Section: Anaesthesiology

Original Research Article

POSTOPERATIVE COGNITIVE DYSFUNCTION IN ELDERLY SURGICAL PATIENTS: ROLE OF ANESTHETIC TECHNIQUES AND PREVENTION STRATEGIES

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ABSTRACT

Background: Postoperative cognitive dysfunction (POCD) is a common neurocognitive complication among elderly surgical patients and is associated with delayed recovery, prolonged hospitalization, and increased postoperative morbidity. Multiple perioperative factors, including anesthetic techniques and intraoperative physiological disturbances, may contribute to the development of POCD. The aim is to evaluate the incidence of postoperative cognitive dysfunction in elderly surgical patients and to assess the association between anesthetic techniques and perioperative risk factors with postoperative cognitive outcomes. **Materials and Methods:** This prospective observational study was conducted in the Department of Anaesthesiology at Government Dindigul Medical College and Hospital from January 2025 to January 2026. A total of 200 patients aged 60 years and above undergoing elective surgeries under general or regional anesthesia were included. Preoperative and postoperative cognitive assessment was performed using the Mini-Mental State Examination (MMSE). Demographic characteristics, comorbidities, anesthetic techniques, intraoperative variables, and postoperative outcomes were recorded and analyzed using SPSS version 25. **Results:** The overall incidence of POCD was 26%. Patients receiving general anesthesia demonstrated a significantly higher incidence of POCD compared with those receiving regional anesthesia (32.1% vs 18.2%; p=0.028). Advanced age, prolonged duration of surgery, intraoperative hypotension, postoperative pain severity, ICU admission, and multiple comorbidities showed significant association with postoperative cognitive dysfunction. Patients with POCD had prolonged hospital stay and higher postoperative complication rates. **Conclusion:** Postoperative cognitive dysfunction remains a significant perioperative complication among elderly surgical patients. Advanced age, hemodynamic instability, prolonged surgery, and general anesthesia were important predictors of POCD. Early perioperative identification of high-risk patients and implementation of preventive strategies may improve postoperative cognitive outcomes in elderly individuals.

INTRODUCTION

The growing proportion of elderly individuals undergoing surgical procedures has resulted in increasing concern regarding postoperative neurocognitive complications. Among these, postoperative cognitive dysfunction (POCD) remains a clinically significant condition characterized by impairment in memory, concentration, executive functioning, and information processing following surgery and anesthesia.[1]

Although cognitive decline may be transient in many patients, persistent dysfunction can adversely affect quality of life, prolong recovery, increase dependency, and contribute to higher morbidity and mortality among older adults.[2]

Advancing age is considered one of the most important risk factors for postoperative cognitive impairment because aging is associated with reduced neuronal reserve, cerebrovascular changes, chronic systemic inflammation, and diminished physiological adaptability to perioperative stress.[3] Elderly patients frequently present with multiple

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comorbidities such as hypertension, diabetes mellitus, coronary artery disease, and chronic pulmonary disorders, all of which may further increase susceptibility to perioperative cerebral injury and cognitive decline. In addition, pre-existing mild cognitive impairment often remains undetected before surgery, thereby increasing postoperative vulnerability.[4]

The pathophysiology of POCD is multifactorial and remains incompletely understood. Several mechanisms have been proposed, including neuroinflammation, cerebral hypoperfusion, oxidative stress, disruption of the blood–brain barrier, anesthetic neurotoxicity, and perioperative metabolic disturbances.[5]

Surgical trauma can trigger systemic inflammatory responses leading to release of cytokines and inflammatory mediators that may contribute to neuronal dysfunction. Intraoperative hypotension, hypoxia, anemia, and prolonged anesthesia exposure have also been implicated in impaired postoperative cognitive outcomes.

