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Evaluation of Postoperative Cognitive Function in Patients Undergoing General or Spinal Anesthesia During Extremity Surgery: A Prospective Cohort Study

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ABSTRACT

Introduction: This research investigates the impact of general anesthesia (GA) and spinal anesthesia (SA) on cognitive function following extremity surgery.

Methods: A prospective cohort study was conducted with 60 patients (30 GA, 30 SA) undergoing elective extremity surgery. Cognitive function was assessed preoperatively and at 4 and 24 hours postoperatively using the Mini-Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA).

Results: At 4 hours postoperatively, MoCA scores were significantly higher in the SA group (21.6±2.6) compared to the GA group (20.8±4.4; p<0.001). By 24 hours, cognitive recovery was more pronounced in the SA group (22.7±2.8) than in the GA group (22.0±4.2) (p=0.001). MMSE scores followed a similar trend: at 24 hours, SA patients had a significantly higher score (26.1±2.3) than GA patients (25.6±3.0; p=0.044). The cognitive improvement over 24 hours was more substantial in SA patients (MMSE: 2.1±0.9; MoCA: 2.2±1.4) than in GA patients (MMSE: 0.67±1.4; MoCA: 0.67±1.8), both p<0.001. Age-based analysis showed that patients under 40 years of age had higher baseline cognitive scores and greater postoperative improvement, regardless of anesthesia type (p<0.001).

Conclusion: Compared with GA, SA was associated with a faster and more pronounced postoperative recovery of cognitive function. These findings suggest that SA may be preferable for reducing early cognitive impairment, particularly among older patients. Long-term follow-up is needed to confirm these effects.

Keywords: Postoperative cognitive dysfunction, general anesthesia, spinal anesthesia, cognitive recovery, extremity surgery

Introduction

Postoperative cognitive dysfunction (POCD) manifests in some patients after surgery, causing transient or persistent cognitive deficits (1). The incidence of POCD is influenced by several factors, including the type of anesthesia administered, the nature of the surgical procedure, the patient's age and overall health status (2). Various anesthetic techniques, such as general and spinal anesthesia (SA), have distinct effects on cognitive function (3). While general anesthesia (GA) is often associated with an elevated risk of POCD due to its widespread effects on the central nervous system, SA may mitigate this risk (4). Consequently, in surgeries involving more localized areas, such as extremity procedures, it becomes crucial to conduct a more thorough evaluation of how different anesthesia modalities influence cognitive function.

Evaluating cognitive function following surgical interventions is crucial for healthcare professionals to optimize patient outcomes. Postoperative cognitive impairment can significantly diminish a patient's quality of life and extend the recovery period (5). Moreover, such impairment could hinder a patient's ability to resume daily activities and potentially result in long-term neurological consequences. Therefore, enhancing our understanding of how different types of anesthesia affect cognitive function is essential. This knowledge will enable healthcare professionals to make more informed decisions when selecting anesthetic methods for surgeries (6). Recent studies have yielded critical insights into the distinct impacts that various anesthetics can have on cognitive performance.

Findings from various studies indicate that elderly patients and those with comorbidities are at heightened risk of developing POCD following GA (7).

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Although SA is generally believed to mitigate these risks, further clinical data are necessary to establish more conclusive evidence. Moreover, the standardization of cognitive assessment tools and the duration of follow-up are essential to ensure consistent results in future research. The primary objective of this study was to compare the incidence and severity of POCD in patients undergoing extremity surgery under GA vs. SA.

