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Impact of Anesthetic Techniques on Postoperative Cognitive Dysfunction Following Neurosurgery

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Abstract

Background: Postoperative cognitive dysfunction (POCD) is a common yet under-recognized complication. Its occurrence can delay recovery, prolong hospitalization, and adversely affect long-term independence. Neurosurgical procedures, due to their complexity and direct cerebral involvement, carry a higher risk of cognitive sequelae. This study aimed to assess the impact of anaesthetic technique TIVA versus inhalational on the incidence and recovery pattern of POCD following neurosurgery and to identify perioperative predictors influencing cognitive outcomes.

Methods: This prospective observational study was conducted at Dhaka Medical College & Hospital, Dhaka, Bangladesh from July, 2023 to June, 2024. The study included 150 adults (18–80 years, ASA I–III) undergoing elective neurosurgical procedures under general anaesthesia at a tertiary centre. Patients received either total intravenous anaesthesia (TIVA) with propofol–remifentanil or inhalational anaesthesia with sevoflurane, as clinically indicated. Intraoperative variables, including duration, blood loss, hypotension, burst suppression, opioid dose, and dexmedetomidine use, were recorded. Cognitive function was assessed preoperatively, on postoperative day 7, and at 1 month using the Montreal Cognitive Assessment (MoCA), Trail Making Test-B, and Verbal Learning Test. POCD was defined as a ≥1 SD decline from baseline in any test. Data were analysed using SPSS 26, with significance set at $P < 0.05$.

Results: Among 150 neurosurgical patients (mean age 56.8 ± 12.1 years), postoperative cognitive dysfunction (POCD) occurred in 32.0% at day 7, with 12.0% showing persistent decline at 3 months. POCD was more frequent with inhalational anaesthesia (37.3%) than with TIVA (26.7%), though not statistically significant. Advanced age (≥65 years), low education level, intraoperative hypotension, and postoperative delirium were significant predictors of POCD, while dexmedetomidine use showed a protective trend. Cognitive scores declined significantly on day 7 but largely recovered or improved by 3 months. The predictive risk-score model demonstrated increasing POCD probability across risk categories, from 9.5% in low-risk to 70.0% in very-high-risk patients.

Conclusion: TIVA tended to reduce POCD compared to inhalational anaesthesia. Older age, low education, hypotension, and delirium increased POCD risk, while dexmedetomidine was protective. Optimizing anaesthesia, maintaining stability, and preventing delirium can help preserve cognition after neurosurgery.

Keywords: Postoperative cognitive dysfunction, neurosurgery, total intravenous anaesthesia (TIVA), inhalational anaesthesia and dexmedetomidine

