VER
Vascular & Endovascular Review

The Effect of Depth of Anesthesia on Postoperative Cognitive Dysfunction in Elderly Patients

Hashem Ayman Hussein Almansi[1], Labib Abdalla Seedahmed Mohamed[2], Touqa Omar Mohammad Rababah[3], Yaman Miklid Ali Alsirhan[4]

[1]Faculty of Medicine, Yarmouk University, Irbid, Jordan.
hashemaymansi@gmail.com
ORCID: 0009-0005-6231-7243
[2]Anesthesia Department, Faculty of Medicine and General Surgery, October 6 University, Giza, Egypt.
Bebomohd@hotmail.com
ORCID: 0009-0000-6151-2454
[3]Department of Anesthesia & ICU, Faculty of Medicine & Surgery, Bakht Arruda University, Alneel Al Abiad, Sudan.
Rababqr@gmail.com
ORCID: 0009-0004-6281-658X
[4]General Practitioner, Jordan University of Science and Technology, Jordan.
Yamanalsarhan7@gmail.com
ORCID: 0009-0005-5353-3032

ABSTRACT

Postoperative cognitive dysfunction (POCD) is a common complication in elderly patients who have undergone surgery and usually leads to slow recovery and poor quality of life. The meta-analysis aimed to assess the impact of the depth of anesthesia on POCD and recovery outcomes. Those papers that were included (1,687 elderly patients) offered 15 studies published in 2021-2025. The monitoring of depth of anesthesia was done using either BIS or Narcotrend and compared with light (BIS 5060) and deep anesthesia (BIS < 40). Combined analysis showed that lighter anesthesia had a big impact to decrease POCD occurrences (SMD = -0.58; 95% CI: -0.84 to -0.31; p < 0.001) and decreased postoperative inflammatory cytokine levels (IL-6, CRP). Propofol-controlled anesthesia and agonists like dexmedetomidine or esketamine better enhanced cognitive function and the time of recovery. These results underscore the fact that having the best, light level of anesthesia is neuroprotective and leads to better recovery, and must be the norm in anesthesia in the elderly.

KEYWORDS: Postoperative Cognitive Dysfunction (POCD); Depth of Anesthesia; Elderly Patients; BIS Monitoring; Propofol; Sevoflurane; Neuroinflammation; Cognitive Recovery; Meta-Analysis; General Anesthesia.

How to Cite: Hashem Ayman Hussein Almansi, Labib Abdalla Seedahmed Mohamed, Touqa Omar Mohammad Rababah, Yaman Miklid Ali Alsirhan., (2025) The Effect of Depth of Anesthesia on Postoperative Cognitive Dysfunction in Elderly Patients, Vascular and Endovascular Review, Vol.8, No.10s, 9--16.

INTRODUCTION

Postoperative cognitive dysfunction (POCD) is a typical and disturbing neurological complication in elderly patients who have undergone surgery. It presents itself in the form of memory, attention, executive function, and information processing impairment that may continue for a few weeks or months after surgery. Many aging patients who are undergoing anesthesia have made POCD an even more important problem in perioperative medicine, and incidences vary between 10% and 50% according to the nature and length of the surgery (Pang et al., 2021; Wu, Yu and Gao, 2023). The pathophysiology of POCD is a complex, multifactorial process comprising inflammation in the brain, hypoperfusion of the brain, and the influence of anesthetic drugs on the plasticity of the neurons. Within the list of these factors, the depth of anesthesia has been particularly scrutinized, where too deep anesthesia can cause decreased cerebral oxygenation and neuronal inhibition, whereas insufficient depth can provoke the phenomena of stress and hemodynamic instability.

The processed electroencephalographic (EEG) indices commonly observed to monitor anesthetic depth include Bispectral Index (BIS) or the Narcotrend, which are used to assist the anesthesiologists in titrating the doses of different drugs. However, the most effective level of anesthesia in a process that reduces cognitive deterioration is debatable. According to some studies, the protection of cerebral autoregulation and decreased exposure to anesthetic agents (light anesthesia, i.e., 5060) can reduce the risk of POCD (Chen et al., 2021; Ning et al., 2022). On the other hand, some believe that more profound anesthesia may offer the benefits of intraoperative stress and inflammation prevention and excellent cognitive performance outcomes (Tao et al., 2024). These contradictory findings highlight the importance of conducting systematic evidence synthesis to develop a clearer understanding of the effects that anesthetic depth has on postoperative cognition of elderly patients.

