International Surgery Journal
Dada OA et al. Int Surg J. 2026 Oct;13(10):1833-1839
https://www.ijsurgery.com
pISSN 2349-3305 | eISSN 2349-2902

DOI: https://dx.doi.org/10.18203/2349-2902.isj20263336

Original Research Article

Perioperative adverse events in neurosurgery – incidence, pattern and associated factors in a Nigerian tertiary hospital

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Received: 15 August 2026
Accepted: 16 September 2026

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ABSTRACT

Background: Perioperative adverse events remain important causes of morbidity and mortality after neurosurgery, particularly in resource-constrained settings. This study evaluated their frequency, pattern and associated factors at a Nigerian tertiary hospital.
Methods: A retrospective observational study was conducted among patients undergoing cranial or spinal neurosurgical procedures at Ekiti State University Teaching Hospital, Ado-Ekiti, Nigeria, from January 2022 to December 2024. Demographic, clinical, operative and outcome data were extracted from hospital records. Associations were assessed using chi-square or Fisher's exact tests, followed by multivariable logistic regression. Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were reported.
Results: Of 126 identified cases, 103 met eligibility criteria. Mean age was 46.9±18.3 years and 65.0% were male. Cranial procedures accounted for 68.9% and emergency procedures for 57.3%. Thirty-four patients (33.0%) experienced at least one perioperative adverse event. The most frequent events were intraoperative hypotension, electrolyte disturbances, excessive blood loss, surgical site infection and reoperation. Neurological improvement occurred in 67.0%, while mortality was 8.7%. Emergency surgery (AOR 2.63, 95% CI 1.10–6.31), ASA III–IV (AOR 2.41, 95% CI 1.01–5.72), blood loss >500 ml (AOR 3.78, 95% CI 1.48–9.67), surgery >4 hours (AOR 2.92, 95% CI 1.19–7.15) and incomplete checklist completion (AOR 3.46, 95% CI 1.01–11.88) were independently associated with adverse events.
Conclusions: Perioperative adverse events were common. Strengthened risk assessment, haemostatic management, operative efficiency and complete checklist implementation may support safer neurosurgical care.

Keywords: Perioperative safety, Neurosurgery, Adverse events, Surgical safety, WHO surgical safety checklist, Nigeria, Postoperative complications

INTRODUCTION

Perioperative safety is fundamental to surgical practice because adverse events occurring around surgery remain causes of preventable morbidity, prolonged hospitalisation, disability and mortality. Neurosurgical procedures carry particular risks because of central nervous system complexity, operations, blood loss and technical or system-related errors.[1,2]

Safe neurosurgical care requires multidisciplinary practice involving surgeons, anaesthetists, nurses and healthcare professionals. Patient optimisation, safety protocols, effective communication and timely recognition of complications are important. Failures may result in hypotension, haemorrhage, surgical site infection, wrong-site surgery, neurological deterioration and death.[3-6]

The World Health Organization (WHO) surgical safety checklist is an important intervention designed to improve communication and ensure completion of safety steps. Its use has been associated with improved compliance with safety processes and perioperative outcomes.[3,7,8] Neurosurgery-specific checklists and structured communication strategies promote safer practice.[9-13] However, implementation remains inconsistent because of resource limitations, organisational barriers and workforce challenges.[8]

International evidence identifies advanced age, poor physiological status, emergency surgery, prolonged operative duration, excessive blood loss and incomplete adherence to safety protocols as factors associated with adverse events.[2,14] Their relevance may differ in resource-constrained settings with delayed presentation, resources and restricted neurocritical care. In Nigeria, neurosurgical services continue to expand despite infrastructural and workforce challenges, while evidence on perioperative adverse events remains limited.[15,16] Therefore, this study evaluated the incidence, pattern and factors associated with perioperative adverse events among patients undergoing neurosurgical procedures at Ekiti State University Teaching Hospital, Ado-Ekiti, Nigeria.