Introduction

Postoperative cognitive dysfunction (POCD), a decline in memory, attention, executive function or processing speed after anaesthesia and surgery, remains a clinically important but incompletely understood complication, especially in older adults and after major procedures.[1,2] Reported incidence varies widely by population, surgery type and the cognitive tests used, but early (within 1 week) POCD rates may exceed 30% after major surgery and remain measurable in a substantial minority at 3 months or later.[2–4] Beyond transient morbidity, POCD has been linked to prolonged hospitalization, delayed return to independence, increased healthcare costs and a possible long-term risk for dementia, giving it clear public-health and patient-centred relevance.[5,6] Neurosurgical patients may be particularly vulnerable because operations often involve direct central-nervous-system pathology, prolonged procedures, potentially large hemodynamic swings, and a higher baseline risk of delirium and neurological complications. Reported POCD in brain and cerebrovascular surgery ranges across studies, but cognitive sequelae, whether transient or persistent, can substantially affect rehabilitation and functional outcome after neurosurgery.[7,8] Globally, the ageing population means an increasing proportion of neurosurgical procedures are performed in older adults, amplifying the potential population burden of POCD and the need for targeted risk-reduction strategies.[2,4] Anaesthetic technique is one potentially modifiable factor that has attracted growing research interest. Several randomized trials and meta-analyses have compared propofol-based total intravenous anaesthesia (TIVA) with inhalational (volatile) anaesthesia for effects on early cognitive outcomes, with a plurality of studies suggesting lower early POCD or delirium rates after TIVA in non-cardiac surgery; meta-analytic effect sizes are modest but consistent in some pooled analyses.[1,3,9] Mechanistic hypotheses include differences in neuroinflammation, cerebral oxidative stress, and haemodynamic stability between techniques, as well as direct effects of inhaled agents on synaptic function and amyloid/τ-related pathways suggested by preclinical work.[10,11] Conversely, other reviews highlight heterogeneity across trials (patient age, surgery type, POCD definition and timing) and caution against generalizing the findings.[2,3] Adjunctive pharmacologic strategies, notably perioperative dexmedetomidine, have also shown promise in reducing early postoperative delirium and cognitive decline in several randomized trials and meta-analyses, possibly via sympatholysis, anti-inflammatory effects and improved sleep architecture.[3,12] However, evidence specific to neurosurgical populations is sparse, and whether dexmedetomidine's apparent benefits interact with the primary anaesthetic modality (TIVA vs volatile) remains unsettled. Significant research gaps persist, as most existing studies combine heterogeneous surgical populations and provide limited data specific to neurosurgery. Evidence primarily focuses on short-term outcomes, while long-term cognitive recovery remains underexplored. Validated predictive models integrating patient, intraoperative, and anaesthetic factors are scarce, and mechanistic trials linking neurophysiological and inflammatory markers to POCD are rare. Therefore, further research should specifically assess POCD incidence and domains after neurosurgery, compare cognitive outcomes between TIVA and inhalational techniques, and identify modifiable intraoperative predictors to enable personalized, evidence-based anaesthetic strategies. The present study aimed to evaluate the impact of anaesthetic techniques on postoperative cognitive dysfunction and identify perioperative predictors in neurosurgical patients.

Methods

This prospective observational study was conducted at Dhaka Medical College & Hospital, Dhaka, Bangladesh from July, 2023 to June, 2024. A total of 150 adult patients undergoing elective neurosurgical procedures under general anaesthesia at a tertiary centre were assessed to assess the impact of anaesthetic technique on postoperative cognitive dysfunction (POCD). Patients

aged 18–80 years with ASA physical status I–III[13] and the ability to complete cognitive testing were included. At the same time, those with pre-existing neurological or psychiatric illness, prior head injury, or major postoperative complications were excluded. Anaesthesia was administered either as total intravenous anaesthesia (TIVA) with propofol–remifentanil infusions or as inhalational anaesthesia with a balanced sevoflurane technique, as per clinical judgement. Standard intraoperative monitoring included ECG, pulse oximetry, capnography, invasive blood pressure, temperature, and processed EEG (BIS). Duration of surgery, blood loss, hypotensive episodes (MAP <65 mmHg), burst suppression, opioid dose, and dexmedetomidine use were recorded. Postoperatively, patients were managed in the ICU, and complications such as delirium, prolonged ventilation, and infection were noted. Cognitive function was assessed preoperatively, on postoperative day 7, and at 1-month follow-up using the Montreal Cognitive Assessment (MoCA),[14] the Trail Making Test-B, and the Verbal Learning Test. POCD was defined as a ≥1 SD decline from baseline in at least one test or in the composite z-score, and severity was graded as mild, moderate, or severe.

Data were analysed using SPSS version 26. Continuous variables were expressed as mean ± SD, and categorical data as frequency and percentage. Paired t-tests compared cognitive changes over time, and Chi-square tests assessed associations with categorical predictors. Univariate logistic regression identified potential predictors of early POCD. A simplified risk-score model was derived from regression coefficients, and statistical significance was set at $P < 0.05$.