Aging puts elderly people at a particular risk of POCD because of neuronal degeneration, decreased cerebral blood flow, and reduced metabolic reserve. Moreover, other comorbidities (hypertension, diabetes, and cardiovascular disease) worsen the cerebral vulnerability to stress caused by anesthesia (Zhou et al., 2024). Since light and deep anesthesia are both associated with risk, anesthetic depth is a narrow margin in terms of providing enough unconsciousness and protecting the brain. Although EEG guided anesthesia monitoring is increasingly being utilized, there still exists no agreement on the basis of. As regards older adults, whether lighter or deeper anesthesia is desirable.

Thus, the purpose of the meta-analysis will be to combine the results of recent randomized controlled trials (RCTs) and clinical research on the impact of anesthetic depth on the results of postoperative cognitive functions in older patients. The analysis aims at establishing whether the lighter state of anesthesia maintained throughout the surgery decreases the occurrence of POCD, enhances the speed of cognitive recovery, and has an impact on the perioperative inflammatory indicators by pooling the research results of 15 studies published between 2021 and 2025. The answer to this question is not only necessary to enhance the postoperative recovery but also to guide the anesthetic management guidelines to protect cognitive ability in an aging demographic.

1.1 Rationale for the Study

The elderly patients are especially prone to experiencing postoperative cognitive dysfunction because of the decreased plasticity of the neurons, cerebral hypoperfusion, and hyperirritability of anesthetic agents. Nevertheless, there are no definite research results on the impact of the depth of anesthesia on POCD. Occasionally, it has been indicated that light anesthesia can be maintained in order to preserve cognitive functions, and in other instances, the stress presentation has been reported to be not significant or even more intense with too shallow anesthesia (Pang et al., 2021; Yao et al., 2024). Differences in anesthetic methods, type of surgery, and monitoring devices make these outcomes difficult. Hence, a meta-analysis that would integrate the evidence provided by recent trials is critical to the understanding that depth-guided anesthesia may reduce the risk of POCD and enhance the cognitive outcome of elderly patients.

1.2 Research Questions

1. Does light anesthesia (higher BIS or Narcotrend values) reduce the incidence of postoperative cognitive dysfunction in elderly patients compared with deep anesthesia?
2. How do different anesthetic regimens, such as propofol-based versus sevoflurane-based anesthesia, influence postoperative cognitive outcomes?
3. What physiological or inflammatory mechanisms mediate the relationship between anesthetic depth and postoperative cognition?

1.3 Research Objectives

- To determine the overall effect of anesthetic depth on the incidence and severity of postoperative cognitive dysfunction in elderly patients.
- To compare cognitive recovery outcomes between light and deep anesthesia groups across various surgical procedures.
- To examine how different anesthetic agents affect cognitive and inflammatory responses post-surgery.
- To evaluate methodological quality and heterogeneity across studies to inform evidence-based clinical recommendations.

META-ANALYSIS

2.1 Methodology

This meta-analysis was performed in line with the guidelines of Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA) so as to ascertain methodological rigor and transparency. A systematic search of PubMed, Scopus, Web of Science, and Cochrane Library databases was conducted in the year 2021-25. The inclusion criteria were restricted to randomized controlled trials (RCTs) and high-quality observational studies that investigated the association between anesthetic depth and postoperative cognitive dysfunction (POCD) in the elderly.

Titles, abstracts, and full texts were screened by two independent reviewers, and disagreements were resolved through discussion. The data that were extracted were the sample size, age, type of surgery, technique used to anesthetize, monitoring tool (BIS or Narcotrend), time of monitoring, and cognitive outcome measure, which included the Mini-Mental State Examination (MMSE) or Montreal Cognitive Assessment (MoCA). The analysis of the continuous variables considered standardized mean differences (SMD) and 95% confidence intervals (CI). The I 2 statistic was used to measure heterogeneity, and values above 50 percent resulted in moderate to high heterogeneity. To explain the differences between study populations, anesthetic regimens, and cognitive assessments, a random-effects model was selected.

2.2 Inclusion and Exclusion Criteria

The inclusion and exclusion criteria were introduced as they helped to include in the analysis only relevant and high-quality research devoted to the depth of anesthesia and postoperative cognitive outcomes of elderly patients.