The influence of anesthetic technique on postoperative cognition has been extensively debated. General anesthesia has traditionally been considered a possible contributor to cognitive decline because of exposure to inhalational or intravenous anesthetic agents that may affect neuronal activity and cerebral autoregulation. Conversely, regional anesthesia may theoretically reduce neurocognitive complications by limiting systemic drug exposure and attenuating stress responses. However, available evidence remains inconsistent, and several studies have failed to demonstrate a definitive superiority of one anesthetic technique over another in preventing POCD.[6]

Therefore, it is likely that perioperative physiological stability and patient-related risk factors may play a more critical role than the anesthetic technique alone. Early identification of patients at risk for POCD is essential because preventive strategies may substantially improve postoperative outcomes. Optimization of comorbid conditions, avoidance of deep anesthesia, maintenance of adequate cerebral perfusion, multimodal analgesia, and early postoperative mobilization have all been suggested as beneficial perioperative interventions.[7]

Despite increasing awareness, data regarding POCD in elderly Indian surgical populations remain limited, particularly in tertiary care teaching hospitals.

Hence, the present prospective observational study was undertaken at Government Dindigul Medical College to evaluate the incidence of postoperative cognitive dysfunction in elderly surgical patients and to analyze the association between anesthetic techniques, perioperative risk factors, and postoperative cognitive outcomes.

MATERIALS AND METHODS

Study Design: This prospective observational study was conducted to evaluate postoperative cognitive dysfunction (POCD) in elderly surgical patients and to assess the influence of anesthetic techniques and perioperative risk factors on postoperative cognitive outcomes.

Study Setting: The study was carried out in the Department of Anaesthesiology at Government Dindigul Medical College and Hospital, Tamil Nadu, India.

Study Period: The study was conducted over a period of one year from January 2025 to January 2026.

Study Population: The study population consisted of elderly patients aged 60 years and above undergoing elective surgical procedures under general or regional anesthesia.

Sample Size: A total of 200 patients were included in the study using consecutive sampling.

Ethical Approval: Institutional Ethics Committee approval was obtained prior to commencement of the study. Written informed consent was obtained from all participants or their legally authorized representatives in accordance with ethical guidelines for biomedical research involving human participants.[8]

Inclusion Criteria

Patients fulfilling the following criteria were included in the study:

- Age 60 years and above
- Patients undergoing elective surgery
- Patients receiving general or regional anesthesia
- Patients willing to provide informed consent
- Patients able to participate in cognitive assessment

Exclusion Criteria

Patients with the following conditions were excluded:

- Previously diagnosed dementia
- Severe psychiatric illness
- History of major cerebrovascular accident with neurological deficit
- Severe visual or hearing impairment affecting cognitive evaluation
- Emergency surgical procedures
- Preoperative intensive care unit admission
- Refusal to participate in the study

Preoperative Assessment: A detailed preoperative evaluation was performed for all enrolled patients. Demographic details including age, gender, body mass index, educational status, and associated comorbidities were recorded. Clinical evaluation included assessment of hypertension, diabetes mellitus, ischemic heart disease, chronic obstructive pulmonary disease, renal dysfunction, and other systemic illnesses.

Perioperative risk stratification was performed using the American Society of Anesthesiologists (ASA) physical status classification system.[9]

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Baseline cognitive function was assessed one day before surgery using the Mini-Mental State Examination (MMSE), which is a validated tool commonly used for perioperative cognitive evaluation in elderly individuals.[10]

The MMSE evaluates orientation, memory, attention, language, and visuospatial function with a total score of 30 points.

Intraoperative Assessment

All patients were monitored intraoperatively using standard monitoring techniques including:

- Electrocardiography
- Pulse oximetry
- Noninvasive blood pressure monitoring
- Respiratory rate monitoring
- Temperature monitoring

The anesthetic technique was selected by the attending anesthesiologist based on surgical requirements and patient condition.

The following intraoperative variables were documented:

- Type of anesthesia
- Duration of surgery
- Duration of anesthesia
- Intraoperative hypotension
- Oxygen desaturation episodes
- Blood loss
- Intravenous fluid administration
- Blood transfusion
- Opioid administration
- Sedative drug usage

Intraoperative hypotension was defined as a reduction in mean arterial pressure greater than 20% from baseline for more than five minutes.[11]

Postoperative Assessment

Postoperative evaluation included assessment of:

- Pain using Visual Analog Scale (VAS)
- Delirium
- Sleep disturbance
- Postoperative complications
- ICU admission
- Duration of hospital stay

Postoperative cognitive assessment using MMSE was performed at 24 hours and 72 hours following surgery. A reduction in postoperative MMSE score compared with preoperative baseline score was considered indicative of postoperative cognitive dysfunction.