Results

The mean age was 56.8 ± 12.1 years, with most (73.3%) being under 65 years. Males constituted a slightly higher proportion (57.3%) than females (42.7%). Regarding education, 36.0% had primary or lower education, 39.3% had secondary education, and 24.7% attained tertiary education. Most participants (64.0%) were classified as ASA I–II, while 36.0% were ASA III. Hypertension was present in 42.7% and diabetes in 22.0% of individuals. The mean baseline Montreal Cognitive Assessment (MoCA) score was 25.8 ± 2.9, indicating generally preserved cognitive function across the cohort [Table 1].

The majority of surgeries were supratentorial tumor resections (42.7%), followed by intradural spine procedures (21.3%), posterior fossa surgeries (19.3%), and aneurysm clippings (16.7%). More than half of the operations (56.0%) lasted ≤4 hours, while 44.0% exceeded 4 hours. Most patients (84.0%) had an estimated blood loss of ≤500 mL. Intraoperative hypotension occurred in 30.0% of cases, depth index <40 for ≥10 minutes was noted in 22.0%, and burst suppression lasting >5 minutes in 14.0%. A higher opioid dose (>50 MME) was administered in 28.7% of patients, and dexmedetomidine was used in 40.0%. The anaesthetic techniques were equally distributed, with 50.0% receiving inhalational anaesthesia and 50.0% total intravenous anaesthesia (TIVA) [Table 2].

Table 1: Baseline characteristics of the study population (n = 150)

Variable	Category	n (%) / Mean ± SD
Age, years	Mean ± SD	56.8 ± 12.1
Age group	<65 years	110 (73.3)
	≥65 years	40 (26.7)
Sex	Male	86 (57.3)
	Female	64 (42.7)
Education	≤Primary	54 (36.0)
	Secondary	59 (39.3)
	≥Tertiary	37 (24.7)
ASA class	I–II	96 (64.0)
	III	54 (36.0)
Hypertension	Present	64 (42.7)
Diabetes	Present	33 (22.0)
Baseline MoCA	Mean ± SD	25.8 ± 2.9

Table 2: Intraoperative and surgical characteristics (n = 150)

Variable	Category	n (%)
Surgery type	Supratentorial tumor	64 (42.7)
	Posterior fossa	29 (19.3)
	Aneurysm clipping	25 (16.7)
	Intradural spine	32 (21.3)
Duration	≤4 h	84 (56.0)
	>4 h	66 (44.0)
Estimated blood loss	≤500 mL	126 (84.0)
	>500 mL	24 (16.0)
Intraoperative hypotension	≥2 episodes	45 (30.0)
Depth index <40	≥10 min	33 (22.0)
Burst suppression	>5 min	21 (14.0)
Opioid dose	>50 MME	43 (28.7)
Dexmedetomidine use	Yes	60 (40.0)
Anaesthetic technique	Inhalational	75 (50.0)
	TIVA	75 (50.0)

Delirium, as assessed by the CAM-ICU, was present in 17.3% of patients. Prolonged ICU stay (>24 hours) occurred in 26.7%, while 16.0% required mechanical ventilation for more than 12 hours. Moderate to severe pain (NRS >4) at 24 hours postoperatively was reported by 31.3% of patients. Sleep disruption on the first postoperative night affected 40.0% of individuals, and postoperative infections of any type were noted in 8.7% of the study population [Table 3].

POCD was more frequent with inhalational anaesthesia (37.3%) than with TIVA (26.7%), though this difference was not statistically significant (P = 0.14). Older age (≥65 years) was significantly associated with a higher incidence of POCD (55.0% vs 23.6%; OR = 2.10, P = 0.03). Similarly, patients with lower education (≤primary) had a higher risk than those with higher education (42.6% vs 26.0%; OR = 1.95, P = 0.046). Intraoperative hypotension (≥2 episodes) was also a significant predictor (46.7% vs 25.7%; OR = 2.40, P = 0.014). Other intraoperative variables, including depth index <40 (P = 0.85), burst suppression >5 minutes