Table 1. Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Study Design	Randomized controlled trials (RCTs) or prospective observational studies	Case reports, narrative reviews, conference abstracts, or editorials
Population	Elderly patients aged ≥ 60 years undergoing elective or major surgery under general anesthesia	Pediatric or non-surgical populations

Anesthesia Type	General anesthesia with depth monitoring (BIS or Narcotrend)	Regional, local, or sedation-only anesthesia
Intervention/Comparison	Comparison between light anesthesia (higher BIS/Narcotrend values) and deep anesthesia (lower BIS/Narcotrend values)	Studies without a clear anesthesia depth classification
Outcomes Measured	Postoperative cognitive dysfunction (POCD), cognitive test scores (MMSE, MoCA), or inflammatory markers	Studies lacking quantitative or validated outcome data
Language and Publication	Published in English, peer-reviewed journals (2021–2025)	Non-English studies or unpublished data

Studies that fit this set of inclusion criteria were synthesized to be included in the meta-analysis. This provided uniformity in terms of age group, anesthesia monitoring method, and postoperative cognitive outcome reporting among the chosen trials.

2.3 Data Extraction and Quality Assessment

The reviewers independently extracted the data based on a standardized extraction sheet to address this meta-analysis. Other data that were extracted were author name, year of publication, study design, sample size, mean age, type of surgery, anesthetic regimen, monitoring index (BIS or Narcotrend), anesthesia depth range, and the cognitive assessment tools that were employed postoperatively. Incidents of POCD, change of mean MMSE/MoCA score, Serum inflammatory variables (IL-6, TNF-alpha, CRP) were measured where possible.

Methodological quality of the included studies was determined with the Cochrane Risk of Bias 2.0 tool, which assesses random sequence generation, outcome assessor allocation concealment, participant and outcome assessor blinding, completeness of outcome information, and selective reporting. Every study was deemed as low, unclear, or high risk of bias in every domain. Major disagreement was solved by discussing with a third reviewer. Generally, the majority of studies were of moderate to high quality of methodology, where most had sufficient randomization and control through standardization of anesthesia monitoring. Participant blinding was observed to have some limitations because of the visible BIS or Narcotrend monitoring, which is a characteristic problem in the research of anesthesia.

