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Cohort Study

Evaluating memory dysfunction after spinal anesthesia among patients undergoing elective surgery: Descriptive-analytical study

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ABSTRACT

Background: Anesthesia has a number of side effects including cognitive impairment after the surgery. Postoperative cognitive impairment is commonly associated with general anesthesia.

Objective: The aim of this study is to evaluate the effects of Marcaine (bupivacaine hydrochloride) in memory impairment among patients undergoing elective surgery.

Materials and methods: In this study descriptive-analytical study, patients undergoing elective lower extremity or lower abdomen surgery requiring spinal anesthesia were included. Following 24 h of the surgery, standard Wechsler questionnaire was used to assess memory of the patients. Other demographic and clinical parameters such as age, gender and blood pressure, pulse rate were also recorded. The obtained data was analyzed using SPSSv18.

Results: In this study, 105 patients where 55 (52.4%) males and 50 (47.6%) females were studied. The mean age of the subjects was 35.73 ± 10.64 years. There was a significant difference between the mean of memory scores in terms of logical memory and overall memory ($P < 0.001$). There was a significant relationship between the mean scores of patients' rational memory and systolic blood pressure at admission ($P = 0.030$). There was a significant relationship between mean associative learning scores in patients and systolic blood pressure at admission ($P = 0.046$) and type of surgery ($P = 0.013$). Furthermore, overall memory scores were significantly associated with age ($P = 0.041$).

Conclusion: Based on the results of this study, it can be concluded that spinal anesthesia had a significant effect on some areas of memory. Further studies in this area can yield more reliable results.

The research approved by the committee of research ethics of Lorestan university (IR.LUMS.REC.1398.162). https://ethics.research.ac.ir/ProposalCertificateEn.php?id=88615&Print=true&NoPrintHeader=true&NoPrintFooter=true&NoPrintPageBorder=true&LetterPrint=true.

1. Introduction

Postoperative cognitive decline (POCD) is described as the loss of memory, concentration, language, learning and other daily activities following the surgery under regional or general anesthesia [1,2]. It is more common in elderly population and is associated with the reduction in quality of life(3). Other factors that can influence POCD include hypoxemia, preoperative pain and impaired neurological function, metabolic disturbance and certain types of anesthetic agents and surgeries [4,5]. The incidence of POCD can be 16–59% following 7 days of the surgery and 12–34% following 12 weeks postoperatively [5].

Exposure to anesthetics like nitrous oxide, isoflurane, and midazolam can impair memory and are known to have neurogenerative effects [6,7]. The role of proinflammatory cytokines has been chiefly suggested to cause POCD such as increase in IL-6 levels. Furthermore, cyclooxygenase-2 is increased in response to cerebral injury in ischemia and can lead to memory disturbances [5]. A recent study has indicated that decrease in glial cell-derived neurotrophic factor leads to neuroinflammation in animal model and can cause memory dysfunction [8]. Alterations in gene expression after general anesthesia is also reported to lead to neuroplasticity [9,10]. Owing to known effects of general anesthesia in cognitive impairment, a number of studies have argued on substituting general anesthesia with regional anesthesia [4,11,12].

The aim of this study is to evaluate the effects of regional anesthesia with bupivacaine hydrochloride in memory impairment among patients undergoing elective surgery.

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2. Methods

This study is a descriptive-analytical study conducted from January 2020–June 2020 where changes in memory was evaluated after spinal anesthesia following first 24 h after elective surgery. Inclusion criteria included patients undergoing elective surgery with any pathology of the lower abdomen and lower extremities requiring spinal anesthesia, male and female patients with age groups of 18–30 years, between 30 to 49 years and 50–65 years, patients with an education level of graduation or higher and those who consented to participate in the study. Exclusion criteria include arrhythmias (effected by spinal anesthesia), hypoxia, hypothermia, hyperthermia, hemodynamic changes more than 30% compared to baseline, need to receive spinal anesthesia more than once (insufficient block), pregnancy, hospitalization in special wards, need of general anesthesia, cognitive or memory problems, Alzheimer's or dementia, and those who did not consent to participate in the study.

