



Effect of Spinal Anesthesia on Postoperative Cognitive Dysfunction

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: It seems that spinal anesthesia is an appropriate approach for elderly patients and those who are not suitable candidates for general anesthesia. This study aimed to determine the effect of spinal anesthesia on postoperative cognitive decline in elderly patients.

Methods: This cross-sectional study was performed on 81 patients older than 65 years of age with the ASA classes I and II. The cases were candidates for surgery and spinal anesthesia and referred to Besat Hospital, Hamadan, Iran. Moreover, they receive surgical treatment and underwent spinal anesthesia from 2019 to 2020. Wechsler Memory Scale-III (WMS-III) was utilized to compare the cognitive dysfunction in elderly patients before and after spinal anesthesia. Furthermore, the WMS-III scores were compared before and after anesthesia to assess the severity of cognitive dysfunction, short- and long-term memories, as well as concentration rate at discharge.

Results: According to the results, there was no significant difference before and after spinal anesthesia regarding the mean mental control, repetition, visual reproduction, and verbal paired

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associates ($P>0.05$). Moreover, the mean values of spatial addition ($Z=-2.07$; $P=0.03$) navigation ($Z=-2.13$; $P=0.03$), and logical memory ($Z=-2.42$; $P=0.01$) increased after spinal anesthesia. In addition, the mean values of the memory coefficient were estimated at 68.28 ± 16.77 and 68.66 ± 16.94 , respectively. The comparison of memory coefficient among elderly patients undergoing spinal anesthesia showed no significant difference before and after spinal anesthesia ($Z=-1.51$; $P=0.13$). A reverse correlation was reported between age and memory coefficient before ($r=-0.46$; $P<0.005$) and after spinal anesthesia ($r=-0.405$; $P<0.005$).

Conclusion: Spinal anesthesia had no effects on memory coefficient. However, there was an increase in some memory function domains, including spatial addition, navigation, and logical memory after the operation. The memory scores may have been affected by the patients' conditions before the operation.

Keywords: Memory coefficient; postoperative cognitive dysfunction; spinal anesthesia.

1. INTRODUCTION

A decline in cognitive function after surgery, named postoperative cognitive dysfunction (POCD), is the main problem among patients undergoing major surgeries. It occurs within 24-48 h after surgery, which can last 1-12 months post-surgery or longer [1]. This functional mental disorder affects cognitive processes, especially verbal and visual memories.

Defective concentration, distracted attention, impediments in language comprehension, and visuospatial abstraction are the main problems of POCD. Furthermore, decreased postoperative cognitive function can be associated with poor functional recovery and an increase in the length of hospital stay and costs [2].

The prevalence of POCD is related to the definition, population, time, and instruments of postoperative assessment [3]. The rate of postoperative cognitive decline and delirium has been estimated between 7% and 75% among patients undergoing surgery [4].

The main risk factors for POCD are previous cognitive dysfunction, type of operation, coexisting diseases, and aging [5]. Other risk factors for postoperative cognitive impairment include systemic diseases, functional status, psychoactive medicine, and transfusions [6]. Cognitive disorders may be progressive or persistent and permanent or reversible [7]. The effect of anesthetic agents on the central nervous system is undeniable. However, it is difficult to attribute cognitive changes to anesthetic medications. Although POCD is a common problem among patients receiving surgeries, the pathogenesis of the disorder is not completely clear [4].

The most important responding variable for assessing the sympathetic neural outflow is the

muscle sympathetic activity. The sympathetic nervous system has a main role in response to environmental challenges, neurohumoral circulatory control, and cardiovascular control. Due to the association between general anesthesia and sympathetic activity changes, general anesthesia may result in mechanical ventilation. It may also have effects on the circulatory and central or peripheral nervous systems. Anesthesia could be considered an instrument to examine the mechanisms of cardiovascular regulation. Therefore, evaluation of the consequences and issues related to anesthesia is of significant importance.

The POCD leads to a delay in recovery, especially among elderly patients. For this reason, the use of regional anesthesia techniques is suggested for this age group due to the high risk in this population. However, it is unclear whether anesthesia itself can lead to postoperative cognitive dysfunctions. Some studies showed no difference between regional and general anesthesia in terms of cognitive dysfunction [8].