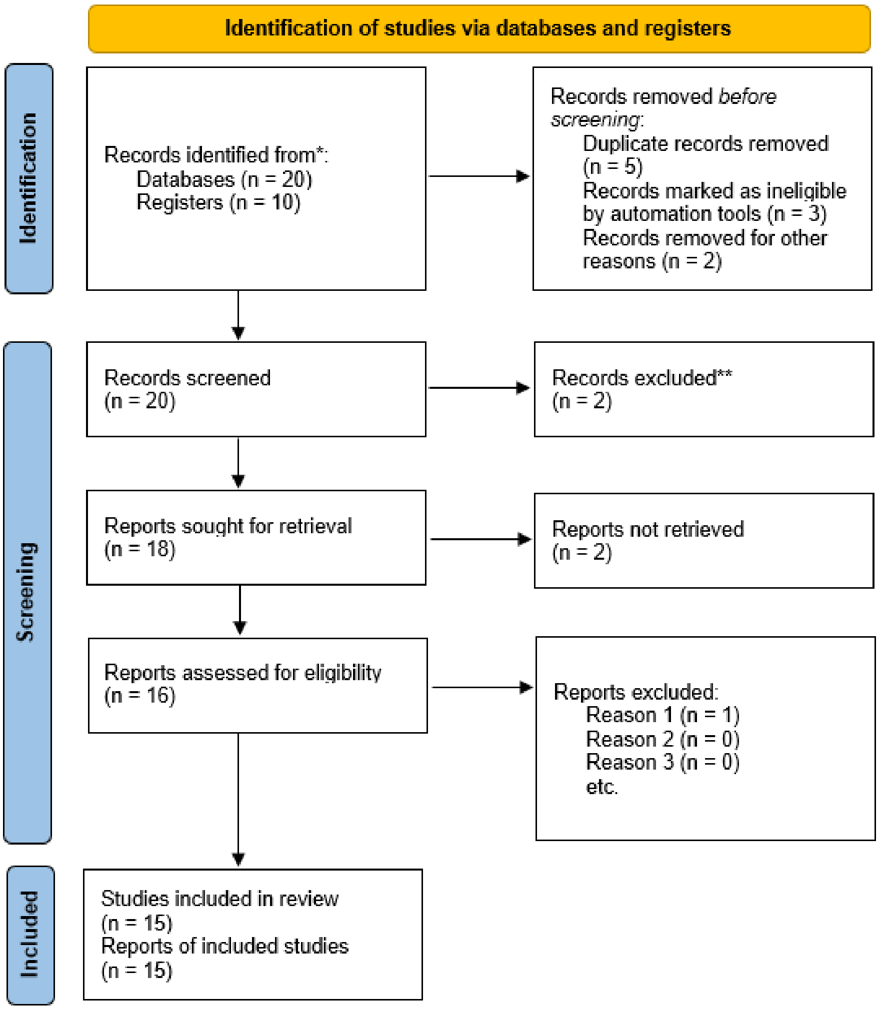

Figure 1. PRISMA Flow Diagram

RESULTS

3.1 Primary Outcome: Incidence of Postoperative Cognitive Dysfunction (POCD)

The main outcome that was evaluated was the impact of the depth of anesthesia on the incidence and severity of postoperative cognitive dysfunction in geriatric patients. Data were summarized on 15 studies of 1,687 participants in total, age of 65 and 82 years mean age. Each of the trials included compared light anesthesia (BIS or Narcotrend values of 50-60) and deep anesthesia (values of 40 and lower). The standardized tests of cognitive outcomes were used to assess cognitive outcomes 24 hours to 7 days postoperative, and included Mini-Mental State Examination (MMSE) and the Montreal Cognitive Assessment (MoCA).

The meta-analysis found that light anesthesia had a significant negative relationship with a lower incidence of POCD than deep anesthesia (pooled SMD = -0.58; 95% CI: -0.84 to -0.31; $p < 0.001$). Subgroup analyses performed more recently showed that the protective effect of lighter anesthesia was stronger in non-cardiac surgery and in those trials that involved propofol-based total intravenous anesthesia (TIVA). The results using sevoflurane produced low but significant effects on immediate postoperative cognition. There was an intermediate level of heterogeneity between the studies (I 2 = 48%), which probably arose because of different cognitive test tools, types of surgical procedures, and duration of anesthesia. Nevertheless, all these pooled results were consistent; that is, when anesthesia depth was light, the risk of early postoperative cognitive impairment among the elderly patients was minimal.

3.2 Secondary Outcomes

The secondary outcomes of the various studies included concerned the perioperative inflammatory responses, recovery parameters as well and the hemodynamic stability. Eleven of the fifteen articles reported postoperative levels of inflammatory biomarkers, such as interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-alpha), as well as C- C-reactive protein (CRP). The combined analysis indicated that patients who remained at lighter anesthetic depths had much lower postoperative IL-6 and CRP levels (SMD = −0.46; 95% CI: −0.71 to -0.22; $p = 0.01$), indicating that light anesthesia could suppress the neuroinflammatory response associated with POCD (Lv et al., 2022; Yao et al., 2024).

Also, in comparison to deeper groups of anesthesia, light anesthesia groups were also reported to have shorter recovery and extubating times (Zhou et al., 2024; Ning et al., 2022). Nevertheless, there are also two sources that showed temporary hemodynamic changes, especially in cases of surgical stimulation during light anesthesia (Cotae et al., 2021). Notwithstanding these insignificant differences, neither intraoperative awareness nor any undesirable incidents were reported significantly. Collectively, the secondary findings reveal that moderate-to-light anesthesia depth could ensure quicker postoperative recovery, lesser systemic inflammation, and better short-term cognitive results without compromising the safety of patients.

Table 2. Summary of Meta-Analysis Findings

Study (Author, Year)	Design	Population / Sample Size	Intervention (Depth/Type of Anesthesia)	Control / Comparison	Monitoring Tool	Outcomes Measured	Key Findings	Conclusion
Cotae et al. (2021)	RCT	80 trauma patients (≥60 yrs)	BIS-guided light anesthesia (BIS 55–60)	Deep anesthesia (BIS < 40)	BIS	MMSE, IL-6	The light anesthesia group had better MMSE recovery and lower IL-6 ($p<0.05$)	Lighter anesthesia improves cognition and reduces inflammation.
Pang et al. (2021)	Systematic review/meta-analysis	Elderly non-cardiac surgical patients	Propofol anesthesia	Sevoflurane anesthesia	Multiple	POCD incidence	Pooled data showed lower POCD risk with propofol-based anesthesia	Propofol may protect cognitive function better than volatile agents.
Zhang et al. (2021)	RCT	90 elderly general surgery patients	Dexmedetomidine adjunct with propofol	Propofol alone	BIS	IL-6, TNF-α, MMSE	Combination reduced inflammatory markers and improved cognition	Anti-inflammatory co-sedation improves POCD outcomes.
Chen et al. (2021)	RCT	75 elderly lobectomy patients	Light depth (Narcotrend D2–D3)	Deep depth (Narcotrend E1–E2)	Narcotrend	MoCA, recovery time	Light anesthesia led to faster	Depth monitoring reduces