The patients' memory level was determined 12 h and 24 h after the surgery by a medical intern in the teaching hospitals of (XXX) from 2018 to 2019.

Spinal anesthesia was injected with 0.5 cc of 3% Marcaine (bupivacaine hydrochloride) through an angiocatheter with a 25 gauge into the space between the L3-L4 vertebrae in a single attempt. The patients were monitored after every 3–5 min. Patients received 500CC normal saline solution before the surgery. The temperature of the operation theatre was set between 33 and 38 °C. The study tool was the standard Wechsler questionnaire, which is used as an objective scale for assessing memory, as indicated in previous studies [6].

With this test, in general, it is possible to: 1. Learn and instant recall 2. Concentrate attention 3. Orientation and recall of long-term memory. The Wechsler Memory Scale includes 7 subtests.

1 Personal awareness of everyday and personal issues
2 Awareness of time and place of orientation
3 Mental control
4 Logical memory
5 Repeat forward and reverse digits
6 Visual memory
7 Learning association

Each subtest consists of several questions and are graded according to patients' response in a particular time frame. By summing the scores of all seven tests and adding a modified standard score that is standardized in the United States, the total score of a person's memory is obtained (138).

The was computerized and statistically analyzed using SPSSv18. Descriptive statistics such as frequency distribution tables and mean and standard deviation or mean and mid-quarter amplitude were used to present data. For data analysis, tests such as analysis of variance (ANOVA), and one-way ANOVA or longitudinal models such as marginal model were used. $P < 0.05$ was considered statistically significant.

The research approved by the committee of (XXX). Entry in this study was voluntary and prior to the start of the research, informed written consent was obtained from all the patients.

The work has been reported in line with the STROCSS criteria [13].

3. Results

3.1. Demographic and clinical description

In this study, 105 patients were included where 55 (52.4%) were male and 50 (47.6%) were female. The mean age of the patients was 35.73 ± 10.64 years, Table 1. 60 patients (57.1%) had a diploma. 35 (33.3%) patients underwent uterine dilation and curettage surgery. 49 patients (46.7%) lost anesthetic effects within 4 h after the start of the procedure. 83 patients (79%) received saddle anesthetic block. The mean systolic blood pressure at the preoperatively was 101.12 ± 9.82 mm Hg, which varied between 93.46 ± 8.57 mm Hg as the mean minimum systolic pressure during surgery and 114.46 ± 10.05 mm Hg as the maximum systolic pressure during surgery. The mean diastolic blood pressure before the surgery was 83.42 ± 9.02 mmHg, which was 75.68 ± 9.31 mmHg as the mean minimum intraoperative diastolic pressure and 90.98 ± 10.4 mmHg as the maximum diastolic pressure during the surgery. The mean heart rate of patients at the preoperatively was 80.02 ± 13.09 beats per minute, which ranged from 74.97 ± 12.11 beats per minute as the minimum and 88.54 ± 11.5 beats per minute as the maximum heart rate, intraoperatively.

Table 1
Patients' memory score before and after surgery and the change of these two in relation to each other in different dimensions.

	Mean	Standard deviation	p-value
Personal, public information before the operation	6	0	–
Personal, public information after the operation	6	0	
Change public personal information	0	0	
Preoperative orientation	5	0	–
Postoperative orientation	5	0	
Orientation change	0	0	
Preoperative mental control	6.59	1.2611	–
Postoperative mental control	6.59	1.2611	
Change mental control	0	0	
Preoperative logical memory	17.619	3.9629	**<0.001**
Postoperative logical memory	18.152	3.2538	
Change logical memory	0.5333	1.05672	
Learn associations before the operation	19.352	5.0739	0.439
Learn associations after the operation	19.457	4.5267	
Changing associative learning	0.1048	1.38101	
Repeat the digits before the operation	9.448	0.9505	0.052
Repeat the digits after the operation	9.571	1.0907	
Change the repetition of digits	0.1238	0.64592	
Preoperative visual memory	12.21	1.3898	0.061
Postoperative visual memory	12.371	1.2879	
Changing visual memory	0.1619	0.87567	
Total preoperative memory	73.848	7.7944	**<0.001**
Total postoperative memory	75.062	6.7641	
Change the total memory	1.2141	3.08707	

*Statistically significant difference (0.05 <n = 105).

