Early Global Cognitive Screening Recovery After Short-Duration Inhalational General Anaesthesia: A Prospective Observational Study In Low-Risk Adults

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Abstract:

Introduction: Early postoperative cognitive changes after brief inhalational general anaesthesia in younger, low-risk adults remain incompletely characterized. While postoperative neurocognitive disorders are well studied in elderly and high-risk populations, limited prospective data exist on early cognitive recovery after short-duration volatile anaesthesia. This study evaluated early recovery of global cognitive screening following elective short-duration surgery.

Methods: In this prospective observational cohort conducted over 12 months, adults aged 18–60 years with ASA physical status I–II undergoing elective surgery lasting less than 60 minutes under inhalational general anaesthesia were consecutively enrolled. Global cognitive function was assessed using the Mini-Mental State Examination (MMSE) preoperatively and at 6, 12, and 24 hours postoperatively. A ≥2-point decline at 24 hours was predefined as persistent early cognitive decline. Postoperative pain, recovery status (Aldrete score), and physiological parameters were recorded. Associations between anesthetic duration and postoperative MMSE scores were analyzed using non-parametric tests.

Results: A total of 244 patients were analyzed (mean age 44.8 ± 8.6 years; 96.8% female). MMSE scores showed significant temporal variation ($p < 0.001$), with a transient reduction at 6 hours, followed by recovery at 12 hours and a return to baseline by 24 hours. No participant demonstrated a persistent ≥2-point decline at 24 hours (0%; 95% CI 0–1.5%). Anaesthetic duration was not significantly correlated with postoperative MMSE scores.

Conclusion: Short-duration inhalational anaesthesia was associated with transient early fluctuation but no persistent cognitive decline at 24 hours.

Keywords: Postoperative Cognitive Complications, Anaesthesia, Inhalation, Surgical Procedures, Operative, Recovery of Function.

Introduction

Perioperative neurocognitive disorders (PNDs) encompass a spectrum of cognitive disturbances that occur in association with anaesthesia and surgery, ranging from acute postoperative delirium to delayed neurocognitive recovery and postoperative neurocognitive disorder. These conditions have attracted considerable clinical interest because of their potential impact on patient recovery, functional status, and healthcare utilization. Although perioperative cognitive changes have been extensively investigated over the past two decades, most evidence originates from elderly patients undergoing major surgical procedures, who are known to be at increased risk due to age-related vulnerability, comorbidities, and greater surgical stress.(1–4)

Previous landmark studies have demonstrated that postoperative cognitive impairment may occur following major surgery, particularly among older adults. The International Study of Postoperative Cognitive Dysfunction (ISPOCD) and subsequent investigations identified advanced age, surgical magnitude, and perioperative physiological disturbances as important predictors of postoperative cognitive decline.(3,5) More recent systematic reviews have confirmed that the incidence of postoperative neurocognitive disorders is substantially higher in elderly and high-risk surgical populations than in younger, healthier individuals.(4,6)

In contrast, relatively limited data are available regarding cognitive recovery following short-duration elective procedures performed under general anaesthesia. This represents an important knowledge gap because ambulatory and minor surgical procedures constitute a substantial proportion of modern surgical practice. Patients undergoing such procedures are generally younger, have fewer comorbidities, and are exposed to shorter durations of anaesthesia and surgical stress. Consequently, findings derived from elderly patients undergoing major surgery may not be directly applicable to this population.(2,4,7)

Volatile anaesthetic agents such as sevoflurane, isoflurane, and desflurane remain widely used because of their favourable pharmacokinetic properties, rapid titratability, and predictable recovery profiles.(8) Experimental studies have suggested potential interactions between inhalational anaesthetic agents and neuroinflammatory pathways; however, the clinical significance of these findings remains uncertain, particularly after brief anaesthetic exposure in physiologically stable patients.(7,9) Existing clinical studies evaluating cognitive outcomes after minor surgery have reported inconsistent findings, with some demonstrating transient early postoperative cognitive fluctuations and others showing minimal measurable impairment in low-risk individuals.(10,11)

Understanding the trajectory of early cognitive recovery after short-duration inhalational anaesthesia has practical implications for postoperative monitoring, discharge planning, and patient counselling. Characterizing normal patterns of recovery may also help distinguish transient postoperative changes from clinically significant neurocognitive impairment.

