility, SAS has limitations. It is derived from three intraoperative variables: EBL, lowest HR, and lowest MAP. While these factors are important, they do not encompass the full spectrum of physiological changes that may occur during surgery, nor do they account for preoperative risk factors like patient comorbidities or the type and complexity of neurosurgical procedures. This doesn't account for specific neurosurgical parameters or pre-existing conditions, which were present in our cohort (hypertension 30%, diabetes 15%, cardiovascular disease 10%).[15] The emergency nature of most cases (65%) in our study might have influenced outcomes, as suggested by Clark et al in their comprehensive review.[16] Further studies could explore combining SAS with other risk assessment tools or modifying SAS to better reflect neurosurgical patient characteristics.[17]

Our study has several strengths, including a reasonably large sample size and the focus on neurosurgical patients, a group that has been less studied in the context of SAS. However, it also has limitations, such as single centre study which may limit the generalizability of our findings. Additionally, we did not analyze the influence of specific neurosurgical procedures on the predictive value of SAS, which could be a direction for future research. Future research should explore SAS modifications specific to neurosurgery, particularly considering the unique aspects of emergency versus elective procedures.[18,19]

CONCLUSIONS

SAS is a practical, reliable tool for predicting postoperative outcomes in neurosurgery. Its application can aid perioperative decision-making, optimize resource allocation, and improve patient outcomes.

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CONFLICT OF INTEREST: None

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