Table 3: Early postoperative course and complications (within 7 days)

Variable	Category	n (%)
Delirium (CAM-ICU)	Present	26 (17.3)
ICU stay	>24 h	40 (26.7)
Mechanical ventilation	>12 h	24 (16.0)
Pain at 24 h	NRS >4	47 (31.3)
Sleep disruption (night 1)	Yes	60 (40.0)
Infection (any)	Yes	13 (8.7)

(P = 0.23), and dexmedetomidine use (P = 0.23), showed no significant associations. Delirium was strongly correlated with POCD, with affected patients showing a markedly higher rate (61.5% vs 25.8%; OR = 3.50, P = 0.002) [Table 4].

On postoperative day 7, 32.0% of patients exhibited POCD, with 18.0% classified as mild, 10.0% as moderate, and 4.0% as severe, while 68.0% showed no cognitive decline. At three months, 12.0% of patients had persistent POCD (≥1 SD decline), 20.0% recovered to baseline cognitive levels, and 6.0% demonstrated improvement beyond baseline. The most commonly affected cognitive domain was memory (11.3%), followed by executive function (8.7%), attention (5.3%), and multiple domains (6.7%). Intraoperative factors potentially related to POCD included hypotension in 30.0%, burst suppression in 14.0%, and dexmedetomidine use in 40.0% of cases. The mean recovery duration for affected patients was 7.8 ± 3.2 weeks, indicating a generally favorable recovery trend over time [Table 5].

Table 6 presents the longitudinal changes in neurocognitive performance from baseline to postoperative day 7 and at 3 months among 150 patients. The mean Montreal Cognitive Assessment (MoCA) score declined significantly from 25.8 ± 2.9 at baseline to 24.5 ± 3.1 on day 7 (Δ = −1.3, P < 0.001, d = 0.43), with 20.0% showing a clinically meaningful decline (≥1 SD). By 3 months, MoCA scores improved slightly above baseline (26.2 ± 2.8; Δ = +0.4, P = 0.040).

Table 4: Univariate associations logistic regression for early pocd (Postop Day 7, $n = 150$)

Variable	Comparison	POCD *n*/*N* (%)	OR (95% CI)	*P*-value
Anaesthetic technique	Inhalational vs TIVA	37.3% vs 26.7%	1.63 (0.85–3.12)	0.14
Age	≥65 vs <65 years	55.0% vs 23.6%	2.10 (1.06–4.15)	0.03
Education	≤Primary vs >Primary	42.6 % vs 26.0%	1.95 (1.01–3.77)	0.046
Intraop hypotension	≥2 vs <2 episodes	46.7% vs 25.7%	2.40 (1.19–4.86)	0.014
Depth index <40 ≥10 min	Yes vs No	33.3% vs 31.6%	1.08 (0.49–2.35)	0.85
Burst suppression >5 min	Yes vs No	42.9% vs 30.2%	1.74 (0.69–4.12)	0.23
Dexmedetomidine use	Yes vs No	26.7% vs 35.6%	0.66 (0.33–1.30)	0.23
Delirium (CAM-ICU)	Present vs Absent	61.5% vs 25.8%	3.50 (1.57–7.82)	0.002

Table 5: Severity pattern and recovery status of postoperative cognitive dysfunction (POCD)

Variable	Category	*n* (%)
POCD severity on Day 7	Mild (0.5–1 SD decline)	27 (18.0)
	Moderate (1–2 SD decline)	15 (10.0)
	Severe (>2 SD decline)	6 (4.0)
	No POCD	102 (68.0)
POCD persistence at 3 months	Persistent (still ≥1 SD decline)	18 (12.0)
	Recovered to baseline	30 (20.0)
	Improved above baseline	9 (6.0)
Domains affected (Day 7)	Memory only	17 (11.3)
	Executive function only	13 (8.7)
	Attention only	8 (5.3)
	Multiple domains	10 (6.7)
Correlated intraoperative factors	Intraop hypotension ≥2 episodes	45 (30.0)
	Burst suppression >5 min	21 (14.0)
	Dexmedetomidine use	60 (40.0)
Mean recovery duration (weeks)	Mean ± SD	7.8 ± 3.2