METHODS

Study design and setting

This retrospective observational study was conducted at the Neurosurgery Unit of Ekiti State University Teaching Hospital (EKSUTH), Ado-Ekiti, Ekiti State, Nigeria. EKSUTH is a tertiary referral centre that provides specialist neurosurgical services to patients from Ekiti State and neighbouring states in south-western Nigeria. The study reviewed eligible neurosurgical cases managed between January 2022 and December 2024.

Study population

The study population comprised patients who underwent cranial or spinal neurosurgical procedures during the study period. Patients of all ages and both sexes were eligible, subject to the predefined inclusion and exclusion criteria.

Eligibility criteria

Patients were included if they underwent a cranial or spinal neurosurgical procedure at EKSUTH between January 2022 and December 2024, had complete demographic, clinical, operative and postoperative records available for review, and had documented postoperative outcomes before hospital discharge. Patients were excluded if they had incomplete medical records, missing operative notes, missing postoperative outcome data or were managed conservatively without undergoing a neurosurgical procedure.

Sampling technique

Total population sampling was employed. All eligible cases identified during the study period were included. A total of 126 neurosurgical cases were identified. Twenty-three were excluded because of incomplete records (n=11), missing operative notes (n=7) or unavailable postoperative outcome data (n=5), leaving 103 cases for analysis.

Data collection

Data were extracted retrospectively from patients' case notes, theatre registers, anaesthetic records and admission registers using a structured data collection proforma. Variables included age, sex, neurosurgical diagnosis, admission Glasgow coma scale (GCS) score, comorbidities, American Society of Anesthesiologists (ASA) physical status, type of surgery (cranial or spinal), nature of surgery (elective or emergency), operative duration, estimated intraoperative blood loss, blood transfusion, completion of the WHO surgical safety checklist, postoperative intensive care unit (ICU) admission, perioperative adverse events, neurological outcome, Glasgow outcome score (GOS), ICU stay, hospital stay, 30-day readmission and in-hospital mortality.

Definition of perioperative adverse events

A perioperative adverse event was defined as an undesirable clinical event occurring during surgery or before hospital discharge that was attributable to the surgical procedure, anaesthesia or perioperative care and required clinical intervention or influenced patient outcome. Documented adverse events included intraoperative hypotension, excessive blood loss, electrolyte disturbances, surgical site infection, cerebrospinal fluid leakage, postoperative seizures, reoperation, venous thromboembolism and other clinically documented perioperative complications. In-hospital mortality was analysed separately as a secondary outcome.

Outcome measures

Neurological outcome at discharge was assessed using the GOS. Glasgow Outcome Score was used as a global measure of neurological outcome across the cohort; its limitations in capturing procedure-specific functional outcomes, particularly among patients undergoing spinal surgery, were recognised.

Statistical analysis

Data were entered into and analysed using IBM statistical package for the social sciences (SPSS) statistics version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized using means and standard deviations or medians with interquartile ranges, as appropriate. Categorical variables were presented as frequencies and percentages. Associations between clinical variables and perioperative adverse events were assessed using Pearson's chi-square test or Fisher's exact test where appropriate. Candidate variables with bivariate associations and/or clinical relevance were considered for multivariable logistic regression; the final model included the variables presented in Table 5. Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were calculated, and a two-tailed p value <0.05 was considered statistically significant. Given the limited number of adverse-event cases, adjusted estimates were interpreted cautiously.

Ethical considerations

Ethical approval was obtained from the Research and Ethics Committee of Ekiti State University Teaching Hospital, Ado-Ekiti, Nigeria, before commencement of the study. The requirement for individual informed consent was waived because of the retrospective nature of the study and use of anonymized hospital records. Confidentiality was maintained by removing patient identifiers during data extraction, analysis and reporting.

RESULTS

Patient selection

During the three-year study period, 126 neurosurgical cases were identified. Hospital records were available for all cases. Twenty-three were excluded because of incomplete medical records (n=11), missing operative notes (n=7) or unavailable postoperative outcome data (n=5). Consequently, 103 cases met the eligibility criteria and were included in the final analysis (Figure 1).