Outcome Measures

Primary Outcome

- Incidence of postoperative cognitive dysfunction among elderly surgical patients.

Secondary Outcomes

- Comparison of POCD between general and regional anesthesia groups.
- Identification of perioperative risk factors associated with POCD.
- Association between postoperative complications and cognitive dysfunction.
- Length of hospital stay among patients with POCD.

Statistical Analysis

Collected data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) software version 25.

- Continuous variables were expressed as mean ± standard deviation.
- Categorical variables were expressed as frequency and percentage.
- Chi-square test was used for comparison of categorical variables.
- Independent sample t-test was used for comparison of continuous variables.
- Logistic regression analysis was performed to identify independent predictors of POCD.
- A p-value less than 0.05 was considered statistically significant.[12]

RESULTS

Demographic Characteristics: A total of 200 elderly patients undergoing elective surgical procedures were included in the study. The mean age of the study population was 68.4 ± 6.2 years, with the majority of patients belonging to the 60–69 years' age group. [Figure 1]

Among the study participants, 118 (59%) were males and 82 (41%) were females. Most patients had at least one associated medical comorbidity, with hypertension and diabetes mellitus being the most commonly observed conditions. [Table 1]

The mean body mass index of the study population was 24.8 ± 3.6 kg/m². Educational status varied among participants, and lower educational attainment was more frequently observed among patients who developed postoperative cognitive dysfunction (POCD).

Clinical Profile and Comorbidities: Among the enrolled patients, hypertension was present in 96 (48%) patients, diabetes mellitus in 82 (41%), ischemic heart disease in 28 (14%), and chronic obstructive pulmonary disease in 19 (9.5%). According to ASA physical status classification, 74 (37%) patients belonged to ASA grade I, 98 (49%) to ASA grade II, and 28 (14%) to ASA grade III. [Table 2]

Patients with multiple comorbidities demonstrated a higher incidence of postoperative cognitive decline compared to patients without significant systemic illness.

Surgical and Anesthetic Characteristics: General anesthesia was administered in 112 (56%) patients, while 88 (44%) patients underwent surgery under regional anesthesia. [Figure 2]

The mean duration of surgery was 124.6 ± 38.2 minutes, and the average duration of anesthesia was 146.3 ± 41.5 minutes. [Table 3]

Intraoperative hypotension occurred in 46 (23%) patients, while transient oxygen desaturation episodes were observed in 18 (9%) patients. The

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mean estimated blood loss was significantly higher among patients undergoing major abdominal and orthopedic procedures.

Patients who received general anesthesia had comparatively longer operative duration and greater opioid exposure than those receiving regional anesthesia.

Incidence of Postoperative Cognitive Dysfunction: The overall incidence of POCD observed in the present study was 26% (52 patients). Cognitive decline was identified based on reduction in postoperative MMSE scores compared with baseline assessment. Among patients receiving general anesthesia, POCD was observed in 36 (32.1%) patients, whereas only 16 (18.2%) patients in the regional anesthesia group developed postoperative cognitive dysfunction. The difference between the two groups was statistically significant ($p = 0.028$). [Table 4, Figure 3]

The majority of patients who developed POCD demonstrated mild to moderate impairment in attention, short-term memory, and orientation during the early postoperative period.

Association Between Perioperative Factors and POCD: Advanced age was significantly associated with postoperative cognitive dysfunction. Patients aged above 70 years demonstrated a higher incidence of POCD compared with younger elderly patients. Intraoperative hypotension was observed more frequently among patients who developed POCD than among those without cognitive decline. [Figure 4]

Similarly, prolonged duration of surgery and anesthesia showed significant association with postoperative cognitive impairment. [Table 5]

Patients with higher postoperative pain scores and increased opioid requirements demonstrated greater incidence of POCD. ICU admission and postoperative sleep disturbances were also more common among cognitively affected patients.

The incidence of POCD was notably higher among patients with multiple comorbidities and higher ASA grades.