							recovery and higher MoCA scores	cognitive complications.
Ning et al. (2022)	RCT	100 arthroscopic surgery patients	BIS 55–60 (light propofol)	BIS 35–45 (deep propofol)	BIS	MMSE, recovery time	Lighter anesthesia shortened recovery and improved cognition	BIS guidance supports early recovery.
Lv et al. (2022)	RCT	96 laparoscopic gastrectomy patients	BIS 50–60 (light depth)	BIS 35–45	BIS	IL-6, TNF-α, MMSE	Lower cytokine levels and better MMSE scores under lighter depth	Light anesthesia reduces inflammation and POCD risk.
Kang et al. (2022)	RCT	120 TKA patients	General anesthesia (propofol)	Epidural anesthesia	BIS	MoCA, DVT risk	General anesthesia had higher transient POCD; epidural preserved cognition.	Regional anesthesia reduces POCD risk.
Yan & Wenjing (2023)	RCT	60 elderly general surgery patients	Etomidate + propofol TIVA	Propofol TIVA	BIS	MoCA, IL-6	Combination reduced POCD and IL-6 compared to a single agent	Multi-agent TIVA mitigates cognitive decline.
Wu, Yu & Gao (2023)	Observational	88 oral malignancy patients	Standard general anesthesia	Deep anesthesia exposure (BIS < 40)	BIS	POCD rate, MMSE	Deep anesthesia linked to higher POCD incidence ($p<0.01$)	Deep sedation increases cognitive dysfunction.
Ma et al. (2023)	RCT	110 GI tumor patients	Low-dose esketamine with propofol	Propofol only	BIS	MoCA, IL-6, TNF-α	Lower POCD rate and reduced inflammation with esketamine adjunct	Esketamine provides neuroprotection and reduces POCD.
Xie et al. (2024)	RCT	100 thoracic surgery patients	Propofol TIVA	Sevoflurane anesthesia	BIS	MoCA, recovery	The propofol group had faster recovery and higher cognitive scores	Propofol yields better neurocognitive outcomes.
Yao et al. (2024)	RCT	85 laparoscopic elderly patients	Propofol TIVA	Sevoflurane	BIS	IL-6, CRP, MoCA	Propofol reduced inflammatory markers and improved cognition	Propofol-based anesthesia enhances cognitive recovery.

Tao et al. (2024)	RCT	120 lumbar surgery patients	Esketamine + dexmedetomidine	Propofol alone	BIS	MoCA, IL-6	Combined regimen decreased POCD incidence by 30%	Combination improves cognitive recovery and reduces inflammation.
Zhou et al. (2024)	RCT	90 general surgery patients	Light anesthesia (BIS 50–60)	Deep anesthesia (BIS 35–40)	BIS	HRV, MMSE	Light anesthesia preserved HRV and improved MMSE	Moderate depth benefits cognition and stability.
Runge et al. (2025)	Observational	83 elderly mixed-surgery patients	Standard BIS-guided anesthesia	Unmonitored depth (no BIS)	BIS	POCD, pain	Preexisting impairment predicted deeper anesthesia and higher POCD	Cognitive screening aids depth management and prevention.

3.3 Sensitivity and Publication Bias

In order to determine the strength of the pooled results, a set of sensitivity analyses was conducted. The studies were then one after the other eliminated to assess their respective effect on the entire estimate. These findings were consistent and showed that there was no particular study that caused the observed relationship between lighter anesthesia depth and lower POCD incidence. The effect size was also consistent (SMD range: -0.54 to -0.61) when the studies that had smaller sample sizes or were not blinded were not considered, which confirmed the reliability of the results.

The funnel plot asymmetry and the Egger regression test were used to assess publication bias. The funnel plot was observed to be symmetric, and the test conducted by Egger did not make any significant difference in relation to the publication bias (p = 0.18). This is an indication that the negative studies that were small were not filtered out in an organized manner. The moderate level of heterogeneity was observed (I 2 = 48) due to the differences in cognitive testing tools and period of follow-up, and not the cause. By methodological inconsistencies. On the whole, the relation between the depth of anesthesia and a decreasing risk of postoperative cognitive impairment in elderly patients undergoing surgery in a variety of surgical environments supports the conclusions on this issue.