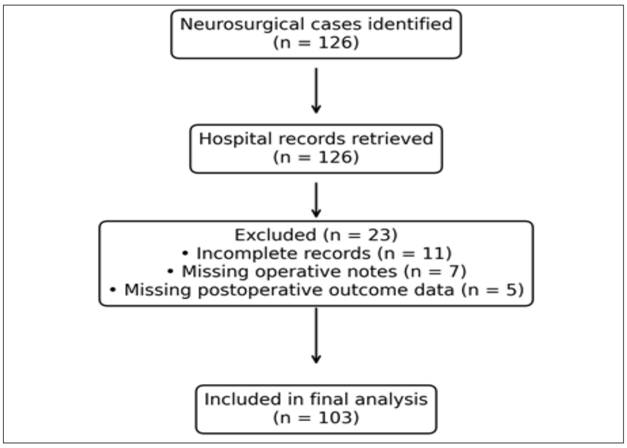

Figure 1: STROBE flow diagram of patient selection.

Sociodemographic and clinical characteristics

A total of 103 patients underwent neurosurgical procedures. The mean age was 46.9±18.3 years. Patients aged 40–59 years constituted the largest age group (38.8%), followed by those aged 20–39 years (30.1%), while patients younger than 20 years accounted for 7.8% (Table 1). There were 67 (65.0%) males and 36 (35.0%) females, giving a male-to-female ratio of approximately 1.9:1. Cranial procedures accounted for 71 (68.9%) operations and spinal procedures for 32 (31.1%). Emergency procedures represented 59 (57.3%) cases and elective procedures 44 (42.7%). Regarding preoperative physical status, 49 (47.6%) patients were ASA II, 33 (32.0%) ASA III, 14 (13.6%) ASA I and 7 (6.8%) ASA IV.

Table 1: Sociodemographic and clinical characteristics of patients (n=103).

Variables	Frequency	Percentage
Age group (years)		
<20	8	7.8
20–39	31	30.1
40–59	40	38.8
≥60	24	23.3
Sex		
Male	67	65.0
Female	36	35.0
Type of surgery		
Cranial	71	68.9
Spinal	32	31.1
Nature of surgery		
Elective	44	42.7
Emergency	59	57.3
ASA class		
I	14	13.6
II	49	47.6
III	33	32.0
IV	7	6.8
Comorbidity		
Hypertension	31	30.1
Diabetes	12	11.7

ASA=American Society of Anesthesiologists; GCS=Glasgow coma scale; SD=standard deviation

Hypertension was the commonest comorbidity, occurring in 31 (30.1%) patients, while diabetes mellitus was present in 12 (11.7%). The mean admission GCS score was 12.8±2.9. The distribution of neurosurgical diagnoses is shown in Figure 2.

Operative characteristics and perioperative safety measures

Almost all procedures were performed under general anaesthesia (98.1%), and all were consultant-led (Table 2). Thirty-seven (35.9%) procedures lasted longer than four hours, while estimated intraoperative blood loss exceeded 500 ml in 29 (28.2%) patients. Blood transfusion was required in 26 (25.2%) cases. The WHO surgical safety checklist was completed in 95 (92.2%) procedures, and prophylactic antibiotics were administered to all patients. None of the procedures utilised an operating microscope. Following surgery, 46 (44.7%) patients required postoperative ICU admission (Table 2).

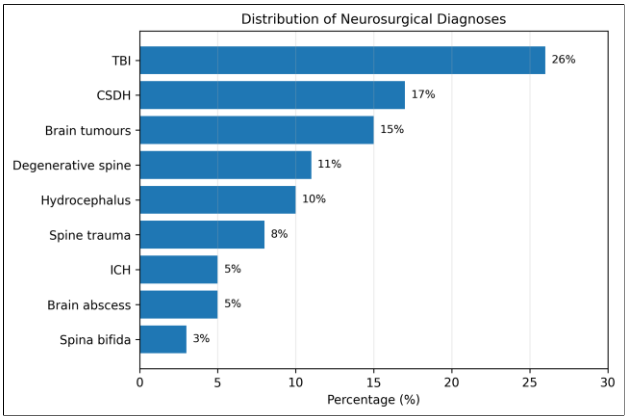

Figure 2: Distribution of neurosurgical diagnoses.