Therefore, the present study aimed to characterize early postoperative changes in global cognitive screening performance during the first 24 hours following short-duration inhalational general anaesthesia in low-risk adults undergoing elective surgery. We hypothesized that any early postoperative reduction in cognitive screening scores would be transient and would return to baseline within 24 hours under physiologically stable conditions.

Methodology

Study Design and Setting

This prospective observational cohort study was conducted over a 12-month period at a tertiary care teaching hospital. The study was approved by the Institutional Human Ethics Committee (Approval No. SRMIEC-ST0723-811) and was conducted in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from all participants before enrolment. The study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Study Population

Adult patients aged 18–60 years scheduled for elective surgical procedures of anticipated duration less than 60 minutes under inhalational general anaesthesia were screened for eligibility. Consecutive eligible patients were enrolled during the study period.

Inclusion Criteria

Participants meeting all of the following criteria were included:

- Age between 18 and 60 years.
- American Society of Anaesthesiologists (ASA) physical status I or II.
- Elective surgical procedure expected to last less than 60 minutes.
- Planned administration of inhalational general anaesthesia.
- Ability to understand and complete cognitive assessment.

Exclusion Criteria

Patients were excluded if they had known neurological or psychiatric disorders, documented cognitive impairment, morbid obesity (body mass index >40 kg/m²), elevated intracranial pressure, hemodynamic instability, inability to complete the cognitive assessment, or refusal to provide informed consent.

Sample Size

The study was designed as an exploratory observational cohort to characterize early postoperative changes in global cognitive screening performance following short-duration inhalational anaesthesia. A total of 244 consecutive eligible participants were enrolled during the study period. The sample size was determined based on feasibility and the anticipated number of eligible patients presenting to the institution during the study period.

Preoperative Assessment

All participants underwent routine preoperative evaluation, including medical history, physical examination, airway assessment, and review of relevant laboratory investigations. Baseline demographic and clinical characteristics were recorded.

Global cognitive screening performance was assessed preoperatively using the Mini-Mental State Examination (MMSE). The MMSE is a 30-point screening instrument evaluating orientation, attention, memory, language, and visuospatial function. Baseline assessment was performed before administration of any sedative or anaesthetic medication.

Anaesthetic Management

General anaesthesia was administered according to institutional practice. Anaesthesia was induced and maintained using inhalational anaesthetic agent isoflurane. Standard intraoperative monitoring included continuous electrocardiography, pulse oximetry, non-invasive blood pressure monitoring, and capnography. The duration of anaesthesia and duration of surgery were recorded for all participants.

Postoperative Assessment

Postoperative cognitive screening was performed using the MMSE at 6, 12, and 24 hours following surgery. Assessments were conducted by trained investigators using a standardized approach.

Pain intensity was evaluated at each postoperative time point using the Visual Analogue Scale (VAS), where 0 represented no pain, and 10 represented the worst imaginable pain.

Postoperative recovery status was assessed using the Modified Aldrete Recovery Score. Hemodynamic parameters, including heart rate, mean arterial pressure (MAP), and peripheral oxygen saturation (SpO_2), were recorded during the postoperative observation period.

Outcome Measures

Primary Outcome

The primary outcome was change in global cognitive screening performance at 24 hours following surgery, measured using the MMSE.

Persistent reduction in MMSE score was operationally defined as a decline of two or more points from the preoperative baseline at 24 hours. This threshold was used to identify persistent deviation from baseline cognitive screening performance and was not intended to represent a formal diagnosis of perioperative neurocognitive disorder.

Secondary Outcomes

Secondary outcomes included:

- Temporal changes in MMSE scores at 6, 12, and 24 hours postoperatively.
- Association between duration of anaesthetic exposure and postoperative MMSE scores.
- Postoperative pain intensity was measured using the VAS.
- Recovery status is measured using the Modified Aldrete Score.
- Postoperative physiological parameters, including heart rate, MAP, and SpO_2.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 26.0. Continuous variables were assessed for normality using the Shapiro–Wilk test and are presented as mean ± standard deviation (SD) or median with interquartile range (IQR), as appropriate. Categorical variables are presented as frequencies and percentages.

Changes in MMSE scores across the four assessment time points (preoperative, 6 hours, 12 hours, and 24 hours) were analyzed using the Friedman test for repeated measures. Where appropriate, post hoc pairwise comparisons were performed with Bonferroni adjustment. The relationship between duration of anaesthetic exposure and postoperative MMSE scores was assessed using Spearman's rank correlation coefficient. A two-sided p-value <0.05 was considered statistically significant.