Similarly, Trail Making Test-B scores worsened postoperatively (95 ± 40 s vs 82 ± 35 s; $\Delta = +13$, $P < 0.001$, $d = 0.36$), with 22.0% showing ≥1 SD decline, but largely normalized by 3 months (78 ± 33 s; $\Delta = -4$, $P = 0.090$). Verbal learning performance also declined transiently on day 7 (38 ± 10 vs 42 ± 9; $\Delta = -4$, $P < 0.001$, $d = 0.44$) before improving beyond baseline at 3 months (43 ± 9; $\Delta = +1$, $P = 0.030$).

The composite *z*-score, reflecting overall cognitive function, dropped significantly from baseline (0.00 ± 1.00) to day 7 (−0.36 ± 0.98; $P < 0.001$, $d = 0.36$), with 32.0% meeting the threshold for meaningful decline. Partial recovery was evident at 3 months (−0.12 ± 0.94; $P = 0.060$), with persistent decline observed in 18.0%. Overall, the data indicate a transient, mild-to-moderate cognitive decline in the early postoperative period, followed by substantial recovery by 3 months [Table 6].

Among the evaluated predictors, postoperative delirium emerged as the strongest independent

determinant of POCD, with adjusted odds ratios (OR) of 3.02 (95% CI: 1.24–7.36) at day 7 and 2.61 (95% CI: 1.10–6.20) at 1 month, corresponding to the highest assigned score of +3. Intraoperative hypotension (≥2 episodes) was also a significant predictor (adjusted OR = 2.19 and 1.95, respectively) and was assigned +2 points as a strong risk factor. Advanced age (≥65 years) and low educational level (≤primary) showed moderate risk associations, each earning +1 point. The inhalational anaesthetic technique, compared with TIVA, trended toward a higher risk (adjusted ORs of 1.72 and 1.48, respectively) but did not reach statistical significance, warranting a +1 point. In contrast, dexmedetomidine use was associated with a lower risk of POCD (adjusted OR = 0.61 and 0.67), earning a −1 point as a protective factor [Table 7].

Among the 150 patients, 28.0% were classified as low risk (scores 0–1), showing only 9.5% POCD incidence on day 7 and 4.8% at 1 month, with a predicted probability of 0.10 (95% CI: 0.05–0.18). The moderate-risk group (scores 2–3) comprised 44.7% of participants, with observed POCD rates of 29.9% at day 7 and 17.9% at 1 month (predicted probability 0.25; 95% CI: 0.18–0.34). High-risk patients (scores 4–5) accounted for 20.7% of the cohort and showed substantially higher POCD rates 52.0% at day 7 and 29.0%

Table 6: Change in neurocognitive scores from baseline to day 7 and 3 months (n = 150)

Measure	Time point	Mean ± SD	Change vs Baseline (Mean Δ)	*P*-value (paired)	Effect size (Cohen's d)	MCID decline ≥1 SD *n* (%)
MoCA (0–30)	Baseline	25.8 ± 2.9	–	–	–	–
	Day 7	24.5 ± 3.1	−1.3	<0.001	0.43	30 (20.0)
	3 months	26.2 ± 2.8	+0.4	0.040	0.14	14 (9.3)
Trail making test-B (s) ↓ better	Baseline	82 ± 35	–	–	–	–
	Day 7	95 ± 40	+13	<0.001	0.36	33 (22.0)
	3 months	78 ± 33	−4	0.090	0.12	18 (12.0)
Verbal learning – Total recall	Baseline	42 ± 9	–	–	–	–
	Day 7	38 ± 10	−4	<0.001	0.44	27 (18.0)
	3 months	43 ± 9	+1	0.030	0.11	16 (10.7)
Composite *z*-score	Baseline	0.00 ± 1.00	–	–	–	–
	Day 7	−0.36 ± 0.98	−0.36	<0.001	0.36	48 (32.0)
	3 months	−0.12 ± 0.94	−0.12	0.060	0.12	27 (18.0)