Table 2: Operative characteristics and perioperative safety measures (n=103).

Variable	Frequency	Percentage
General anaesthesia	101	98.1
Consultant-led surgery	103	100.0
Surgery >4 hours	37	35.9
Estimated blood loss >500 ml	29	28.2
Blood transfusion required	26	25.2
WHO surgical safety checklist completed	95	92.2
Prophylactic antibiotic administered	103	100.0
Operating microscope used	0	0.0
ICU admission after surgery	46	44.7

WHO=World Health Organization; ICU=intensive care unit

Pattern of perioperative adverse events

Overall, 34 of 103 patients experienced at least one perioperative adverse event, corresponding to an incidence proportion of 33.0% over the study period. The most frequently reported events were intraoperative hypotension (10.7%), electrolyte disturbances (9.7%), excessive blood loss (8.7%), surgical site infection (7.8%) and reoperation (6.8%). Other documented complications occurred less frequently (Figure 3). In-hospital mortality was analysed separately and was 8.7% (Table 3).

Clinical outcomes following neurosurgery

Neurological improvement at discharge was observed in 69 (67.0%) patients, while neurological status remained unchanged in 22 (21.4%) and deteriorated in 12 (11.6%) (Table 3). Based on the GOS, 58 (56.3%) patients achieved good recovery, 19 (18.5%) had moderate disability, 14 (13.6%) had severe disability, three (2.9%) remained in a persistent vegetative state and nine (8.7%) died before discharge. The median ICU stay was 3 days (interquartile range: 2–6 days), while the median hospital stay was 11 days (interquartile range: 8–17 days). Six (5.8%) patients were readmitted within 30 days of discharge (Table 3).

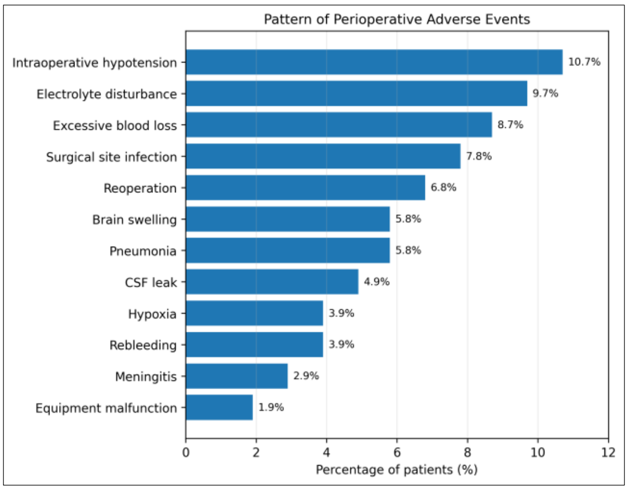

Figure 3: Pattern of perioperative adverse events among neurosurgical patients. Mortality was analysed separately as a clinical outcome.

Table 3: Clinical outcomes following neurosurgery (n=103).

Outcome	Frequency	Percentage
Neurological improvement	69	67.0
Neurological status unchanged	22	21.4
Neurological deterioration	12	11.6
Good recovery (GOS 5)	58	56.3
Moderate disability (GOS 4)	19	18.5
Severe disability (GOS 3)	14	13.6
Persistent vegetative state (GOS 2)	3	2.9
Death (GOS 1)	9	8.7
30-day readmission	6	5.8

GOS=Glasgow outcome score

Factors associated with perioperative adverse events

Bivariate analysis demonstrated significant associations between perioperative adverse events and age ≥60 years (p=0.031), emergency surgery (p=0.014), ASA III–IV (p=0.009), estimated blood loss >500 ml (p <0.001), blood transfusion (p<0.001), operative duration >4 hours (p=0.003), incomplete WHO surgical safety checklist completion (p=0.018) and admission GCS <13 (p=0.011) (Table 4).