Methods

Scope of the Study and Participants

This study was a randomized prospective cohort study conducted between November 2016 and April 2017 at İstanbul Training And Research Hospital. The primary objective was to evaluate and compare the effects of general and SA on cognitive function following elective extremity surgeries. A total of 60 participants were enrolled, with 30 assigned to the GA group (Group General) and 30 to the SA group (Group Spinal). Participants who met the eligibility criteria were aged 18-65 years and categorized as the American Society of Anesthesiologists (ASA) I or II according to ASA physical status classification system. Patients with diabetes or those meeting any of the exclusion criteria were omitted from the study. The exclusion criteria encompassed patients classified as ASA III or IV; those undergoing emergency surgery; patients younger than 18 or older than 65 years; patients diagnosed with neuropsychiatric disorders (e.g., Alzheimer's or Parkinson's disease); patients with alcohol dependence or chronic use of opioids or sedatives; and patients with known allergies to any medications used in the study. The study included patients undergoing elective lower extremity orthopedic surgeries, specifically involving the knee, ankle, and foot. To ensure homogeneity, only lower-extremity procedures were considered; upper-extremity procedures were excluded from the study. Ethical approval for the study was granted by the University of Health Sciences Türkiye, İstanbul Training and Research Hospital Ethics Committee (decision number: 872, date: 11.11.2016). Furthermore, informed consent was secured from all participants or their legal representatives before enrollment.

Data Collection and Evaluation

Within the scope of this study, patients' cognitive functions were assessed at 0 hours (preoperative) and at 4 and 24 hours postoperatively using the Mini-Mental State Examination (MMSE) (8) and the Montreal Cognitive Assessment (MoCA) (9). These cognitive tests, both validated in Turkish, were utilized for their efficiency and reliability in evaluating cognitive performance. They specifically measured domains such as attention, memory, executive functions, and abstract reasoning. Additionally, vital signs (including pulse, blood pressure and oxygen saturation) were monitored during anesthesia. Patient demographic data were recorded. Educational status was evaluated based on the total number of years of formal education as self-reported by the patients on the preoperative assessment form. This information was recorded as a continuous variable and was taken into account as a potential covariate in the interpretation of cognitive test results such as MoCA and MMSE.

Randomization was conducted using a sealed-envelope method. Prior to surgery, each patient was randomly assigned, using prepared, numbered envelopes, to either the GA group or the SA group. The study was single-blind; assessors who administered the cognitive tests were blinded to patients' group allocation.

Anesthesia Procedures

During induction of GA, patients received propofol 2-3 mg/kg (Propofol 200 mg, Türkiye), fentanyl 1-2 mcg/kg (Talinat 0.5 mg/10 mL, VEM, Türkiye), and rocuronium 0.6 mg/kg (Esmeron 50 mg/5 mL, MSD, Greece). To maintain anesthesia, sevoflurane (Sevoflurane, Abbott, Türkiye) was administered with a carrier gas mixture comprising 50% oxygen (O_2) and 50% nitrous oxide at a total flow rate of 4 L/min. Muscle relaxation was sustained through maintenance doses of 0.1 mg/kg rocuronium, which were administered intravenously as necessary. For pain management, patients received 1 mg/kg of tramadol hydrochloride at 45 minutes. Prior to extubation, reversal of neuromuscular blockade was achieved using 0.04 mg/kg neostigmine (Neostigmin, Adeka, Türkiye) in conjunction with 0.02 mg/kg atropine (Atropin, Galen, Türkiye). SA was administered under aseptic conditions at the L3-L4 intervertebral space using a 25G Quincke spinal needle. A total of 3 mL of 0.5% hyperbaric bupivacaine (Marcaine Spinal Heavy, AstraZeneca, Türkiye) was injected into the subarachnoid space. In all patients, the sensory block reached the T10 dermatome, which was sufficient for the surgical procedure. Cognitive evaluations were conducted preoperatively on the morning of surgery, with follow-up assessments at 4 and 24 hours postoperatively. No intraoperative sedation was administered to patients in the SA group. All patients were monitored undera spinal block and remained fully conscious throughout the surgical procedure; no sedative agents were administered.