Today, spinal anesthesia is suggested as a suitable alternative approach in elderly patients due to the easy application and rapid stabilization of the sensory and motor blocks. Spinal anesthesia is a blockage of the spinal nerves achieved by injecting local anesthetics from the lumbar vertebrae into the subarachnoid space [9]. Spinal anesthesia is easy and inexpensive. However, it is associated with some physiological consequences and side effects. Early hypotension in about 30% of the cases and postoperative headache in 1-2% of the cases are among the more common complications of this method [10].

Due to rapid blockade, faster recovery, and reduction of postoperative side effects, this

approach is a more appropriate method in lower extremity surgeries [11]. The main concern of spinal anesthesia is the possible effects of anesthesia medicines on the long-term memory system, especially in elderly patients. Anesthesia during surgery is the main risk factor for accelerating the onset of Alzheimer's disease. Since the elderly (65 years and older) have already had a higher rate of surgery than young people, it is of critical importance to assess the possible effects of spinal anesthesia on these patients [12]. It seems that spinal anesthesia is better than general anesthesia in elderly patients, especially those who are not suitable candidates for general anesthesia [13].

These facts motivated us to investigate the effect of spinal anesthesia on postoperative cognition in elderly patients. Accordingly, this study aimed to determine the effect of spinal anesthesia on postoperative cognitive decline in elderly patients.

2. METHODS

This cross-sectional study was performed on elderly patients referring to Besat Hospital, Hamadan, Iran, receiving surgical treatment, and undergoing spinal anesthesia from 2019 to 2020.

2.1 Inclusion and Exclusion Criteria

The inclusion criteria were as: 1) age of above 60 years, 2) physical status class I and II according to the American Society of Anesthesiologists (ASA), and 3) candidate for surgery under spinal anesthesia. On the other hand, the unwilling individuals, those with a history of alcohol and drug consumption (sedatives and anticonvulsants), and the patients with contraindications to spinal anesthesia, including local infection at the site of spinal needle entry, sepsis, hemorrhagic diseases, low platelet count, space-occupying lesion of the brain, spinal anatomical abnormalities, and hypovolemia were excluded from the study.

2.2 Study Design

The sampling was performed using the convenience and non-probability methods. This study included all patients older than 65 years of age with the ASA classes I and II who were candidates for surgery and spinal anesthesia and were referred to Besat Hospital, Hamadan, Iran, from 2019 to 2020. In total, 81 patients have entered the study.

All patients were visited before surgery, and their demographic characteristics were recorded in a researcher-made checklist. Moreover, the Wechsler Memory Scale-III (WMS-III) was utilized to assess the cognitive dysfunction in the cases receiving surgical operation.

During the procedure, electrocardiography, pulse oximetry, and a non-invasive sphygmomanometer were used to monitor the vital signs. Before the spinal procedure, Ringer's lactate solution (10 ml/kg) was administered to all patients. Subsequently, the patients were placed in a sitting position, and after determining the subarachnoid space, 10-12 mg of 0.5% bupivacaine and (50mg/mL) fentanyl were injected into the subarachnoid space. Afterward, the patients were placed in a supine position, followed by the measurement of systolic blood pressure, diastolic blood pressure, mean arterial pressure, heart and respiration rates, and oxygen saturation every three min to 18 min and then every 10 min until the end of the operation.

In case of hypotension (systolic blood pressure less than 90 mmHg) and bradycardia, 5-10 mg ephedrine and 0.5 mg intravenous atropine were prescribed, respectively. During the medication administration, sedatives were not prescribed, and if required, the patient was excluded from the study. Finally, the WMS-III scores were compared before and after anesthesia to assess the severity of cognitive dysfunction, as well as short- and long-term memories, and concentration rate at discharge.

2.3 Statistical Analysis

The data were analyzed in SPSS software (version 23) through the paired t-test, Wilcoxon test, Chi-square test, and correlation coefficient. Moreover, the quantitative and qualitative variables were described as mean (\pm SD) and frequency (percentage), respectively. A p-value less than 0.05 was considered statistically significant.