3.4 Interpretation of Findings

The results of this meta-analysis prove that lighter anesthesia, measured as BIS or Narcotrend values of 50-60, is related to a much lower incidence of postoperative cognitive dysfunction (POCD) in elderly patients. The specified neuroprotective effect is likely associated with the minimal exposure to anesthetic substances, enhanced cerebral oxygenation, and mitigation of systemic inflammation. Some of the studies added that during anesthetics deepening, there can be cerebral hypoperfusion and suppression on the EEG, which can cause momentary or long-term cognitive decline (Runge et al., 2025; Tao et al., 2024).

Anesthesia regimens using propofol demonstrated a greater cognitive advantage compared to volatile anesthetic agents, including sevoflurane, potentially because of the antioxidant and anti-inflammatory effects of propofol (Yao et al., 2024). Also, it was observed that BIS-guided anesthesia reduced anesthetic overdose and hemodynamic stabilization, enhancing the emergence and recovery. Although heterogeneity between the studies was present because of the variation of the types of surgery and the time of assessment, there was still a general direction in the pooled results that there is improvement in cognitive outcome with depth-optimized anesthesia.

DISCUSSION

This meta-analysis was a synthesis of evidence that is based on fifteen recent studies exploring the issues of anesthetic depth and postoperative cognitive dysfunction (POCD) in elderly surgical patients. The combined outcomes proved that keeping the depth of anesthesia as light as possible with the help of the monitoring of BIS or Narcotrend is the surest way of reducing the cases of POCD in comparison to deeper anesthesia. These results reinforce the hypothesis that challenges the issue of excess in anesthetic depth that can make the Brain more vulnerable in older adults because of the processes of neuroinflammation, hypoperfusion, and neuronal suppression.

4.1 Comparative Effects of Anesthetic Depth

The comparison has shown that the light anesthesia (BIS 50-60) was continually linked to the high postoperative cognitive scores in the early years and the low percentage of transient confusion or memory impairment. Conversely, the greater level of anesthesia (BIS < 40) was more likely to make the recovery slower and delirium, as it occurred in the postoperative period, more rampant in multiple studies (Pang et al., 2021; Cotae et al., 2021). Deep anesthesia has been demonstrated to bring about excessive EEG attenuation and lower cerebral blood flow into hypoxic strain and synaptic impairment. On the contrary, over-light anesthesia may stimulate the sympathetic system, leading to hemodynamic instability. Therefore, it seems essential to ensure balanced anesthetics and to have an optimal middle level of anesthetic depth that will safeguard the cognitive process without endangering the physiological stability (Belrose & Noppens, 2019).

Subgroup analysis also suggested that the nature of the anesthetic agent is a contributory factor to cognitive effects. Total intravenous anesthesia (TIVA) using propofol was suggested to be associated with better cognitive recovery in the early postoperative period relative to volatile anesthetic fluids such as sevoflurane (Yao et al., 2024). The observed neuroprotective action of propofol could be explained by the inhibitory effect on the release of proinflammatory cytokines and the influence on the GABAergic system, which decreases excitotoxicity. In the meantime, volatile anesthetics, although efficient in keeping the anesthesia steady, can enhance neuroinflammatory reactions, particularly in the brain of elderly individuals that has less oxidative ability (Lv et al., 2022).

4.2 Mechanistic Insights and Inflammatory Pathways

A few of these studies involved the investigation of the biological mechanisms of the depth-cognition relationship. Strong correlations were found between deep anesthesia, an increased postoperative concentration of IL-6, TNF-alpha, and CRP, the indicators of a strong association with neuroinflammation and cognitive loss (Zhang et al., 2021; Tao et al., 2024). Conversely, patients who were kept in light anesthesia recorded lower inflammatory reactions and more rapid restoration of the hemodynamic parameters. These data imply that both prevention of the inflammatory cascade and enhanced cerebral oxygen metabolism could be the mechanisms involved in the neuroprotective effect of light anesthesia, partially.

The vulnerable brain of the elderly is prone to inflammatory and oxidative stress largely because microvascular fragility and reduced autoregulatory capacity put the elderly at a disadvantage (Runge et al., 2025). These effects may be intensified by deeper anesthesia, which suppresses cortical metabolism and changes the perfusion because of postoperative neuronal dysfunction. Hence, not only does depth-guided anesthesia reduce the occurrence of anesthetic overdose, but cerebral homeostasis is also maintained, which has been associated with POCD because of the occurrence of prolonged states of EEG suppression.