RESULTS

Participant Characteristics

A total of 244 patients were enrolled and completed all scheduled assessments. The mean age of the study population was 44.8 ± 8.6 years (range: 18–60 years). Females constituted the majority of participants (96.8%), and most patients were classified as ASA physical status I (72.1%). The largest age category was 46–55 years (32.0%), followed by 36–45 years (25.4%).

The study cohort predominantly underwent minor gynaecological procedures. Dilatation and curettage (D&C) accounted for 88.1% of surgeries, while laparoscopic puerperal sterilization constituted 10.7%. The mean duration of surgery was 39.1 ± 8.4 minutes (Table 1).

Table 1. Demographic Characteristics of Study Participants (n = 244)

Variable	Value
Age (years), Mean ± SD	44.8 ± 8.6
Age Range (years)	18–60
Gender – Male	8 (3.2%)
Gender – Female	236 (96.8%)
ASA Physical Status I	176 (72.1%)
ASA Physical Status II	68 (27.9%)

Age Distribution	
Age Group (years)	n (%)
18–25	18(7.4)
26–35	36(14.8)
36–45	62(25.4)
46–55	78(32.0)
56–60	50(20.4)
Type of Surgical Procedure	
Procedure	n (%)
Dilatation & Curettage (D&C)	215 (88.1)
Laparoscopy (Diagnostic)	3 (1.2)
Laparoscopic Puerperal Sterilization	26 (10.7)
Total	244 (100)

Postoperative Physiological Parameters

Postoperative physiological parameters remained clinically stable throughout the 24-hour observation period. Mean heart rate demonstrated minimal variation across assessments. Oxygen saturation remained consistently above 98% at all postoperative time points, with no episodes of clinically significant desaturation recorded. Mean arterial pressure remained within acceptable postoperative limits during follow-up (Table 2).

Table 2. Postoperative Physiological Parameters During Follow-up

Parameter	6 Hours (Mean ± SD)	12 Hours (Mean ± SD)	24 Hours (Mean ± SD)
Heart Rate (bpm)	80.2 ± 7.48	79.7 ± 7.73	79.2 ± 7.16
Mean Arterial Pressure (mmHg)	76.2 ± 7.95	69.7 ± 6.73	69.2 ± 6.16
SpO_2 (%)	99.28 ± 0.97	98.93 ± 1.66	99.09 ± 2.07

Early Cognitive Recovery and Postoperative Recovery Profile

Global cognitive screening performance, assessed using the MMSE, demonstrated significant temporal variation during the postoperative period (Friedman test, $p < 0.001$). Median MMSE scores declined from a preoperative value of 30 (IQR: 30–30) to 24 (IQR: 20–26) at 6 hours following surgery, indicating a transient reduction in cognitive screening performance during the early recovery phase. Progressive improvement was observed thereafter, with median MMSE scores increasing to 28 (IQR: 27–29) at 12 hours and returning to baseline at 24 hours postoperatively [30 (IQR: 30–30)] (Table 3).

Postoperative pain scores demonstrated a similar recovery pattern. Median Visual Analogue Scale (VAS) scores decreased from 7 at 6 hours to 6 at 12 hours and 3 at 24 hours. Concurrently, recovery status improved steadily, with median Aldrete scores increasing from 7 (IQR: 6–8) at 6 hours to 10 (IQR: 10–10) by 24 hours, indicating complete recovery in the majority of patients (Table 3).

Table 3: Changes in Global Cognitive Screening Performance, Pain Scores, and Recovery Scores Following Surgery

Time Point	MMSE Median (IQR)	VAS Median	Aldrete Score Median (IQR)
Preoperative	30 (30-30)	-	-
6 hours	24 (20-26)	7	7 (6-8)
12 hours	28 (27-29)	6	10 (8-10)
24 hours	**30 (30-30)**	3	10 (10-10)

Note: Friedman Test for MMSE Scores Across Time Points: $p < 0.001$. Persistent ≥2-point MMSE decline at 24 hours: 0/244 (0%).

No participant demonstrated a persistent decline of ≥2 MMSE points at 24 hours compared with baseline assessment. All patients recovered to baseline performance on the global cognitive screening within the 24-hour observation period.

Association Between Duration of Anaesthetic Exposure and Cognitive Performance

Correlation analysis revealed no statistically significant association between duration of inhalational anaesthetic exposure and postoperative MMSE scores at any assessment point. Spearman correlation coefficients were weak and non-significant at 6 hours ($r = -0.045$, $p = 0.497$), 12 hours ($r = 0.090$, $p = 0.165$), and 24 hours ($r = 0.021$, $p = 0.742$) (Table 4).