Table 7: Predictive model and simplified risk-score for postoperative cognitive dysfunction (POCD) at day 7 and 1 month (n = 150)

Predictor	Adjusted OR (Day 7)	Adjusted OR (1 Month)	β	Assigned score	Direction
Age ≥ 65 y	1.88 (0.88–4.00)	1.72 (0.80–3.68)	0.63	+1	Higher risk
Low education (≤ Primary)	1.76 (0.86–3.57)	1.63 (0.78–3.41)	0.56	+1	Higher risk
≥ 2 episodes of intra-op hypotension	2.19 (1.03–4.68)	1.95 (0.91–4.20)	0.78	+2	Strong risk factor
Post-op delirium (CAM-ICU +)	3.02 (1.24–7.36)	2.61 (1.10–6.20)	1.11	+3	Major determinant
Inhalational technique (ref = TIVA)	1.72 (0.84–3.55)	1.48 (0.72–3.08)	0.54	+1	Trend toward risk
Dexmedetomidine use (Yes)	0.61 (0.28–1.35)	0.67 (0.30–1.47)	–0.49	–1	Protective

at 1 month (predicted probability 0.46; 95% CI: 0.33–0.60). The very-high-risk group (scores ≥6), though small (6.6%), demonstrated the highest vulnerability, with 70.0% developing POCD by day 7 and 50.0% persisting at 1 month (predicted probability 0.67; 95% CI: 0.48–0.83) [Table 8].

The dual-colored forest plot compares independent predictors of POCD at two postoperative time points. On Day 7, significant risk factors included age ≥ 65 years, ≥ 2 intra-operative hypotensive episodes, and post-operative delirium, with odds ratios exceeding 2.0. Low educational attainment and inhalational anaesthesia showed a mild association, whereas dexmedetomidine use demonstrated a protective trend (OR < 1). By 1 month, the impact of most variables attenuated, although delirium and intra-operative instability continued to predict persistent POCD [Figure 1].

The line graph in Figure 2 depicts the temporal trend of POCD incidence following neurosurgery. The proportion of patients exhibiting POCD decreased markedly from approximately 30% at Day 7 to 5% at 1 Month, indicating substantial cognitive recovery during the early postoperative period [Figure 2].

The conceptual framework in Figure 3 outlines the hypothesized mechanisms by which anaesthetic techniques may influence the development of postoperative cognitive dysfunction in neurosurgical patients. Both anaesthetic choice and perioperative risk factors such as

Table 8: Predicted probability of POCD by total risk-score category

Risk-score range	*n* (%)	Observed POCD day 7 *n* (%)	Observed POCD 1 month *n* (%)	Predicted probability (95 % CI)
0 – 1 (Low risk)	42 (28.0)	4 (9.5)	2 (4.8)	0.10 (0.05–0.18)
2 – 3 (Moderate risk)	67 (44.7)	20 (29.9)	12 (17.9)	0.25 (0.18–0.34)
4 – 5 (High risk)	31 (20.7)	16 (52.0)	9 (29.0)	0.46 (0.33–0.60)
≥ 6 (Very high risk)	10 (6.6)	7 (70.0)	5 (50.0)	0.67 (0.48–0.83)