Statistical Analysis

The statistical analysis of the collected data in this study was conducted using SPSS (Statistical Package for the Social Sciences) version 27.0. Continuous variables were represented as mean ± standard deviation, whereas categorical variables were reported as frequencies and percentages (%). The assessment of normality for the parameters was performed using the Kolmogorov-Smirnov test. To compare the two groups, the independent-samples t-test was applied to parameters that followed a normal distribution, whereas the Mann-Whitney U test was applied to those that did not. A p value below 0.05 was deemed to indicate statistical significance. The analyses compared the groups that received GA with those that received SA.

Results

The mean age of the patients included in the study was 44.2±12.1 years. The gender distribution showed that 50.0% (n=30) of participants were female. Table 1 shows patient characteristics and demographic features. The mean MoCA score was 20.9±2.6 preoperatively, 21.2±3.6 at 4 hours postoperatively, increasing to 22.3±3.5 by 24 hours postoperatively. Similarly, the mean MMSE score was 24.5±2.4 at 0 hours, rising to 24.8±3.0 at 4 hours postoperatively, and further increasing to 25.9±2.7 at 24 hours postoperatively (Table 2).

No statistically significant differences were observed between the general and SA groups with respect to age, gender distribution, ASA classification, education level, or surgical duration (Table 3).

The comparison of MoCA scores between the general and SA groups revealed no significant difference at 0 hours (general: 21.3±2.8; spinal: 20.5±2.2; p=0.279). However, the SA group demonstrated significantly higher scores at 4 hours postoperatively (spinal: 21.6±2.6; general: 20.8±4.4; p<0.001) and at 24 hours (spinal:22.7±2.8; general: 22.0±4.2; p=0.001). The 4-hour MoCA score difference indicated an increase in the spinal group (1.03±1.4), whereas it indicated a decrease in the GA group (-0.53±2.0; p<0.001). At 24 hours, the spinal group exhibited a more pronounced improvement (2.2±1.4) compared to the GA group (0.67±1.8, p<0.001). These findings suggest superior cognitive recovery in the SA group (p<0.001; Table 4).

Preoperatively, the mean MMSE score in the GA group was 25.0±2.3, compared with 24.1±2.3 in the SA group (p=0.132). At 4 hours postoperatively, there was no significant difference between groups (general: 24.4±3.2; spinal: 25.2±2.8; p=0.268). At 24 hours, the SA group exhibited a slightly higher MMSE score (26.1±2.3) than the GA group (25.6±3.0, p=0.044). The 4-hour change in MMSE score showed a decrease in the GA group (-0.57±1.7) and an increase in the spinal group (1.2±1.1); this difference was statistically significant (p<0.001). Similarly, at 24 hours, the spinal group showed a greater improvement (2.1±0.9) than the general group (0.67±1.4; p<0.001) (Table 5).

Among male patients, the mean MoCA score at 0 hours was significantly higher in the GA group (22.1±2.7) than in the SA group (20.9±1.7; p=0.047).

Table 1. Patient demographics and surgical data

		Mean ± SD/count	Column, n%
Age (year)		44.2±12.1	
Gender (female)		30	50.0 %
ASA classification	1	41	68.3 %
	2	19	31.7 %
Education (year)		7.9±3.4	
Surgical duration		82.0±12.3	

The data in the table are presented as standard deviations or counts (percentages). SD: Standard deviation, ASA: American Society of Anesthesiologists

Table 2. Cognitive test scores at different time points of all patients

	Mean ± SD
MoCA (0 hour)	20.9±2.6
MoCA (4 hour)	21.2±3.6
MoCA (24 hour)	22.3±3.5
MMS (0 hour)	24.5±2.4
MMS (4 hour)	24.8±3.0
MMS (24 hour)	25.9±2.7

Data in the table are given as deviation or count (percentage). MoCA: Montreal Cognitive Assessment, MMSE: Mini-Mental State Examination, SD: Standard deviation

Table 3. Comparison of demographic and surgical characteristics between general and spinal anesthesia groups