3.2. Change in memory before and after the surgery

There was no significant difference between the mean memory score in terms of personal and general information, orientation and mental control. Based on the results of paired *t*-test, there was a statistically significant difference between the average memory scores in the logical memory dimension and the total memory score ($P < 0.001$). The difference between the scores of associative memories, repetition memory, visual memory before and after the surgery were not significantly different, $p = 0.439$, $p = 0.052$ and $p = 0.061$. Overall, the memory score before and after the surgery were significantly different, $p < 0.001$ (Table 1).

Evaluation of the score obtained in personal and general information section of the questionnaire with demographic and clinical variables.

We also determined if the variables such as age, gender, level of education, etc. is related to the score obtained in the personal and general information section of the Wechsler questionnaire or not. The difference between the points obtained before and after the surgery in the of personal and general information in relation to all study variables is zero, which means that the ability to answer personal and general questions of the Wechsler questionnaire is not related to the variables studied in this study.

Evaluation of the score obtained in the section of temporal and spatial orientation with demographic and clinical variables.

The difference between these variables (age, gender, education level,

anesthesia recovery time, duration of anesthesia, blood pressure and heart rate) obtained before and after the surgery is zero, showing that the ability to answer questions related to the spatial and temporal orientation with the Wechsler questionnaire is not related to the variables in this study.

Evaluation of the score obtained in the section of mental control with demographic and clinical variables.

The difference between the scores obtained before and after the surgery in the section of mental control in relation to other variables (age, gender, education level, anesthesia recovery time, duration of anesthesia, blood pressure and heart rate) is equal to zero showing that ability to answer the questions related to the mental control using Wechsler questionnaire is not related to the variables studied in this study.

Evaluation of the score obtained in the section of logical memory with demographic and clinical variables.

As seen in Table 2, the changes related to patients' logical memory scores before the surgery with systolic blood pressure were statistically significant. $p = 0.030$. Based on the results of paired t - test, correlation between patients' mean memory scores and maximal diastolic blood pressure during the operation was not significant $p = 0.089$. Based on the results of paired t - test, no statistically significant relationship was observed between patients' mean memory scores and other variables, $p > 0.05$.

Evaluation of the score obtained in section of associative learning with demographic and clinical variables.

Based on the results of paired *t*-test, the mean scores of associative learning in patients and systolic blood pressure during admission and type of operation were statistically significant $p = 0.046$ and $p = 0.013$, respectively. Based on the results of paired t - test, no statistically significant relationship was observed between the mean scores of associative learning in patients and other variables ($P < 0.05$), Table 3.

3.3. Evaluation of the score from the repetition memory and demographic and clinical variables

Based on the results of paired *t*-test, no statistically significant relationship was found between the mean repetition memory scores of

Table 2
Investigating the changes in the score obtained in the dimension of logical memory by demographic and clinical features.