No statistically significant associations were observed for sex (p=0.542) or type of surgery (cranial versus spinal; p=0.168).

Table 4: Bivariate analysis of factors associated with perioperative adverse events.

Variable	Adverse event, n=34	No adverse event, n=69	P value
Age ≥60 years	13	11	0.031
Male sex	24	43	0.542
Emergency surgery	25	34	0.014
Cranial surgery	27	44	0.168
ASA III–IV	19	21	0.009
Blood loss >500 ml	17	12	<0.001
Blood transfusion	16	10	<0.001
Surgery >4 hours	18	19	0.003
WHO checklist not completed	6	2	0.018
Admission GCS <13	21	24	0.011

ASA=American Society of Anesthesiologists; GCS=Glasgow coma scale. Pearson's chi-square test or Fisher's exact test was used where appropriate. A p value <0.05 was considered statistically significant

Table 5: Multivariable logistic regression for factors associated with perioperative adverse events.

Variable	AOR	95% CI	P value
Emergency surgery	2.63	1.10–6.31	0.031
ASA III–IV	2.41	1.01–5.72	0.047
Blood loss >500 ml	3.78	1.48–9.67	0.005
Surgery duration >4 hours	2.92	1.19–7.15	0.019
WHO checklist not completed	3.46	1.01–11.88	0.048
Admission GCS <13	1.74	0.73–4.13	0.211

AOR=Adjusted odds ratio; CI=confidence interval; ASA=American Society of Anesthesiologists; GCS=Glasgow coma scale; WHO=World Health Organization. Candidate variables with bivariate associations and/or clinical relevance were considered for multivariable modelling; the final model included the variables shown. A p value <0.05 was considered statistically significant

Multivariable analysis of factors associated with perioperative adverse events

The final multivariable logistic regression model included six variables (Table 5). Emergency surgery was independently associated with perioperative adverse events (AOR 2.63, 95% CI 1.10–6.31; p=0.031), as was ASA physical status III–IV compared with ASA I–II (AOR 2.41, 95% CI 1.01–5.72; p=0.047). Blood loss >500 ml had the largest adjusted odds ratio (AOR 3.78, 95% CI 1.48–9.67; p=0.005). Operative duration >4 hours (AOR 2.92, 95% CI 1.19–7.15; p=0.019) and incomplete WHO surgical safety checklist completion (AOR 3.46, 95% CI 1.01–11.88; p=0.048) were also independently associated with adverse events. Admission GCS <13 was not independently associated after adjustment (AOR 1.74, 95% CI 0.73–4.13; p=0.211).

DISCUSSION

Sociodemographic and clinical characteristics

Most patients were adults, with males accounting for almost two-thirds of the study population. Cranial procedures predominated and emergency operations constituted more than half of all surgeries. Hypertension was the commonest comorbidity, while nearly half of patients were classified as ASA II. The male predominance and concentration within the economically productive age group are consistent with reports from Nigeria and other low- and middle-income countries, where trauma, chronic subdural haematoma and brain tumours contribute substantially to neurosurgical workload.[17,18] The high proportion of emergency procedures may reflect delayed presentation and limited opportunities for comprehensive preoperative optimization in resource-constrained settings.[14]

Operative characteristics and perioperative safety measures

Nearly all procedures were performed under general anaesthesia and were consultant-led. More than one-third lasted over four hours, over one-quarter involved blood loss exceeding 500 ml, and approximately one-quarter required transfusion. The WHO surgical safety checklist was completed in more than 90% of procedures, while prophylactic antibiotics were universally administered and 44.7% required postoperative ICU admission. Prolonged operative duration and substantial blood loss may increase physiological instability and postoperative complications.[2,9] High checklist compliance is consistent with evidence that checklists improve teamwork, communication and perioperative safety.[3,8,10] Complete checklist implementation should remain a priority.