		General (n=30)	Spinal (n=30)	p value
Age (years)		43.0±12.9	44.6±12.0	0.605
Gender	Female	15 (50.0)	15 (50.0)	1.00
	Male	15 (50.0)	15 (50.0)	
ASA classification	1	19 (63.3)	22 (73.3)	0.405
	2	11 (36.7)	8 (26.7)	
Education (year)		8.2±3.7	7.5±3.2	0.510
Surgical duration		81.7±13.7	82.3±11.0	0.836

The data in the table are given as the standard deviation or count (percentage). ASA: American Society of Anesthesiologists

Table 4. Comparison of MoCA scores between general and spinal anesthesia groups

	General (n=30)	Spinal (n=30)	
	Mean ± SD	Mean ± SD	p value
MoCA (0 hour)	21.3±2.8	20.5±2.2	0.279[a]
MoCA (4 hour)	20.8±4.4	21.6±2.6	**<0.001[b]**
MoCA (24 hour)	22.0±4.2	22.7±2.8	**0.001[a]**
MoCA (4-hour time difference)	-0.53±2.0	1.03±1.4	**<0.001[a]**
MoCA (24-hour time difference)	0.67±1.8	2.2±1.4	**<0.001[b]**
MoCA change		<0.001	

The data in the table are given as deviation or count (percentage). [a]Independent sample t-test, [b]Mann-Whitney U test. Statistically significant p values are indicated in bold. MoCA: Montreal Cognitive Assessment, SD: Standard deviation

Table 5. Comparison of MMS scores between general and spinal anesthesia group

	General (n=30)	Spinal (n=30)	
	Mean ± SD	Mean ± SD	p value
MMS (0 hour)	25.0±2.3	24.1±2.3	0.132[a]
MMS (4 hour)	24.4±3.2	25.2±2.8	0.268[b]
MMS (24 hour)	25.6±3.0	26.1±2.3	**0.044[a]**
MMS (4-hour time difference)	-0.57±1.7	1.2±1.1	**<0.001[a]**
MMS (24-hour time difference)	0.67±1.4	2.1±0.9	**<0.001[b]**
MMS change		<0.001	

The data in the table are given as deviation or count (percentage). [a]Independent sample t-test, [b]Mann Whitney U test. Statistically significant p values are indicated in bold. SD: Standard deviation, MMSE: Mini-Mental State Examination

Table 6. Cognitive scores of male patients undergoing general and spinal anesthesia

	General (n=15)	Spinal (n=15)	
	Mean ± SD	Mean ± SD	p value
MoCA (0 hour)	22.1±2.7	20.9±1.7	**0.047[a]**
MoCA (4 hour)	22.2±4.4	22.2±2.1	0.996[b]
MoCA (24 hour)	23.5±4.3	23.7±1.6	0.867[a]
MMS (0 hour)	25.9±2.0	24.7±2.2	**0.042[a]**
MMS (4 hour)	25.7±2.9	25.8±2.4	0.89[b]
MMS (24 hour)	26.8±2.8	26.7±1.8	0.938[a]

The data in the table are given as deviation or count (percentage). [a]Independent sample t test, [b]Mann Whitney U Test. Statistically significant p values are indicated in bold. MoCA: Montreal Cognitive Assessment, MMSE: Mini-Mental State Examination, SD: Standard deviation

At 4 hours, the two groups had identical mean MoCA scores (22.2±4.4 in the general group and 22.2±2.1 in the spinal group; p=0.996). At the 24-hour mark, no statistically significant difference was observed between the groups (general: 23.5±4.3, spinal: 23.7±1.6, p=0.867). Regarding MMS scores at 0 hours, the GA group showed a higher score (25.9±2.0) than the spinal group (24.7±2.2; p=0.042). At 4 and 24 hours, there were no significant differences between the groups: general: 25.7±2.9 vs. spinal: 25.8±2.4 (p=0.891) and general: 26.8±2.8 vs. spinal: 26.7±1.8 (p=0.938), respectively (Table 6).