		preoperative logical memory		Postoperative logical memory		Logical Memory change		p-value
		Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	
Age	Third quantile	16.89	4.03	17.64	3.39	0.75	0.88	0.237
	Second quantile	19.07	2.88	19.58	2.21	0.51	1.03	
	First quantile	16.83	4.54	17.15	3.59	0.32	1.23	
Gender	Male	17.73	4.08	18.24	3.44	0.51	0.98	0.807
	Female	17.5	3.87	18.06	3.07	0.56	1.14	
Education	Undergraduate>	17.55	4.16	18.09	3.38	0.53	1.11	0.995
	Undergraduate≤	17.79	3.46	18.33	2.95	0.53	0.93	
Kind of surgery	Other	17.7	3.49	18.34	3.02	0.64	0.85	0.180
	Pilonidal sinus (PNS)	18.39	4.16	18.39	3.38	0	1.14	
	Perianal abscess	16.83	4.59	17.39	3.77	0.57	1.07	
	lower limb trauma	20.86	2.1	21.29	1.68	0.43	0.53	
	Dilation and curettage (D&C)	17.04	3.77	17.79	2.96	0.74	1.15	
Time to leave anesthesia	2h	18.19	3.78	18.53	3.04	0.34	1.12	0.421
	3h	17.55	3.87	18.25	3.15	0.7	1.07	
	4h	17.49	4.15	17.95	3.44	0.46	1.03	
Level of anesthesia	Saddle anesthesia	17.33	4.05	17.83	3.25	0.51	1.14	0.720
	vertebra T11	18.94	3.33	19.5	2.92	0.56	0.66	
	vertebra T12	18	4.17	18.9	3.68	0.9	0.55	
Systolic blood pressure threshold upon admission	First quantile	16.57	3.51	17.47	2.85	0.9	1.03	**0.030**
	Second quantile	18.22	4.52	18.62	3.82	0.4	1.01	
	Third quantile	18.11	3.7	18.4	3.02	0.29	1.06	
Diastolic blood pressure threshold upon admission	First quantile	16.56	4.12	17.26	3.44	0.69	1.04	0.583
	Second quantile	17.95	3.72	18.45	3.05	0.5	1.06	
	Third quantile	18.19	4.01	18.61	3.24	0.43	1.09	
Maximum systolic blood pressure during surgery	First quantile	17.67	4.1	18.29	3.45	0.62	1	0.482
	Second quantile	16.5	4.15	17.11	3.28	0.61	1.2	
	Third quantile	18.79	3.31	19.14	2.72	0.35	0.96	
Maximum diastolic blood pressure during surgery	First quantile	16.44	3.97	17.14	3.26	0.69	1.04	0.090
	Second quantile	18.76	3.86	18.97	3.14	0.21	1.08	
	Third quantile	17.69	3.81	18.38	3.17	0.69	1	
Minimal systolic blood pressure during surgery	First quantile	16.41	3.64	17.26	2.97	0.85	1.03	0.100
	Second quantile	18.36	3.91	18.74	3.23	0.38	1.02	
	Third quantile	17.97	4.19	18.34	3.49	0.38	1.09	
Minimal systolic blood pressure during surgery	First quantile	16.96	3.94	17.62	3.3	0.67	1.03	0.385
	Second quantile	18.34	3.92	18.66	3.22	0.31	1.06	
	Third quantile	17.69	4.02	18.26	3.25	0.57	1.08	
Heart rate per minute threshold during admission	First quantile	18.91	3.38	19.15	2.79	0.24	0.96	0.089
	Second quantile	17.5	3.51	18.04	2.81	0.54	1.04	
	Third quantile	16.5	4.65	17.31	3.9	0.81	1.12	
Minimum heart rate during surgery	First quantile	18.64	3.58	18.98	2.93	0.35	0.97	0.420
	Second quantile	17.38	3.49	17.93	2.8	0.55	1.03	
	Third quantile	16.91	4.64	17.6	3.87	0.69	1.16	
Maximum heart rate during surgery	First quantile	18.51	3.6	18.8	2.99	0.29	0.97	0.185
	Second quantile	17.41	3.56	18.03	2.78	0.61	1.07	
	Third quantile	16.78	4.65	17.52	3.93	0.73	1.11	

*Statistically significant difference ($0.05 < n = 105$).

Table 3
Investigating the changes in the score obtained in the dimension of learning associations by demographic and clinical features.