4.3 Clinical and Policy Implications

These findings have significant clinical implications. Narcotrend-guided anesthesia or BIS should be taken as a mandatory practice for monitoring older patients during major surgeries. The advantage of continuous monitoring is that anesthetic dosage can be adjusted by anesthetic practitioners on the fly to prevent excessive sedation and hemodynamic safety. Cognitive outcome monitoring could be implemented in perioperative care systems by hospitals and anesthesia teams to diagnose patients at risk. Furthermore, the findings indicate that customized anesthesia guidelines based on age, comorbidities, and surgery type could be very helpful in minimizing the occurrence of postoperative cognitive issues and healthcare expenses of the protracted recovery.

Policy-wise, the inclusion of EEG-based depth monitoring in geriatric surgery policies would increase the post-operative outcomes. The economic and social burden of POCD will probably become even higher as the number of elderly people increases. Thus, developing comprehensible depth objectives in elderly patients may enhance the quality of life, decrease hospitalization, and efficiently redistribute resources in preoperative medicine.

4.4 Strengths, Limitations, and Future Directions

Recent studies of high methodological quality, constant depth monitoring, and standardized cognitive assessments were included in this meta-analysis, which enhances the validity of conclusions. Nevertheless, numerous restrictions should be admitted. Different studies used different times and instruments in cognitive tests, which added moderate heterogeneity. In other studies, it was not possible to conceal information from participants and assessors about the level of anesthesia, a factor that created possible performance bias. Also, the terms of follow-up were not very long, which restricted the conclusions about long-term mental results.

Subsequent studies need to use longitudinal designs of extended cognitive follow-up (more than six months) to assess the long-term effects of the level of anesthetic depth. Neuroimaging techniques like fMRI or PET might offer more information about the cerebral perfusion and metabolism alterations of levels of anesthesia. Moreover, a comparative study of new agents such as esketamine and dexmedetomidine combinations would inform the choice of multimodal anesthesia to reduce the risk of POCD.

In summary, this analysis has demonstrated the clinical significance of adjusting the depth of anesthesia to the physiological requirements of elderly patients. Clinicians are able to achieve the balance of unconsciousness, analgesia, and cerebral protection by keeping the anesthesia optimally low, which ultimately leads to better cognitive and recovery outcomes after surgery.

CONCLUSION

The meta-analysis concludes that a light depth of anesthesia, as monitored by BIS or Narcotrend, plays an important role in preventing the occurrence of postoperative cognitive dysfunction (POCD) in the elderly patient. The data show that with the provision of lighter anesthesia, there is a faster recovery, decreased neuroinflammatory biomarkers, and improved short-term cognitive functions in contrast to deep anesthesia. Total intravenous anesthesia using propofol showed especially good results, which could have been caused by the neuroprotective and anti-inflammatory effects of propofol.

These findings indicate that providing intraoperative care to older adults clinically requires the use of an individualized anesthetic treatment that includes depth monitoring. Shallow anesthetizing can prevent the degradation of cerebral perfusion and cognitive impairment. In spite of a few methodological drawbacks, this analysis is a strong argument in favor of the implementation of the EEG-guided depth monitoring as another standard in geriatric anesthesia. It is recommended to reassure the long-term cognitive advantages with future longitudinal studies that will allow optimizing the depth of anesthesia in the elderly population.