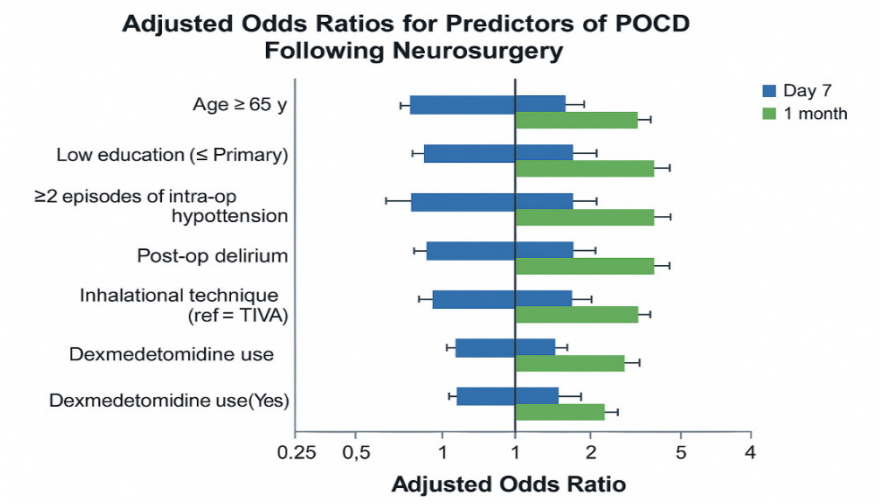

Figure 1: Adjusted odds ratios for predictors of POCD following neurosurgery (day 7 and 1 month).

age, intraoperative hemodynamic fluctuations, and depth of anaesthesia interact to modulate neuronal vulnerability and cognitive outcomes. Optimized anaesthetic approaches and risk mitigation can reduce the likelihood of cognitive decline, while adverse intraoperative events and physiological stressors increase the risk of POCD [Figure 3].

Discussion

Our findings underscore that postoperative cognitive dysfunction (POCD) is a common yet largely transient complication after neurosurgery.

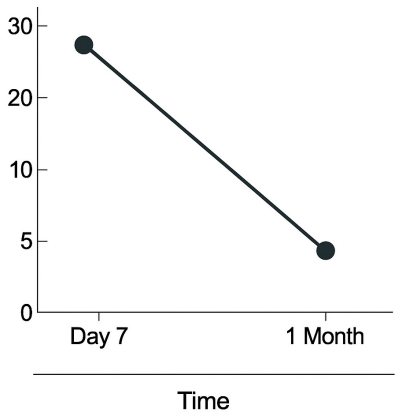

Figure 2: Trend of postoperative cognitive dysfunction from day 7 to 1 month.

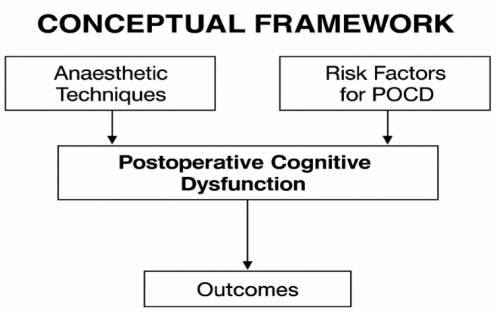

Figure 3: Conceptual framework illustrating the pathways linking anaesthetic techniques to postoperative cognitive dysfunction (POCD) following neurosurgery.

In our cohort, about one-third of patients exhibited POCD at one week, with most showing substantial recovery by three months. This early POCD incidence (~30%) aligns with reported rates in other surgical populations (roughly 10–54% within weeks post-surgery).[15] The resolution within 3 months (persistent POCD ~12%) is consistent with previous studies showing a long-term decline in 10–20% of elderly surgical patients.[16] Notably, memory was the most affected cognitive domain, consistent with reports that memory and executive function are particularly vulnerable in POCD.[17] We observed a higher POCD rate with inhalational anaesthesia than with total intravenous anaesthesia (TIVA) (37.3% vs 26.7%), though not statistically significant. This trend supports evidence suggesting cognitive benefits of TIVA. Negrini et al. reported significantly lower odds of POCD with TIVA within 30 days postoperatively (OR ~0.46).[1] A systematic review by Kampman et al. also indicated a 38% relative risk reduction in early POCD with TIVA0.[4] Propofol-based TIVA appears to induce a lower neuroinflammatory response than volatile agents.[18] Yao et al. found higher cognitive scores and lower cytokine levels postoperatively in elderly patients receiving propofol vs sevoflurane.[19] Similarly, a 2023 network meta-analysis by Zeng et al. ranked propofol among the best agents for minimizing POCD risk, while sevoflurane was associated with the highest risk.[20] Our non-significant result reflects limited power, though the direction aligns with the existing literature. Some studies, however, found no difference between anaesthetic types,[21] reflecting heterogeneity in definitions, surgical types, and follow-up timing. Consistent with prior literature, advanced age (≥65 years) emerged as a strong predictor of POCD.[22] Older patients have reduced cognitive reserve and are more susceptible to anaesthetic and surgical stress.[23] Lower educational attainment was also associated with greater POCD risk, supporting the cognitive reserve hypothesis.[24] Intraoperative hypotension (≥2 episodes) significantly predicted POCD in our cohort. This concurs with multiple studies identifying hypotension as