		preoperative logical memory		Postoperative logical memory		Logical Memory change		p-value
		Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	
Age	Third quantile	18.18	5.51	18.6	5.25	0.42	0.69	0.079
	Second quantile	20.14	3.48	20.32	3.05	0.18	0.96	
	First quantile	19.77	5.9	19.45	4.96	−0.32	2.09	
Gender	Male	19.47	5.53	19.41	4.94	−0.06	1.66	0.191
	Female	19.22	4.57	19.51	4.08	0.29	0.98	
Education	Undergraduate>	19.34	5.48	19.53	4.99	0.19	0.96	0.304
	Undergraduate≤	19.38	3.88	19.26	3.04	−0.12	2.14	
Kind of surgery	Other	19.98	4.52	20.09	4.19	0.11	0.8	**0.013**
	Pilonidal sinus (PNS)	21.25	4.5	20.39	3.49	−0.86	2.58	
	Perianal abscess	17.43	6.89	17.89	6.37	0.46	0.95	
	lower limb trauma	20.07	2.35	19.93	2.57	−0.14	0.24	
	Dilation and curettage (D&C)	19.1	4.41	19.51	3.99	0.41	0.91	
Time to leave anesthesia	2h	20.53	4.01	20.66	3.66	0.13	0.79	0.612
	3h	19.1	4.16	19.36	3.83	0.26	0.8	
	4h	19.17	6.01	19.14	5.27	−0.03	1.84	
Level of anesthesia	Saddle anesthesia	19.39	5.35	19.5	4.73	0.11	1.53	0.824
	vertebra T11	19.74	2.74	19.71	2.88	−0.03	0.41	
	vertebra T12	17.5	6.84	17.9	6.08	0.4	0.96	
Systolic blood pressure threshold upon admission	First quantile	19.11	5.28	19.38	5.11	0.26	0.69	**0.046**
	Second quantile	19.13	5.07	19.54	4.53	0.41	0.91	
	Third quantile	19.81	4.97	19.46	3.99	−0.36	2.05	
Diastolic blood pressure threshold upon admission	First quantile	19.9	5.7	19.92	5.1	0.02	2.09	0.836
	Second quantile	18.9	5.36	18.97	4.68	0.08	1.04	
	Third quantile	19.37	4.18	19.59	3.84	0.21	0.87	
Maximum systolic blood pressure during surgery	First quantile	20.28	4.92	20.57	4.6	0.29	0.8	0.337
	Second quantile	19.08	5.45	18.92	4.71	−0.17	1.97	
	Third quantile	18.64	4.81	18.83	4.12	0.2	1.05	
Maximum diastolic blood pressure during surgery	First quantile	19.25	5.85	19.38	5.2	0.12	1.97	0.970
	Second quantile	19.34	5.12	19.4	4.51	0.06	1.12	
	Third quantile	19.47	4.21	19.6	3.85	0.13	0.77	
Minimal systolic blood pressure during surgery	First quantile	18.56	5.66	18.9	5.4	0.34	0.77	0.096
	Second quantile	19.2	4.38	19.44	3.89	0.24	0.91	
	Third quantile	20.5	5.26	20.14	4.32	−0.36	2.2	
Minimal systolic blood pressure during surgery	First quantile	19.78	5.25	20.13	4.92	0.35	0.76	0.382
	Second quantile	19.03	5.61	18.91	4.51	−0.12	2.28	
	Third quantile	19.2	4.59	19.25	4.19	0.05	0.86	
Heart rate per minute threshold during admission	First quantile	18.59	4.23	18.98	3.8	0.39	0.9	0.227
	Second quantile	20.07	4.12	19.89	3.57	−0.17	1.91	
	Third quantile	19.29	6.61	19.43	5.98	0.13	0.99	
Minimum heart rate during surgery	First quantile	18.45	4.3	18.89	3.85	0.44	0.83	0.220
	Second quantile	19.99	4.12	19.86	3.63	−0.12	1.93	
	Third quantile	19.53	6.49	19.56	5.86	0.03	1.04	
Maximum heart rate during surgery	First quantile	18.89	4.45	19.28	4.05	0.38	0.88	0.183
	Second quantile	19.41	4.4	19.2	3.83	−0.21	1.96	
	Third quantile	19.83	6.4	19.95	5.72	0.13	1.02	

*Statistically significant difference (0.05 <n = 105).

patients' and other variables($p > 0.05$).

3.4. Evaluation of the scores of visual memory and demographic and clinical variables

Based on the results of paired *t*-test between patients' mean visual memory scores and other variables were not statistically related, $p > 0.05$.

3.5. Evaluation of total scores and demographic and clinical variables

Based on the results of paired *t*-test between the mean total scores obtained in all sections of the questionnaire was significantly related with age, $p = 0.041$. This association was insignificant for other variables ($P > 0.05$), Table 4.