Postoperative Outcomes: Patients who developed postoperative cognitive dysfunction had prolonged hospital stay compared with patients without POCD. The mean duration of hospital stay among POCD patients was 8.6 ± 2.4 days, whereas patients without cognitive dysfunction had an average stay of 5.2 ± 1.8 days. Postoperative complications including respiratory infections, delayed mobilization, and postoperative delirium were more frequently observed among patients with cognitive dysfunction. [Table 6]

Most patients demonstrated gradual improvement in cognitive function during follow-up; however, a subset of elderly patients continued to exhibit persistent cognitive impairment at the time of discharge.

Patients who developed POCD also demonstrated significantly longer duration of surgery compared with patients without postoperative cognitive impairment. [Figure 5]

Multivariate Analysis: Logistic regression analysis identified advanced age, general anesthesia, prolonged duration of surgery, intraoperative hypotension, and postoperative pain severity as independent predictors of postoperative cognitive dysfunction. [Table 7]

Among these variables, prolonged surgery duration and intraoperative hypotension demonstrated the strongest association with postoperative cognitive decline.

Summary of Major Findings: The present study demonstrated that postoperative cognitive dysfunction is a relatively common complication among elderly surgical patients. General anesthesia, prolonged surgery, hemodynamic instability, postoperative pain, and associated comorbidities significantly increased the risk of POCD. Early perioperative identification of high-risk patients and implementation of preventive strategies may improve postoperative cognitive outcomes in elderly individuals.

Table 1: Demographic Characteristics of the Study Population (n = 200)

Variable	Frequency (n)	Percentage (%)	p-value
Age Group (years)			0.003
60–69	118	59.0	
70–79	64	32.0	
≥80	18	9.0	
Gender			0.214
Male	118	59.0	
Female	82	41.0	
Body Mass Index (kg/m²)	24.8 ± 3.6	—	0.087
Educational Status			0.041
Illiterate	42	21.0	
Primary school	76	38.0	
Secondary school	58	29.0	
Graduate and above	24	12.0	

Table 2: Distribution of Comorbidities and ASA Physical Status

Variable	Frequency (n)	Percentage (%)	p-value
Hypertension	96	48.0	0.018
Diabetes Mellitus	82	41.0	0.024

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Ischemic Heart Disease	28	14.0	0.037
Chronic Obstructive Pulmonary Disease	19	9.5	0.046
Chronic Kidney Disease	11	5.5	0.061
ASA Grade I	74	37.0	0.009
ASA Grade II	98	49.0	0.013
ASA Grade III	28	14.0	0.004

Table 3: Surgical and Anesthetic Characteristics

Variable	Frequency (n) / Mean ± SD	p-value
General Anesthesia	112 (56.0%)	0.028
Regional Anesthesia	88 (44.0%)	0.028
Duration of Surgery (minutes)	124.6 ± 38.2	0.0001
Duration of Anesthesia (minutes)	146.3 ± 41.5	0.0003
Intraoperative Hypotension	46 (23.0%)	0.0004
Oxygen Desaturation Episodes	18 (9.0%)	0.033
Mean Blood Loss (mL)	312 ± 104	0.019
Blood Transfusion Required	26 (13.0%)	0.027
Opioid Administration	134 (67.0%)	0.016

Table 4: Incidence of Postoperative Cognitive Dysfunction According to Anesthetic Technique

Anesthetic Technique	Total Patients	POCD Present	POCD Absent	Incidence (%)	p-value
General Anesthesia	112	36	76	32.1	0.028
Regional Anesthesia	88	16	72	18.2	0.028
Total	200	52	148	26.0	0.028

Table 5: Association Between Perioperative Variables and POCD

Variable	POCD Present (n=52)	POCD Absent (n=148)	p-value
Mean Age (years)	72.1 ± 5.8	66.9 ± 5.7	0.003
Intraoperative Hypotension	24 (46.1%)	22 (14.9%)	0.0004
Duration of Surgery (minutes)	154.2 ± 32.4	113.8 ± 28.6	0.0001
Duration of Anesthesia (minutes)	176.3 ± 36.8	134.2 ± 31.5	0.0002
Postoperative Pain Score (VAS)	6.8 ± 1.2	4.9 ± 1.1	0.012
ICU Admission	18 (34.6%)	14 (9.5%)	0.0008
Sleep Disturbance	21 (40.3%)	26 (17.6%)	0.015
Blood Loss >500 mL	16 (30.7%)	19 (12.8%)	0.021
Opioid Requirement	39 (75.0%)	95 (64.2%)	0.039