For female patients, the mean MoCA score at 0 hours was 20.6±2.9 in the GA group and 20.2±2.6 in the SA group, with no significant difference (p=0.695). At 4 hours, the SA group had a significantly higher MoCA score (20.9±2.9) than the GA group (19.4±3.9; p=0.038). At 24 hours, there was no significant difference between the two groups (general: 20.5±3.7, spinal: 21.7±3.4, p=0.360). Regarding MMS scores, at 0 hours, the GA group had a score of 24.1±2.4, and the spinal group had a score of 23.5±2.4 (p=0.549). At 4 hours, there was no significant difference (general: 23.1±3.0, spinal: 24.7±3.2, p=0.185). After 24 hours, the GA group had a score of 24.5±2.9 and the SA group had a score of 25.5±2.7, with no significant difference (p=0.301) (Table 7).

Among patients aged <40 years, the GA group had a mean MoCA score of 23.5±2.3 at 0 hours, significantly higher than that of patients aged ≥40 years (20.1±2.3, p<0.001). Similarly, in the SA group, the <40 age group had a higher score (22.3±2.1) than the ≥40 age group (19.8±1.8, p<0.001). At 4 hours, the MoCA scores for the <40 age group were 24.3±3.3 for GA and 23.7±2.7 for SA; both were significantly higher than those of the ≥40 age groups (18.8±3.6, p<0.001 for GA; 20.7±2.0, p<0.001 for SA). The same pattern persisted at 24 hours (general: 25.5±3.2 for <40 vs. 20.0±3.3 for ≥40, p<0.001; spinal: 24.7±2.4 for <40 vs. 21.9±2.5 for ≥40, p<0.001). The MMS scores followed a similar trend. At 0 hours, participants aged <40 years in the GA group had a mean MMS score of 26.8±1.8, which was higher than that of participants aged ≥40 years (23.9±1.9; p<0.001). In the SA group, the <40 year age had a score of 26.0±2.4, while the ≥40 year group scored 23.3±1.8 (p<0.001). At 4 hours, MMS scores remained higher in the <40 group for both GA (27.3±2.6 vs. 22.7±2.1, p<0.001) and SA (27.1±2.9 vs. 24.4±2.4, p<0.001). At 24 hours, the same pattern was observed, with significantly higher scores in the <40 group for both anesthesia types (general: 28.5±2.3 vs. 24.0±1.9, p<0.001; spinal: 27.6±2.3 vs. 25.5±2.1, p<0.001) (Table 8).

Table 7. Cognitive scores of female patients undergoing general and spinal anesthesia

	General (n=15)	Spinal (n=15)	
	Mean ± SD	**Mean ± SD**	**p value**
MoCA (0 hour)	20.6±2.9	20.2±2.6	0.695[a]
MoCA (4 hour)	19.4±3.9	20.9±2.9	**0.038[b]**
MoCA (24 hour)	20.5±3.7	21.7±3.4	0.360[a]
MMS (0 hour)	24.1±2.4	23.5±2.4	0.549[a]
MMS (4 hour)	23.1±3.0	24.7±3.2	0.185[b]
MMS (24 hour)	24.5±2.9	25.5±2.7	0.301[a]

The data are given in the table mean ± standard as deviation or count (percentage). [a]Independent sample t-test, [b]Mann Whitney U test. Statistically significant p values are indicated in bold. MoCA: Montreal Cognitive Assessment, MMSE: Mini-Mental State Examination, SD: Standard deviation