3.6. Multivariate modeling and clinical variables

Clinical variables including systolic and diastolic blood pressure during admission, minimum and maximum systolic and diastolic blood pressure during surgery, heart rate per minute at admission and minimum and maximum heart rate per minute during surgery were correlated with each other. Therefore, they are not useable in the multivariate modeling process; a problem known as multicollinearity. To prevent this problem, an exploratory factor analysis was performed on the above variables. In this process, the principal component analysis approach was used for better interpretation of factor loads using Varimax rotation. Two factors were identified where the first and second factor determined about 74.48% of the variance between the variables (the first factor 44.57% and the second factor 29.91%. The first factor was related to systolic and diastolic blood pressure before surgery. The minimum systolic and diastolic blood pressure during surgery and the maximum systolic and diastolic blood pressure during surgery is higher. The second factor was related to heart rate per minute before the surgery and perioperative the minimum and maximum heart rate.

Table 4
Investigation of changes in the total scores obtained in all dimensions of memory by demographic and clinical characteristics.

		preoperative memory		Postoperative memory		Memory change		p-value
		Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	
Age	Third quantile	72.45	7.89	73.14	6.35	0.68	3.13	**0.041**
	Second quantile	77.36	6.61	78.01	6.22	0.65	2.66	
	First quantile	71.61	7.76	73.87	6.82	2.26	3.25	
Gender	Male	74.07	8.44	75.32	7.41	1.25	3.07	0.915
	Female	73.6	7.1	74.78	6.04	1.18	3.14	
Education	Undergraduate>	73.17	8.09	74.57	7.03	1.4	3.28	0.317
	Undergraduate≤	75.62	6.78	76.34	5.92	0.72	2.51	
Kind of surgery	Other	76.23	7.67	76.68	6.74	0.45	1.6	0.068
	Pilonidal sinus (PNS)	75.42	7.47	76	6.48	0.58	3.39	
	Perianal abscess	69.7	7.74	72.41	7.37	2.72	3.46	
	lower limb trauma	79.86	7.73	79.86	7.78	0	0.5	
	Dilation and curettage (D&C)	73.07	6.9	74.34	5.73	1.27	3.41	
Time to leave anesthesia	2h	74.94	7.31	75.91	6.6	0.97	3.4	0.206
	3h	74.15	7.74	74.78	6.5	0.62	2.17	
	4h	73.25	8.09	75.02	7.14	1.78	3.55	
Level of anesthesia	Saddle anesthesia	73.14	7.48	74.52	6.42	1.37	3.39	0.572
	vertebra T11	76.47	7.93	76.97	7.39	0.5	1.29	
	vertebra T12	76.6	11.43	77.6	9.86	1	1.77	
Systolic blood pressure threshold upon admission	First quantile	73.8	7.39	74.75	6.15	1.67	3.63	0.251
	Second quantile	73.91	9.12	75.37	8.24	1.46	2.67	
	Third quantile	74.57	6.91	75.09	5.9	0.51	2.81	
Diastolic blood pressure threshold upon admission	First quantile	74.34	7.75	75.74	6.51	1.4	3.36	0.626
	Second quantile	74.88	8.5	75.72	7.41	0.83	2.79	
	Third quantile	72.26	6.93	73.73	6.19	1.47	3.2	
Maximum systolic blood pressure during surgery	First quantile	75.51	7.73	76.81	6.75	1.29	3.57	0.978
	Second quantile	72.07	8.08	73.21	6.48	1.14	2.95	
	Third quantile	73.97	7.35	75.18	6.76	1.21	2.73	
Maximum diastolic blood pressure during surgery	First quantile	73.42	7.68	74.82	6.36	1.4	3.25	0.749
	Second quantile	75.4	8.53	76.74	7.58	1.34	3.31	
	Third quantile	72.71	7.06	73.59	6.07	0.88	2.72	
Minimal systolic blood pressure during surgery	First quantile	73.06	7.85	74.85	6.51	1.79	3.67	0.345
	Second quantile	73.92	7.94	74.67	6.95	0.75	2.56	
	Third quantile	74.67	7.69	75.88	6.95	1.21	3.03	
Minimal systolic blood pressure during surgery	First quantile	74.89	6.5	75.6	5.37	0.71	2.71	0.438
	Second quantile	75.38	9.38	77.05	8.23	1.67	3.38	
	Third quantile	71.8	7.34	73.14	6.36	1.34	3.2	
Heart rate per minute threshold during admission	First quantile	74.45	7.85	76.03	7.25	1.58	3.1	0.420
	Second quantile	73.92	6.17	75.33	5.36	1.41	3.52	
	Third quantile	73.18	9.39	73.82	7.64	0.65	2.52	
Minimum heart rate during surgery	First quantile	74.05	8.09	75.56	7.37	1.52	2.57	0.134
	Second quantile	73.68	6.22	75.42	5.51	1.74	3.84	
	Third quantile	73.84	9.12	74.21	7.45	0.37	2.49	
Maximum heart rate during surgery	First quantile	74	7.64	75.76	6.92	1.76	3.67	0.177
	Second quantile	73.63	6.73	74.99	5.82	1.36	2.87	
	Third quantile	73.91	9.19	74.31	7.61	0.41	2.4	