a key risk factor.[25,26] Even brief episodes below cerebral autoregulatory thresholds can impair cognition.[27] In contrast, burst suppression and deep anaesthesia (BIS <40) were not significant in our study. While some trials suggest that deep anaesthesia contributes to POCD and that EEG-guided titration may reduce its incidence,[28] this supports a multifactorial aetiology beyond anaesthetic depth alone. Postoperative delirium was a strong POCD predictor, with a threefold increase in risk. This aligns with the literature viewing delirium and POCD as overlapping neurocognitive syndromes.[29] Delirium often indicates underlying vulnerability and has been linked to sustained cognitive decline.[30] Even after apparent resolution, patients with delirium may remain at elevated POCD risk.[31] Prevention and monitoring of delirium could therefore mitigate longer-term cognitive dysfunction. Our finding that dexmedetomidine use was associated with lower POCD risk supports recent evidence. This α2-agonist has anti-inflammatory and neuroprotective properties.[20] Multiple trials have reported reductions in POCD and delirium with dexmedetomidine,[20] though its effects may vary by patient population.[32] Overall, our neurosurgical cohort demonstrates POCD patterns and risk factors consistent with general surgical populations. This reinforces the clinical relevance of modifiable factors like anaesthetic choice and hemodynamic stability in neurosurgical anaesthesia. Given accumulating evidence favoring TIVA, especially propofol-based regimens,[15–17] TIVA may be preferable in high-risk patients. Avoidance of hypotension and delirium, alongside consideration of dexmedetomidine as a neuroprotective adjunct, may further reduce POCD incidence.

Limitations of the Study

This single-center study with a moderate sample size may limit generalizability. Cognitive testing used brief screening tools, which might have missed subtle deficits. Continuous intraoperative data were limited, and unmeasured confounders, such as anxiety or sleep quality, could have influenced the results. Finally, the three-month follow-up may not reflect long-term cognitive outcomes, warranting larger multicenter studies with extended follow-up.

Conclusion

Total intravenous anaesthesia (TIVA) showed a non-significant trend toward lower rates of postoperative cognitive dysfunction compared to inhalational anaesthesia. Advanced age, low educational level, intraoperative hypotension, and postoperative delirium were identified as significant risk factors, while dexmedetomidine use appeared protective. Careful anaesthetic selection, hemodynamic stability, and delirium prevention are key strategies to minimize cognitive decline following neurosurgery.

Recommendations

Future neurosurgical anaesthesia should prioritise individualised strategies to reduce the risk of POCD. Propofol-based TIVA may be preferred for high-risk patients, with strict intraoperative blood pressure control and EEG or BIS monitoring to avoid excessive anesthetic depth. Routine delirium prevention, early cognitive screening, and the judicious use of dexmedetomidine as a neuroprotective adjunct are also recommended. Larger multicenter studies with longer follow-up are needed to validate these findings.

Ethical Approval

The study was approved by the Institutional Ethics Committee.

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