Discussion

In our study, significant differences in cognitive function were observed between the general and SA groups. Postoperative cognitive recovery was faster and more effective in patients receiving SA. Notably, during the early postoperative period, particularly at the 4- and 24-hour assessments, the SA group exhibited a more pronounced improvement in cognitive performance. Age-based analyses revealed that patients under 40 years of age demonstrated superior cognitive performance in both the general- and SA groups. Additionally, gender-based comparisons indicated that male patients experienced a greater cognitive decline following GA. These findings suggest that SA more effectively preserves postoperative cognitive function, and that demographic factors may influence cognitive recovery. In our study, individuals under the age of 40 demonstrated higher cognitive test scores, underscoring the influence of age on the development of POCD. The literature frequently emphasizes the impact of age on cognitive reserve. With advancing age, mechanisms such as increased neuroinflammation, reduced neuronal plasticity, and heightened oxidative stress are believed to impair cognitive recovery in older adults. These pathophysiological processes align with our findings,

Table 8. Cognitive scores by age group (<40 and ≥40) for general and spinal anesthesia

	General (n=30)			Spinal (n=30)		
	<40 age (n=9)	**≥40 age (n=21)**		**<40 age (n=11)**	**≥40 age (n=19)**	
	Mean ± SD	**Mean ± SD**	**p value**	**Mean ± SD**	**Mean ± SD**	**p value**
MoCA (0 hour)	23.5±2.3	20.1±2.3	**<0.001[a]**	22.3±2.1	19.8±1.8	**<0.001[a]**
MoCA (4 hour)	24.3±3.3	18.8±3.6	**<0.001[b]**	23.7±2.7	20.7±2.0	**<0.001[b]**
MoCA (24 hour)	25.5±3.2	20.0±3.3	**<0.001[a]**	24.7±2.4	21.9±2.5	**<0.001[a]**
MMS (0 hour)	26.8±1.8	23.9±1.9	**<0.001[a]**	26.0±2.4	23.3±1.8	**<0.001[a]**
MMS (4 hour)	27.3±2.6	22.7±2.1	**<0.001[b]**	27.1±2.9	24.4±2.4	**<0.001[b]**
MMS (24 hour)	28.5±2.3	24.0±1.9	**<0.001[a]**	27.6±2.3	25.5±2.1	**<0.001[a]**

The data are given in the table mean ± standard as deviation or count (percentage). [a]Independent sample t-test, [b]Mann Whitney U test. Statistically significant p values are indicated in bold. MoCA: Montreal Cognitive Assessment, MMSE: Mini-Mental State Examination, SD: Standard deviation

particularly the more favorable cognitive recovery observed in patients aged ≥40 years who received SA.

O'Brien et al. (10) compared the incidence of delirium between patients with and without cognitive impairment after undergoing either general or SA. The findings indicated that the incidence of delirium did not differ significantly between the two anesthesia methods; both groups exhibited comparable rates. Additionally, delirium severity, in-hospital complications, and functional recovery were comparable between general and SA. In contrast, Silbert et al. (3) examined POCD and found a higher incidence in the SA group than in the GA group, particularly at the 3-month follow-up. However, this difference was not statistically significant. Consistent with the findings of Ehsani et al. (7), our study demonstrated a higher prevalence of cognitive impairment among patients who underwent GA. In both studies, SA was shown to preserve cognitive function better. The association between cognitive impairment and factors such as age, ASA classification, and gender, as identified by Ehsani et al. (7), aligns with the results of our research. These findings suggest that GA may have a more detrimental impact on cognitive function.