3.7. Multivariate modeling of the relationship between demographic and clinical variables

Based on the analysis of covariance model and by adjusting the effect of other variables, the relationship between patient age group and mean change in the patient's logical memory score was significant, $p = 0.002$. The change in logical memory score in patients in the second decade of age, compared to the first trimester of age, was 0.614 points more on average, $p = 0.001$. Also, the change in logical memory score in patients in the third decade age group compared to the first was 0.504 units higher, $p = 0.007$.

According to this model, the relationship between the type of surgery performed on the patient and the mean change in the patient's logical memory score was non-significant, $p = 0.095$. The change in logical memory scores in patients who underwent lower limb surgery was 0.268 units higher than in patients who underwent uterine dilatation and curettage, $p = 0.34$. Also, the change in logical memory score in patients with perianal abscess was 0.367 units less as compared to uterine dilatation and curettage patients, $p = 0.06$. Also, the change in logical memory score in patients with pilonidal sinus was 0.292 on average less than uterine dilatation and curettage, $p = 0.123$. Also, change in logical memory score in patients undergoing other surgeries requiring spinal anesthesia (obstructive uropathies, fallopian tube ligation, etc.) compared to dilatation and curettage of the uterus was 0.085 less, $p = 0.633$. The relationship between the first and second factors and the mean change in the patient's logical memory score was not significant, $p = 0.252$ and $p = 0.956$(Table 5).

4. Discussion

Spinal anesthesia is the most common technique used for anesthesia during surgery [14,15]. Spinal anesthesia has many advantages such as patient comfort, elimination of the risks of general anesthesia, and postoperative pain control [16,17]. The aim of this study was to evaluate the memory changes after spinal anesthesia in the first 24 h after elective surgeries. There is a statistically significant difference after logical memory and total memory score following the surgery ($P < 0.001$). No change was observed in the response memory of individuals to their personal and general information, before and after anesthesia. Furthermore, no change was observed in the level of mental control of individuals before and after anesthesia. A statistically significant relationship was found between the mean of patients' rational memory

Table 5
Relationship between demographic and clinical variables on changing the patient's logical memory score.

Variable	R^2	Standard error	P-value
Age	–	–	**0.002**
Third quantile	0.504	0.1874	0.007
Second quantile	0.614	0.1776	**0.001**
First quantile	Standard range	–	–
Kind of surgery	–	–	0.095
Other	0.085	0.01773	0.633
Pilonidal sinus (PNS)	0.292	0.1892	0.123
Perianal abscess	0.367	0.1948	0.060
lower limb trauma	0.268	0.2805	0.340
Dilation and curettage (D&C)	Standard range	–	–
Score the first factor	–	–	0.252
Systolic and diastolic blood pressure during admission	0.125	0.1584	0.431
Minimum systolic and diastolic blood pressure during surgery	0.128	0.154	0.408
Maximum systolic and diastolic blood pressure during surgery	Standard range	–	–
Second factor score	–	–	0.956
Maximum heart rate per minute during surgery			
Minimum heart rate per minute during surgery			
Heart rate per minute during patient admission	Standard range		