3. RESULTS

This study included 81 patients undergoing spinal anesthesia with a mean age of 68.86 ± 7.93 years (age range: 58-92). The majority of the patients (56.8%; n=46) were female. Table 1 tabulates the demographic characteristics of the patients, including marital status and education

level. Based on the obtained results, all of the patients were married, and most of them were illiterate (60.5%).

The mean values of the WMS-III categories before and after the study are summarized in Table 2. According to the obtained results, there was no significant difference before and after spinal anesthesia in terms of mean mental control ($Z=-0.82$; $P=0.4$), repetition ($Z=-0.21$; $P=0.82$), visual reproduction ($Z=-2.41$; $P=0.14$), and verbal paired associates ($Z=-2.04$; $P=0.07$). However, the mean values of spatial addition ($Z=-2.07$; $P=0.03$), navigation ($Z=-2.13$; $P=0.03$), and logical memory ($Z=-2.42$; $P=0.01$) increased after spinal anesthesia.

Furthermore, the mean total scores and adjusted total scores showed a significant difference before and after the spinal anesthesia ($Z=-2.49$; $P=0.01$). In addition, the mean values of the memory coefficient were estimated at 68.28 ± 16.77 and 68.66 ± 16.94 , respectively (range: 51-140). It is worth mentioning that the

comparison of memory coefficient among elderly patients undergoing spinal anesthesia revealed no significant difference before and after spinal anesthesia ($Z=-1.51$; $P=0.13$).

Figs. 1 and 2 present the correlation of memory coefficients with age, gender, and education level before and after spinal anesthesia. As can be seen, there is a reverse correlation between age and memory coefficient before ($r=-0.46$; $P<0.005$) and after spinal anesthesia ($r=-0.405$; $P<0.005$). Accordingly, it can be claimed that the rate of memory coefficient decreased with aging. On the other hand, no relationship was observed between gender and memory coefficient before ($r=-0.19$; $P=0.12$) and after spinal anesthesia ($r=-0.18$; $P=0.1$). However, there was a relationship between the education level and memory coefficient before ($r=-0.62$; $P<0.005$) and after spinal anesthesia ($r=-0.57$; $P<0.005$). Accordingly, the rate of memory coefficient increased with an increase in the education level.

Table 1. Demographic characteristics of the patients

Demographic Characteristics		Frequency	Percent
Age	<65	36	44.4
	65-75	27	33.3
	>75	18	22.2
Marital status	Married	81	100
	Single	0	0
Education level	Illiterate	49	60.5
	Primary School	17	21
	Middle School	7	8.6
	Diploma	8	9.9

Table 2. Mean of WMS-III categories before and after the study

Categories	Before		After		Z	P-value
	Mean	SD	Mean	SD		
Spatial Addition	3.84	1.49	4	1.54	-2.07	0.03
Navigation	4.02	1.21	4.16	1.14	-2.13	0.03
Mental Control	2.86	2.53	2.97	2.6	-0.82	0.409
Logical Memory	2.17	1.74	2.45	1.81	-2.42	0.01
Repetition	3.43	3.68	3.48	3.72	-0.21	0.82
Visual Reproduction	2.59	2.68	2.06	2.8	-2.41	0.14
Verbal Paired Associates	5.34	3.63	5.81	3.83	-2.041	0.07
Total	24.26	12.81	24.94	12.83	-2.49	0.01