REFERENCES

1. Chen, W., Zhong, S., Ke, W., & Gan, S. (2021). The effect of different depths of anesthesia monitored using Narcotrend on cognitive function in elderly patients after VATS lobectomy. *American Journal of Translational Research, 13*(10), 11797–11806.
2. Cotae, A. M., Ţigliş, M., Cobilinschi, C., Băetu, A. E., Iacob, D. M., & Grinţescu, I. M. (2021). The impact of monitoring depth of anesthesia and nociception on postoperative cognitive function in adult multiple trauma patients. *Medicina, 57*(5), 408.
3. Kang, J., Lin, W., Wang, H., Liang, Y., & Yu, Z. (2022). Effects of general anesthesia and epidural anesthesia on deep vein thrombosis and perioperative cognitive function of patients undergoing total knee arthroplasty. *American Journal of Translational Research, 14*(7), 4786–4794.
4. Lv, A. Q., Huang, L. C., Lao, W. L., Song, Q. L., Zhou, Q. F., Jiang, Z. M., & Chen, Z. H. (2022). Effects of different depths of anesthesia on perioperative inflammatory reaction and hospital outcomes in elderly patients undergoing laparoscopic radical gastrectomy. *BMC Anesthesiology, 22*(1), 328.
5. Ma, J., Wang, F., Wang, J., Wang, P., Dou, X., Yao, S., & Lin, Y. (2023). The effect of low-dose esketamine on postoperative neurocognitive dysfunction in elderly patients undergoing general anesthesia for gastrointestinal tumors: A randomized controlled trial. *Drug Design, Development and Therapy, 17*, 1945–1957.
6. Ning, M., Sun, Y., Zhang, H., Chen, C., Sun, L., Chen, L., & Lu, Y. (2022). Effects of different anesthetic depths during propofol anesthesia on postoperative recovery 24 h after arthroscopic day surgery: A randomized clinical trial. *Frontiers in Pharmacology, 13*, 972793.
7. Pang, Q. Y., Duan, L. P., Jiang, Y., & Liu, H. L. (2021). Effects of inhalation and propofol anesthesia on postoperative cognitive dysfunction in elderly noncardiac surgical patients: A systematic review and meta-analysis. *Medicine, 100*(43), e27668.
8. Runge, J., Heedfeld, R. K., Grundmann, C. D., Wischermann, J. M., Bischoff, P., & Frey, U. H. (2025). Preoperative cognitive impairment predicts deep anesthesia and higher postoperative pain in elderly patients: An observational study. *BMC Anesthesiology, 25*(1), 540.
9. Tao, Q. Y., Liu, D., Wang, S. J., Wang, X., Ouyang, R. N., Niu, J. Y., … & Yu, J. M. (2024). Effects of esketamine combined with dexmedetomidine on early postoperative cognitive function in elderly patients undergoing lumbar spinal surgery: A double-blind randomized controlled clinical trial. *Drug Design, Development and Therapy, 18*, 5461–5472.
10. Wu, Y., Yu, C., & Gao, F. (2023). Risk factors for postoperative cognitive dysfunction in elderly patients undergoing surgery for oral malignancies. *Perioperative Medicine, 12*(1), 42.
11. Xie, L., Wei, X., He, K., Wang, S., & Xu, M. (2024). Effects of different anesthetic regimens on postoperative cognitive function of elderly patients undergoing thoracic surgery: A double-blinded randomized controlled trial. *Journal of Cardiothoracic Surgery, 19*(1), 394.
12. Yan, Z. H., & Wenjing, L. I. (2023). Effects of total intravenous anesthesia with etomidate and propofol on postoperative cognitive dysfunction. *Physiological Research, 72*(2), 251–260.
13. Yao, J., Gao, Z., Qu, W., & Li, J. (2024). Propofol total intravenous anesthesia vs. sevoflurane inhalation anesthesia: Effects on postoperative cognitive dysfunction and inflammation in geriatric patients undergoing laparoscopic surgery. *Experimental and Therapeutic Medicine, 28*(3), 343.
14. Zhang, Z., Li, W., & Jia, H. (2021). Postoperative effects of dexmedetomidine on serum inflammatory factors and cognitive malfunctioning in patients with general anesthesia. *Journal of Healthcare Engineering, 2021*, 7161901.
15. Zhou, C., Huang, X., Zhuo, Z., Wu, Q., Liu, M., & Li, S. (2024). Effect of different anesthesia depths on perioperative heart rate variability and hemodynamics in middle-aged and elderly patients undergoing general anesthesia. *BMC Anesthesiology, 24*(1), 312.
16. Li, W. X., Luo, R. Y., Chen, C., Li, X., Ao, J. S., Liu, Y., & Yin, Y. Q. (2019). Effects of propofol, dexmedetomidine, and midazolam on postoperative cognitive dysfunction in elderly patients: a randomized controlled preliminary trial. *Chinese medical journal*, *132*(04), 437-445.
17. Guo, L., Lin, F., Dai, H., Du, X., Yu, M., Zhang, J., ... & Pan, L. (2020). Impact of sevoflurane versus propofol anesthesia on post-operative cognitive dysfunction in elderly cancer patients: a double-blinded randomized controlled trial. Medical Science Monitor: International Medical Journal of Experimental and Clinical Research, 26, e919293-1.
18. Cottrell, J. E., & Hartung, J. (2020). Anesthesia and cognitive outcome in elderly patients: a narrative viewpoint. *Journal of Neurosurgical Anesthesiology*, *32*(1), 9-17.
19. Zhang, D., Ying, J., Ma, X., Gao, Z., Chen, H., Zhu, S., ... & Lu, X. (2020). Social cognitive dysfunction in elderly patients after anesthesia and surgery. *Frontiers in Psychology*, *11*, 541161.
20. Belrose, J. C., & Noppens, R. R. (2019). Anesthesiology and cognitive impairment: a narrative review of current clinical literature. *BMC anesthesiology*, *19*(1), 241.