Pattern of perioperative adverse events

One-third of patients experienced at least one perioperative adverse event. Intraoperative hypotension, electrolyte disturbances, excessive blood loss, surgical site infection and reoperation were the commonest events. This burden is consistent with evidence that adverse events remain important challenges in neurosurgery because of procedural complexity and inherent central nervous system risks.[1,2] Intraoperative hypotension is particularly concerning because reduced cerebral perfusion may aggravate secondary neurological injury. Excessive blood loss and reoperation may further increase physiological stress. The observed surgical-site infection frequency is comparable with previous Nigerian neurosurgical experience.[15]

Clinical outcomes following neurosurgery

Most patients experienced neurological improvement at discharge, and more than half achieved a good GOS. Mortality was 8.7%, while few patients required 30-day readmission. Neurological deterioration and mortality remain important concerns and may be influenced by disease severity, perioperative complications and limitations in neurocritical care.[18]

Factors associated with perioperative adverse events

Emergency surgery, ASA III–IV status, blood loss exceeding 500 ml, operative duration greater than four hours and incomplete WHO surgical safety checklist implementation were independently associated with adverse events. Emergency surgery may increase risk through physiological instability and limited opportunity for preoperative optimization.[2,14] Higher ASA status reflects greater preoperative physiological risk. Blood loss exceeding 500 ml had the largest adjusted odds ratio and may reflect haemodynamic instability and transfusion requirements.[1] Prolonged surgery was also independently associated with adverse events, consistent with evidence linking lengthy procedures to infection, blood loss, hypothermia and anaesthetic complications.[8,9]

Incomplete checklist implementation remained independently associated with adverse events despite overall utilisation exceeding 90%. This finding supports evidence that structured checklists improve communication, reduce preventable errors and enhance perioperative safety.[3,10,19,20] This association does not establish causation.

Strengths, clinical implications and limitations

This study provides institution-specific evidence on perioperative adverse events in Nigerian neurosurgical practice. Excessive blood loss, prolonged surgery and incomplete checklist implementation are potentially modifiable and provide targets for quality improvement. Strengthening preoperative risk assessment, haemostasis, operative planning, multidisciplinary communication and adherence to safety protocols may support safer care.

Interpretation of the regression findings requires caution. Only 34 patients experienced an adverse event, yet six variables were included in the final model, creating potential for overfitting and imprecise estimates. The retrospective single-centre design, modest sample size and reliance on documented records may also introduce selection and information bias, only in-hospital outcomes were assessed, precluding evaluation of long-term functional recovery. Future prospective multicentre studies with larger samples and pre-specified modelling strategies are needed to validate these associations. Also, the use of GOS as a global outcome measure may not fully capture procedure-specific functional recovery, particularly in patients undergoing spinal surgery.

CONCLUSION

Perioperative adverse events occurred in one-third of neurosurgical patients, with hypotension, electrolyte disturbances, blood loss, infection and reoperation most frequent. Emergency surgery, higher ASA status, excessive blood loss, prolonged surgery and incomplete WHO surgical safety checklist implementation were independently associated with adverse events. Strengthening preoperative optimization, haemostasis, critical care, operative efficiency and checklist compliance may improve safety. Prospective multicentre studies are warranted to strengthen evidence for quality improvement in Nigeria.

ACKNOWLEDGEMENTS

The authors acknowledge the support of the medical, nursing and records staff of the Emergency Departments, Surgical Wards, Intensive Care Unit and Neurosurgical Outpatient Clinic of Ekiti State University Teaching Hospital, Ado-Ekiti, Ekiti State.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Dada OA, Adetoye MO, Okunlola AI, Afolayan JM. Perioperative adverse events in neurosurgery – incidence, pattern and associated factors in a Nigerian tertiary hospital. Int Surg J 2026;13:1833-9.