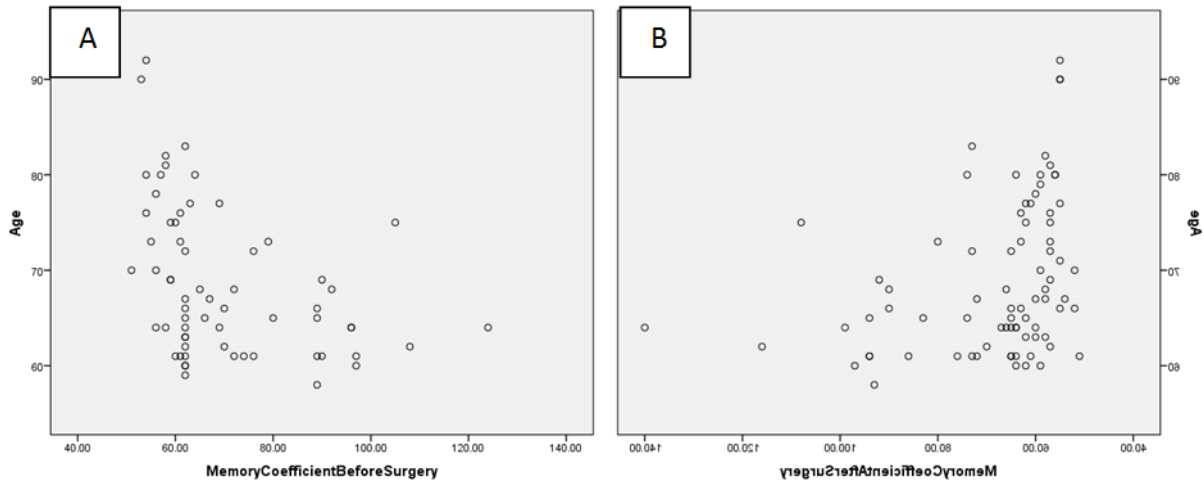


Fig. 1. Correlation of memory coefficient before (A) and after (B) spinal anesthesia with age

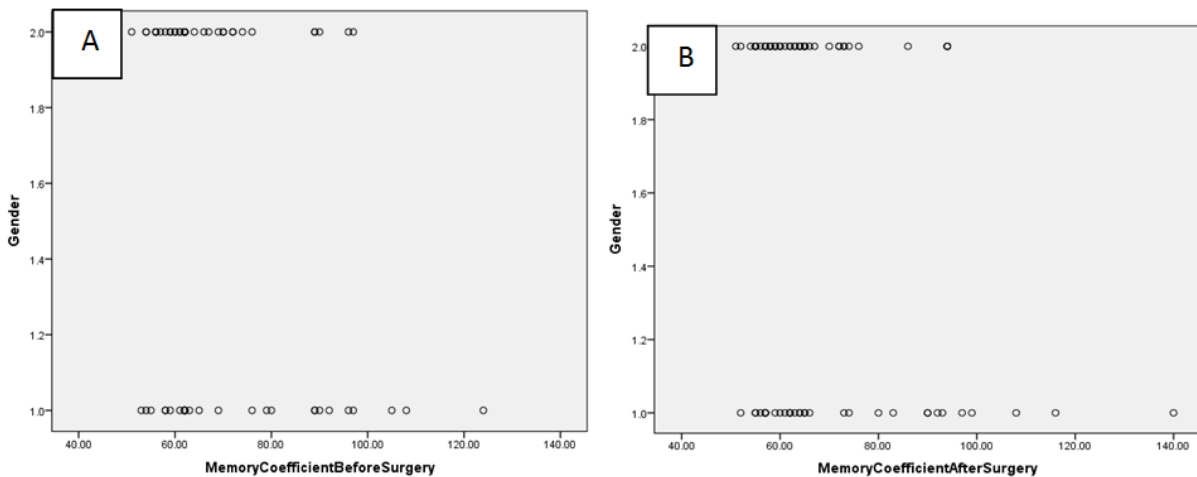


Fig. 2. Correlation of memory coefficient before (A) and after (B) spinal anesthesia with gender

4. DISCUSSION

The present study revealed an increase in spatial addition, navigation, and logical memory after operation; however, there was no change in the mean values of mental control, repetition, visual reproduction, and verbal paired associates. Moreover, an increase was found in the scores of some aspects of memory after the operation, which may be due to an inadequate condition and severe pain before surgery in these patients. However, after adjusting the scores and determining the memory coefficient, no significant difference was found before and after the operation in this regard.

Although the correlation of memory coefficient with age and education level was confirmed, there was no relationship between memory

coefficient and gender. The presence of complications, such as psychological changes along with disruption in daily life activities, memory and speech disorders, progressive memory loss, and other cognitive functions (memory, judgment, and thinking) are characteristic symptoms of cognitive disorders [14,15].