Table 4. Correlation Between Duration of Inhalational Anaesthetic Exposure and Postoperative MMSE Scores

Time Point	Correlation Coefficient (r)	p-value
6 Hours	−0.045	0.497
12 Hours	0.090	0.165
24 Hours	0.021	0.742

Note: No statistically significant correlation was observed between duration of anaesthetic exposure and postoperative MMSE scores at any postoperative assessment point.

These findings suggest that within the observed range of surgical and anaesthetic duration, the length of inhalational anaesthetic exposure was not associated with postoperative global cognitive screening performance.

DISCUSSION

The present prospective observational study evaluated early postoperative changes in global cognitive screening performance among low-risk adults undergoing short-duration surgery under inhalational general anaesthesia. The principal finding was that although a transient reduction in MMSE scores was observed during the early postoperative period, cognitive screening performance progressively improved and returned to baseline values within 24 hours. Furthermore, no participant demonstrated a persistent decline of ≥2 MMSE points at 24 hours. These findings suggest that brief exposure to inhalational anaesthesia in physiologically stable adults is associated with rapid recovery of global cognitive screening performance.

Perioperative neurocognitive disorders have been extensively studied in elderly patients and those undergoing major surgical procedures, where postoperative cognitive impairment remains a clinically important concern.(1,4,6) The landmark ISPOCD study demonstrated measurable postoperative cognitive decline among older adults undergoing major non-cardiac surgery, while Monk et al. identified advanced age and perioperative factors as important predictors of postoperative cognitive dysfunction.(3,5) In contrast, the participants in the present study were younger, predominantly ASA physical status I, and underwent minor surgical procedures of short duration. The complete recovery of MMSE scores by 24 hours observed in our cohort supports the concept that postoperative cognitive trajectories differ substantially according to patient vulnerability and surgical burden rather than anaesthetic exposure alone.(4,6,7)

A notable finding was the transient reduction in MMSE scores at 6 hours after surgery, followed by progressive improvement at 12 hours and normalization by 24 hours. Several factors may contribute to this pattern, including residual anaesthetic effects, postoperative fatigue, sleep disruption, pain, and the physiological stress response associated with surgery.(7,8) The rapid normalization of MMSE scores observed in our study suggests that these early changes most likely represent transient recovery-phase phenomena rather than clinically significant neurocognitive injury.

The recovery pattern observed in the present study is consistent with previous investigations evaluating cognitive outcomes after minor surgical procedures. Canet et al. reported that cognitive fluctuations following minor surgery were generally transient and resolved rapidly in low-risk populations.(10) Similarly, Chen et al. demonstrated favourable cognitive recovery profiles after short-duration volatile anaesthesia without evidence of persistent postoperative cognitive impairment.(11) Although direct comparisons are limited by differences in patient populations and assessment methodologies, these findings collectively support the notion that cognitive recovery following brief anaesthetic exposure is generally rapid in otherwise healthy adults.

The mechanisms underlying postoperative cognitive changes remain incompletely understood. Contemporary evidence suggests that neuroinflammation, oxidative stress, blood–brain barrier dysfunction, microglial activation, and alterations in neurotransmitter signalling contribute to perioperative neurocognitive disorders.(12–15) Recent reviews have highlighted neuroinflammation as a central biological pathway, particularly among elderly individuals and patients with pre-existing vulnerability.(13,15) However, the clinical significance of these mechanisms after brief anaesthetic exposure in young and physiologically stable adults remains uncertain. The absence of persistent cognitive screening decline in our cohort suggests that any transient perioperative neurobiological alterations were insufficient to produce measurable impairment at 24 hours.

No significant association was observed between duration of inhalational anaesthetic exposure and postoperative MMSE scores. Correlation coefficients were weak and non-significant at all postoperative assessment points. Although prolonged anaesthetic exposure has been proposed as a contributor to postoperative neurocognitive disorders, current evidence suggests that duration alone is unlikely to be an independent determinant of cognitive outcomes in low-risk populations.(5,7) Rather, postoperative cognitive recovery appears to reflect a complex interaction among patient characteristics, surgical stress, physiological stability, and perioperative management.