Table 6: Multivariate Logistic Regression Analysis for Predictors of POCD

Variable	Odds Ratio (OR)	95% Confidence Interval	p-value
Age >70 years	2.4	1.3 – 4.5	0.011
General Anesthesia	1.9	1.1 – 3.6	0.026
Prolonged Surgery Duration	3.1	1.7 – 5.2	0.0002
Intraoperative Hypotension	3.8	2.0 – 6.4	0.0001
High Postoperative Pain Score	2.2	1.2 – 4.1	0.018
ICU Admission	2.6	1.4 – 4.8	0.009
Multiple Comorbidities	2.1	1.1 – 3.9	0.022

Table 7: Postoperative Outcomes Among Study Participants

Outcome Variable	POCD Present	POCD Absent	p-value
Mean Hospital Stay (days)	8.6 ± 2.4	5.2 ± 1.8	0.0003
Postoperative Delirium	17 (32.6%)	9 (6.1%)	0.0001
Respiratory Complications	12 (23.0%)	11 (7.4%)	0.021
Delayed Mobilization	28 (53.8%)	32 (21.6%)	0.0005
ICU Stay >48 hours	14 (26.9%)	10 (6.7%)	0.002
Readmission Within 30 Days	7 (13.4%)	5 (3.4%)	0.018
Persistent Cognitive Impairment at Discharge	11 (21.1%)	4 (2.7%)	0.0006

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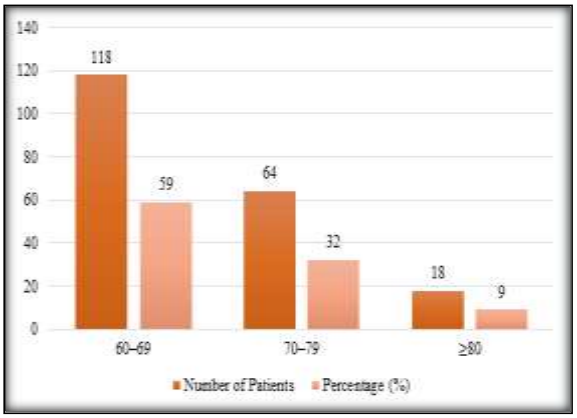