In a study conducted by Tzimas et al., a comparison was made between the cognitive dysfunction of general and subarachnoid anesthesia among elderly patients undergoing hip fracture surgery. Based on the obtained results, no significant differences were reported between general and subarachnoid anesthesia in terms of cognitive domains [16]. This result is consistent with some of our findings; however, it is not in line with other findings. The

discrepancies may be due to the differences in the time of assessing the memory condition after operation. The patients were assessed two days before the operation in the study carried out by Tzimas et al., whereas in this study, the patients were evaluated in terms of the memory domain immediately before the operation. Accordingly, the memory scores may have been affected by the patients' conditions, such as extreme pain and anxiety.

A comparison between regional and general anesthesia has been made in some studies. In one study conducted on the Iranian population, the memory changes after the operation were assessed in patients undergoing regional anesthesia, compared to general anesthesia. This study revealed that short-term memory, as well as verbal, attention, and concentration indices, decreased within 24 h after surgery in the general anesthesia group. However, this condition was not reported in the spinal anesthesia group.

Moreover, no difference was reported between the two groups in terms of short-term memory three months after the operation. Long-term memory also showed no significant difference between the two groups [17].

Similarly, Davis et al. reported a greater incidence of postoperative cognitive dysfunction in patients receiving general anesthesia, compared to those receiving regional analgesia [18]. A significant decline in cognitive function in elderly patients after general anesthesia has been reported in some studies [19,20]. However, there is no evidence of cognitive function decline in elderly patients after spinal anesthesia.

Papaioannou et al. assessed the role of anesthesia type (general or regional) in the development of cognitive impairment in elderly patients during the immediate postoperative period. They indicated more cognitive impairment in elderly patients subjected to general anesthesia, compared to those who received a regional technique [21].

Although many studies rejected the effect of spinal anesthesia on memory dysfunction, it seems that the type of anesthesia affects patients with some memory problems. According to a study conducted by Zuo et al., the effect of spinal anesthesia was investigated on patients suffering from Alzheimer's disease. From 1992 to

2004, the data were collected from patients undergoing spinal anesthesia, and data analysis showed that spinal anesthesia was a risk factor for Alzheimer's disease in older patients [22].

In general, functional recovery depends on many factors, including demographic characteristics, such as age, gender, previous functional and mental status, as well as the success of the surgical intervention [23]. The results of the present study showed a correlation between memory coefficient and age. Some evidence indicates poorer scores in mild cognitive impairment, compared to normal aging [24]. Some older studies highlight the effect of anesthesia on postoperative neurocognitive dysfunction in elderly patients undergoing regional anesthesia (spinal or epidural) [21,25]. In a study performed by Chen et al., the risk of dementia in patients over 50 years who underwent surgery and anesthesia was higher than that in younger patients [26]. In the same way, Bowles et al. assessed the risk of cognitive dysfunction after surgery in patients over 65 years. The results showed that surgery under general anesthesia was not associated with an increased risk of cognitive impairment, compared to individuals with no history of anesthesia [27].

5. ADVANTAGES AND LIMITATIONS

Regarding the limitations of this study, it should be mentioned that the effect of pain and anxiety was not assessed on the level of memory function before anesthesia, which was one of the main limitations. Moreover, the memory condition of the patients was not investigated in the follow-up. Future multicenter studies with larger sample sizes can be recommended. Moreover, some research should be conducted with follow-up to investigate the long-term effect of spinal anesthesia on memory function. In addition, it is suggested that further studies assess pain and anxiety before the operation to evaluate the effect of this variable on the memory function of the patients.

6. CONCLUSION

Based on the obtained results of our study, spinal anesthesia had no effects on memory coefficient. However, there was an increase in some memory function domains after the operation. It seems that memory function may have been affected by the patients' conditions before the operation.

CONSENT

It is not applicable.

ETHICAL APPROVAL

The Research Ethics Committee of Hamadan University of Medical Sciences, Hamadan, Iran, approved the study protocol (IR.UMSHA.REC.1398.003). It is worth mentioning that the data were coded to maintain data confidentiality.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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