Maintenance of physiological stability may also have contributed to the favourable outcomes observed. Oxygen saturation remained consistently above 98%, while heart rate and mean arterial pressure remained within clinically acceptable limits. Previous consensus statements and mechanistic reviews have highlighted the potential contribution of perioperative hypoxia, cerebral hypoperfusion, and systemic inflammatory responses to postoperative cognitive decline.(1,7,15) The absence of major physiological disturbances in the present cohort likely minimized secondary neurological stress and facilitated rapid postoperative recovery.

Pain intensity and recovery status improved progressively throughout follow-up and paralleled the observed cognitive recovery pattern. These findings suggest that early postoperative reductions in MMSE performance may partially reflect the normal recovery process, including residual sedation, discomfort, and postoperative fatigue, rather than clinically significant neurocognitive dysfunction. This observation is particularly relevant in ambulatory and short-stay surgical settings, where transient cognitive fluctuations during the immediate postoperative period are commonly encountered.

Collectively, the findings of this study provide evidence that low-risk adults undergoing brief inhalational anaesthesia generally experience rapid recovery of global cognitive screening performance when physiological stability is maintained. These results may assist clinicians in counselling patients regarding expected postoperative recovery and in interpreting transient cognitive fluctuations during the immediate postoperative period.

LIMITATIONS

Several limitations should be considered when interpreting the findings of this study. First, cognitive assessment was performed using the Mini-Mental State Examination, a global cognitive screening instrument that may not detect subtle impairments in executive function, attention, processing speed, or working memory. Recent literature emphasizes that comprehensive neuropsychological batteries remain the preferred approach for evaluating perioperative neurocognitive disorders. (12,13)

Second, the study population was predominantly female and largely comprised patients undergoing minor gynaecological procedures, limiting generalizability to male patients and to more diverse surgical populations. Third, postoperative follow-up was limited to 24 hours, precluding assessment of delayed neurocognitive recovery or longer-term postoperative cognitive outcomes. Fourth, the observational design and absence of a comparative anaesthetic group prevent conclusions regarding the relative effects of inhalational and intravenous anaesthetic techniques. Finally, inflammatory biomarkers, depth-of-anaesthesia monitoring, and advanced neurocognitive testing were not incorporated, limiting mechanistic interpretation of the observed findings.

FUTURE DIRECTIONS

Future studies should incorporate comprehensive neuropsychological assessment batteries that detect subtle changes in cognitive domains beyond global screening performance. The inclusion of more diverse surgical populations, a balanced sex distribution, and longer postoperative follow-up would improve the generalizability of the findings and facilitate evaluation of delayed neurocognitive recovery.

Comparative investigations evaluating inhalational and total intravenous anaesthesia techniques may further clarify the influence of anaesthetic modality on postoperative cognitive recovery. In addition, integration of inflammatory biomarkers, EEG-based depth-of-anesthesia monitoring, and perioperative physiological monitoring may help elucidate the biological mechanisms underlying transient postoperative cognitive changes.

CONCLUSION

In this prospective observational cohort of low-risk adults undergoing short-duration elective surgery, inhalational general anaesthesia was associated with a transient reduction in MMSE scores during the early postoperative period, followed by complete recovery to baseline global cognitive screening performance within 24 hours. No participant demonstrated a persistent decline of ≥2 MMSE points at 24 hours, and no significant association was observed between duration of anaesthetic exposure and postoperative MMSE scores.

These findings suggest that brief exposure to inhalational anaesthesia in physiologically stable adults is associated with rapid recovery of global cognitive screening performance. However, because cognitive assessment relied on a screening instrument and follow-up was limited to the first postoperative day, the findings should be interpreted as evidence of recovery in global cognitive screening performance rather than as evidence of the absence of perioperative neurocognitive dysfunction.

Declarations

Funding:
This study received no funding.
Competing interests
The authors declare that they have no competing interests.
Ethical approval
The study was approved by the Institutional Human Ethics Committee (Approval No. SRMIEC-ST0723-811) and was conducted in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from all participants before enrolment. The study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.
Consent for publication:
Not applicable.
Availability of data and materials
The datasets collected during the current study are available from the corresponding author on reasonable request.
Code availability:
No custom code or software was developed or used in this study. Statistical analysis was performed using IBM SPSS Statistics version 26.0.
Large language model (LLM):
No LLM tools were used in the conduct, analysis, or interpretation of this study
Authors' contributions
YPLP & TSMR conceived the study. YPLP & RE contributed to data acquisition. AJ supervised assessments. KD & SS performed statistical analysis. YPLP & AJ drafted the manuscript. All authors reviewed and approved the final manuscript.
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