Figure 1: Age Distribution of Study Participants

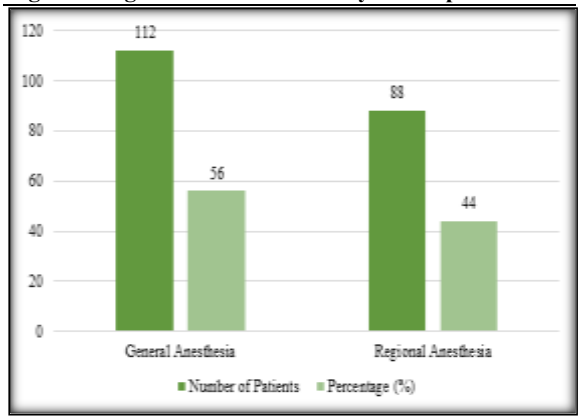

Figure 2: Distribution of Anesthetic Techniques

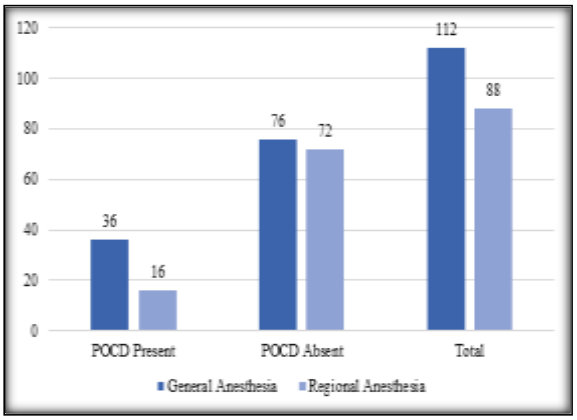

Figure 3: Incidence of POCD According to Anesthetic Technique

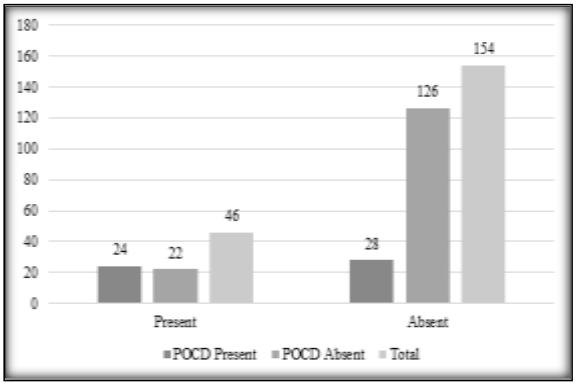

Figure 4: Association Between Intraoperative Hypotension and POCD

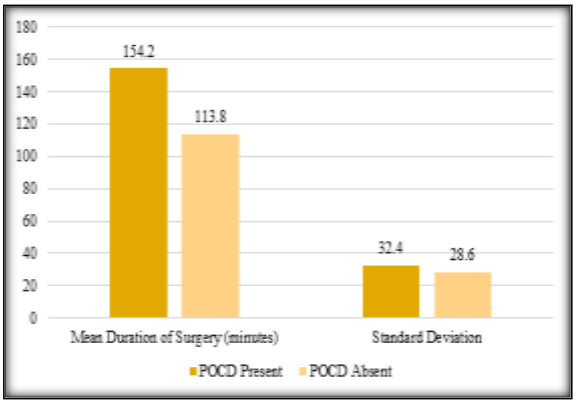

Figure 5: Comparison of Mean Duration of Surgery Between POCD and Non-POCD Groups

DISCUSSION

The present prospective observational study evaluated the incidence of postoperative cognitive dysfunction (POCD) among elderly surgical patients and examined the influence of anesthetic techniques and perioperative risk factors on postoperative cognitive outcomes. The findings of the study demonstrated that POCD remains a frequent postoperative complication in elderly individuals, with an overall incidence of 26%. Advanced age, general anesthesia, prolonged duration of surgery, intraoperative hypotension, postoperative pain, and multiple comorbidities were significantly associated with postoperative cognitive decline.

The observed incidence of POCD in the present study is comparable to findings reported in previous literature, where postoperative cognitive impairment among elderly surgical patients has been documented to range between 10% and 40% depending on patient population, surgical complexity, timing of cognitive assessment, and diagnostic criteria used.[13] Elderly individuals possess reduced neuronal reserve and increased susceptibility to neuroinflammatory responses triggered by surgery and anesthesia, making them particularly vulnerable to perioperative cognitive disturbances.

In the current study, patients receiving general anesthesia demonstrated a significantly higher incidence of POCD compared with those receiving regional anesthesia. Although the exact mechanisms remain uncertain, exposure to systemic anesthetic agents during general anesthesia may contribute to alterations in neurotransmitter regulation, cerebral autoregulation, and neuroinflammatory pathways.[14] Regional anesthesia may attenuate surgical stress responses and reduce systemic exposure to sedative and opioid medications, thereby potentially offering some protective effect against postoperative cognitive impairment. However, it is important to recognize that anesthetic technique alone may not fully explain postoperative cognitive outcomes, as several patient-related and perioperative factors interact in a multifactorial manner.

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Advanced age emerged as one of the strongest predictors of postoperative cognitive dysfunction in the present study. Patients older than 70 years demonstrated greater postoperative decline in MMSE scores compared with younger elderly individuals. Similar observations have been reported in previous studies, emphasizing that aging-related cerebral changes, impaired synaptic plasticity, and pre-existing subclinical cognitive impairment increase vulnerability to postoperative neurocognitive disorders.[15] Furthermore, elderly patients frequently have impaired physiological reserve, which limits their ability to tolerate perioperative hemodynamic fluctuations and inflammatory stress.