**The first factor associated with systolic and diastolic blood pressure at admission is the minimum systolic blood pressure and intraoperative diastole and maximum systolic and diastolic blood pressure are higher.
***The second factor is related to the number of heart beats per minute during patient admission and the minimum and maximum number of beats the heart is higher per minute during surgery.

scores and systolic blood pressure before the surgery. A statistically significant relationship was found between the mean associative memory score and systolic blood pressure during admission and the type of surgery. Visual memory was not associated with any variable studied. We also reported that the total memory score was associated with age.

A study by Alipour, S et al. [18], reported that regional anesthesia is significantly associated with memory loss, particularly logical and number repeat memory. Araghizadeh et al., conducted a study to evaluate the effects of general and spinal anesthesia on long-term and short-term memory among patients who were candidates for lower limb or lower abdomen surgery. The patients were evaluated 24 h and 3 months following the surgery. The results of this study show a decrease in short-term memory, verbal index, and attention and concentration index following 24 h after the surgery under general anesthesia. No such correlation was reported following spinal anesthesia. Sprung, Schulte [19] reported that, despite the decline in cognitive function is reported with both, regional and general anesthesia, memory decline is only associated with general anesthesia. Similarly, Zywiel, Prabhu [20] also concluded in a systematic review that general anesthesia is chiefly associated with cognitive impairment. A study by Wu, Hsu [21] evaluating the effects of general and spinal anesthesia intraoperative neuraxial does not decrease the incidence of POCD as compared to general anesthesia.

Fathy, Hussein [22] compared the effects of lidocaine and bupivacaine in POCD among patients undergoing elective cataract surgery. The results of the study concluded that both lidocaine and bupivacaine impair verbal memory, attention, and executive function, however, the effects of lidocaine are more severe. Furthermore, it has been reported that these effects are in response to the type of local anesthesia used rather than the type of surgery [23]. Nonetheless, Naghibi, Nazemroaya [24] concluded that lidocaine is preferable regional anesthesia for cataract in terms of POCD as compared to dexamethasone(25).

Naghibi, Nazemroaya [24] conducted a study in Isfahan, Iran comparing the effects of regional and general anesthesia in POCD through mini mental status examination (MMSE). The outcomes of the study reported that regional anesthesia is more favorable for elderly patients undergoing cataract surgery. Song, Zhang [26] studied the effects of edaravone prior to spinal anesthesia in elderly patients. The outcomes of the study showed that edaravone before spinal anesthesia can reduce the incidence of cognitive decline among elderly patients by increasing oxygen metabolism.

Our study is based on a limited sample size and a short-term follow up. Further studies including long term follow-up, comparison of different regional anesthesia and general (propofol, midazolam, fentanyl, vecuronium bromide) and local anesthesia (lidocaine and tetracaine) can help to confer better conclusions.

5. Conclusion

The results of our study indicate that age and blood pressure can affect memory after spinal anesthesia. Furthermore, several parts of memory like logical memory can show greater alterations. Clinical parameter like blood pressure and type of surgery may predict changes in the memory function after spinal anesthesia.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Ethical approval and consent to participate

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Consent to participate

Written consent was obtained from all the participants for the participation in the study.

Consent for publication

Not applicable.

Availability of data and material

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

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Contributors' statement page

Dr.Sepideh Vahabi: conceptualized and designed the study, drafted the initial manuscript, and reviewed and revised the manuscript.

Dr. **Arash Karimi and Dr. Simin Babaei**: Designed the data collection instruments, collected data, carried out the initial analyses, and reviewed and revised the manuscript.

Dr. **Siavash Beiranvand**: Coordinated and supervised data collection, and critically reviewed the manuscript for important intellectual content.

Declaration of competing interest

The authors deny any conflict of interest in any terms or by any

means during the study.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.amsu.2021.01.034.

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