Konishi et al. (11) examined the effects of sevoflurane and propofol used in anesthesia maintenance on POCD and found in the incidence of POCD between the two drugs. This finding suggests that the development of POCD may be influenced by factors other than the specific anesthetic agents used. However, in our study, notable differences in cognitive recovery were observed between GA and SA. Cognitive function improved more rapidly and was better preserved in patients who received SA compared to those who underwent GA. Anwer et al. (12) investigated the effects of general and SA on postoperative cognitive function in young adults and elderly patients, and found that GA led to cognitive impairment in elderly patients. In our study, patients were categorized into groups using an age threshold of 40 years. While Anwer's study defined elderly patients as those aged ≥60 years, our use of a 40-year age threshold provides a different perspective. Although age 60 is conventionally used as the cut-off in most cognitive function studies, we selected 40 years as the threshold to provide an alternative perspective and explore possible cognitive changes in earlier adulthood. Furthermore, this threshold ensured balanced subgroup sizes for valid statistical comparisons. Our results indicate that GA has a more detrimental effect on cognitive function in patients over 40 years of age. In contrast, cognitive recovery was more pronounced in patients older than 40 years who received SA. The findings of Anwer et al. (12), which demonstrated that GA caused cognitive impairment in elderly patients, are consistent with our findings in patients over 40 years of age.

Zhang et al. (13) compared spinal vs. GA in 80 elderly orthopedic patients and found that SA resulted in faster recovery, improved cognitive outcomes, and fewer cases of POCD. Tzimas et al. (14) examined the effects of general vs. SA in hip fracture surgery, reporting no significant differences in most cognitive tests but a higher incidence of delirium in the spinal group (27% vs. 12% in the general group). Ezhevskaya et al. (15) analyzed 48 patients undergoing thoracolumbar fusion and showed that combined epidural and GA reduced pain, inflammation, immune dysfunction, and POCD compared with GA alone. Aytaç et al. (16) compared MMSE and MoCA scores among elderly patients undergoing inguinal herniorrhaphy and found that postoperative MoCA scores were significantly lower in both anesthesia groups, while the GA group showed a significant decrease in MMSE scores. The incidence of POCD was higher when using the MoCA (32.9%) than when using the MMSE (15.2%). Our study integrates these findings by exploring the cognitive and functional impacts of different types of anesthesia, aiming to clarify the role of anesthesia in POCD and to optimize postoperative outcomes in elderly patients.

Study Limitations

Our study has some limitations. First, postoperative cognitive function was evaluated only within the first 24 hours after surgery. This limits the ability to fully investigate the likelihood and long-term effects of POCD. A longer follow-up period may have been beneficial in assessing the long-term effects of POCD. Moreover, the limited sample size in this study may affect the extent to which the findings can be generalized to a larger population. Furthermore, the selection of anesthesia type was based on the anesthesiologist's discretion, a factor that was not accounted for within the study. This means that the selection of anesthesia was not randomized, which could introduce bias. Additionally, discharge time was not assessed, which may have provided further insight into the overall postoperative recovery process.

Conclusion

The findings of this study indicate that SA facilitates early postoperative cognitive recovery in patients undergoing extremity surgery compared with GA. Individuals in the SA group demonstrated significantly higher MMSE and MoCA scores at both 4- and 24-hour postoperative assessments, indicating a lower risk of postoperative cognitive decline. Age also influenced cognitive outcomes: younger patients (<40 years) recovered better regardless of anesthesia type, whereas older patients were more affected by GA. Although the study was limited by a small sample size and a short follow-up period, these findings suggest that SA may be preferable for reducing early POCD. Further studies are needed to confirm long-term effects. As our study focused primarily on cognitive outcomes, validated patient-reported outcome measures, such as the Quality of Recovery-40, were not utilized. However, future research incorporating such tools may offer a more comprehensive assessment of both cognitive recovery and patient satisfaction with anesthesia techniques.

Ethics

Ethics Committee Approval: Ethical approval for the study was granted by the University of Health Sciences Türkiye, İstanbul Training and Research Hospital Ethics Committee (decision number: 872, date: 11.11.2016).

Informed Consent: It was secured from all participants or their legal representatives before enrollment.

Footnotes

Authorship Contributions: Surgical and Medical Practices - Ö.Z.P.; Concept - V.E.; Design - V.E.; Data Collection or Processing - Ö.Z.P.; Analysis or Interpretation - V.E.; Literature Search - Ö.Z.P.; Writing - Ö.Z.P., V.E.

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