Intraoperative hypotension showed a significant association with POCD in the present study. Patients who experienced prolonged reductions in mean arterial pressure demonstrated increased incidence of postoperative cognitive impairment. Cerebral hypoperfusion resulting from hypotension may contribute to neuronal ischemia and disruption of cerebral autoregulation, particularly in elderly individuals with underlying vascular disease.[16] Maintenance of adequate intraoperative hemodynamic stability is therefore essential in minimizing perioperative cerebral injury and preserving postoperative cognitive function.

The present study also demonstrated that prolonged duration of surgery and anesthesia were significantly associated with increased risk of POCD. Longer operative duration may result in prolonged exposure to anesthetic agents, greater inflammatory response, increased blood loss, and higher perioperative physiological stress. Similar findings have been reported in earlier investigations evaluating perioperative neurocognitive disorders among elderly patients undergoing major surgery.[17]

Postoperative pain severity and increased opioid requirements were additional factors associated with cognitive decline in the present study. Poorly controlled postoperative pain can activate neuroendocrine stress responses and sleep disturbances, both of which may adversely affect postoperative cognitive recovery. Conversely, excessive opioid administration may contribute to sedation, delirium, and impaired cognitive performance. These findings highlight the importance of balanced multimodal analgesic strategies in elderly surgical patients.

Patients who developed POCD had prolonged hospital stay and increased postoperative complications compared with cognitively unaffected individuals. Delayed mobilization, respiratory complications, and postoperative delirium were more frequently observed among patients with cognitive dysfunction. These findings emphasize the broader clinical significance of POCD beyond transient memory impairment, as postoperative cognitive decline may substantially influence functional recovery, rehabilitation, healthcare utilization, and long-term quality of life.

The strengths of the present study include its prospective design, standardized perioperative assessment, and evaluation of multiple perioperative variables associated with cognitive dysfunction. However, certain limitations should be acknowledged. Cognitive assessment was limited to the early postoperative period, and long-term neurocognitive follow-up was not performed. The study was conducted at a single tertiary care center, which may limit generalizability of findings. In addition, the use of MMSE alone may not detect subtle cognitive changes affecting higher executive functions.

Despite these limitations, the present study highlights the importance of perioperative cognitive assessment in elderly surgical patients. Early identification of high-risk individuals, optimization of comorbid conditions, avoidance of prolonged intraoperative hypotension, careful anesthetic titration, and effective postoperative pain management may contribute to reduction in postoperative cognitive dysfunction and improvement in surgical outcomes among elderly patients.

CONCLUSION

Postoperative cognitive dysfunction is a significant and clinically relevant complication among elderly surgical patients, contributing to delayed recovery, prolonged hospitalization, and increased postoperative morbidity. The present study demonstrated that the incidence of POCD was notably higher among patients with advanced age, multiple comorbid conditions, prolonged surgical duration, intraoperative hypotension, and greater postoperative pain severity. General anesthesia was associated with a comparatively higher occurrence of postoperative cognitive decline when compared with regional anesthesia, although perioperative physiological disturbances and patient-related factors also played a substantial role in the development of cognitive impairment.

The findings of this study emphasize that postoperative cognitive dysfunction is multifactorial in origin and cannot be attributed solely to anesthetic technique. Careful perioperative assessment, optimization of systemic illnesses, maintenance of intraoperative hemodynamic stability, adequate oxygenation, judicious anesthetic administration, and effective postoperative pain management are essential measures that may reduce the risk of postoperative cognitive decline in elderly individuals.

Early identification of high-risk patients through routine cognitive screening and implementation of preventive perioperative strategies may improve postoperative outcomes and quality of life in the aging surgical population. Multidisciplinary perioperative care involving anesthesiologists, surgeons, physicians, nursing staff, and rehabilitation teams is crucial for minimizing postoperative

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neurocognitive complications and enhancing recovery in elderly patients undergoing surgery. Further large-scale multicentric studies with long-term follow-up are required to better understand the underlying mechanisms of POCD and to establish evidence-based preventive protocols for elderly surgical patients.

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