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

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 (affected 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

|                | 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            |         |

*aStatistically 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 |
|---|---|---|---|
| | Mean | Standard deviation | Mean | Standard deviation | Mean | Standard deviation |
| Age | | | | | | |
| Third quantile | 16.89 | 4.03 | 17.64 | 3.39 | 0.75 | 0.88 |
| 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 |
| 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 |
| 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 |
| Pillow lumbar (PNS) | 18.39 | 4.16 | 18.39 | 3.38 | 0.64 | 0.85 |
| 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 |
| Dilatation 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 |
| 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 |
| vertex T11 | 18.94 | 3.33 | 19.5 | 2.92 | 0.56 | 0.66 |
| vertex T12 | 18 | 4.17 | 18.9 | 3.68 | 0.9 | 0.55 |
| Systolic blood pressure threshold upon admission | | | | | | |
| First quantile | 16.57 | 5.31 | 17.47 | 2.85 | 0.9 | 1.03 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 | 0.99 |
| Minimal systolic blood pressure during surgery | | | | | | |
| First quantile | 16.96 | 3.94 | 17.62 | 3.3 | 0.67 | 1.03 |
| 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 |
| 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 |
| 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 |
| 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 \( 0.05 < n = 105 \).
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, heart rate per minute at admission and minimum and maximum systolic and diastolic blood pressure during surgery and the maximum systolic and diastolic blood pressure during surgery were higher. The second factor was related to heart rate per minute before the surgery and perioperative the minimum and maximum heart rate.

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 3.4                   | -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            |         |
| Dilution and curettage (D&K) | 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 | 19.11 5.28 | 19.38 5.11 | 0.26 0.69 | 0.046 |
| First quantile               | 19.13 5.07                  | 19.54 4.53                  | 0.41 0.91             |         |
| Second quantile              | 19.81 4.97                  | 19.46 3.99                  | -0.36 2.05            |         |
| Diastolic blood pressure threshold upon admission | 19.9 5.7 | 19.92 5.1 | 0.02 2.09 | 0.836 |
| First quantile               | 18.9 5.36                   | 18.97 4.69                  | 0.08 1.04             |         |
| Second quantile              | 19.37 4.18                  | 19.59 3.84                  | 0.21 0.87             |         |
| Maximum systolic blood pressure during surgery | 20.28 4.92 | 20.57 4.6 | 0.29 0.8 | 0.337 |
| First quantile               | 19.08 5.45                  | 18.92 4.71                  | -0.17 1.97            |         |
| Second quantile              | 18.64 4.81                  | 18.83 4.12                  | 0.2 1.05              |         |
| Maximum diastolic blood pressure during surgery | 19.25 5.85 | 19.38 5.2 | 0.12 1.97 | 0.970 |
| First quantile               | 19.34 5.12                  | 19.4 4.51                   | 0.06 1.12             |         |
| Second quantile              | 19.47 4.21                  | 19.6 3.85                   | 0.13 0.77             |         |
| Minimal systolic blood pressure during surgery | 18.56 5.66 | 18.9 5.4 | 0.34 0.77 | 0.096 |
| First quantile               | 19.2 4.38                   | 19.44 3.89                  | 0.24 0.91             |         |
| Second quantile              | 20.5 5.89                   | 20.14 4.32                  | -0.06 2.4             |         |
| Minimal systolic blood pressure during surgery | 20.78 5.25 | 20.13 4.92 | 0.35 0.76 | 0.382 |
| First quantile               | 19.03 5.61                  | 18.91 4.51                  | -0.12 2.28            |         |
| Second quantile              | 19.2 4.59                   | 19.25 4.19                  | 0.05 0.86             |         |
| Heart rate per minute threshold during admission | 18.59 4.23 | 18.98 3.8 | 0.39 0.9 | 0.227 |
| First quantile               | 19.07 4.12                  | 19.89 3.57                  | -0.17 1.91            |         |
| Second quantile              | 19.29 6.61                  | 19.43 5.98                  | 0.13 0.99             |         |
| Minimum heart rate during surgery | 18.45 4.3 | 18.89 3.85 | 0.44 0.83 | 0.220 |
| First quantile               | 19.99 4.12                  | 19.86 3.63                  | -0.12 1.93            |         |
| Second quantile              | 19.53 6.49                  | 19.56 5.86                  | 0.03 1.04             |         |
| Maximum heart rate during surgery | 18.89 4.45 | 19.28 4.05 | 0.39 0.88 | 0.183 |
| First quantile               | 19.41 4.4                   | 19.2 3.83                   | -0.21 1.96            |         |
| Second quantile              | 19.83 6.4                   | 19.95 5.72                  | 0.13 1.02             |         |

*(Statistically significant difference (0.05 < n = 105).*
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, \( p = 0.252 \) and \( p = 0.956 \). 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).

### 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 scores and 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 \( p = 0.956 \).
The second factor is related to the number of heart beats per minute during surgery. A study by Wu, Hsu [21] evaluated the effects of regional anesthesia on POCD, concluding in a systematic review that general anesthesia is chiefly associated with cognitive impairment. A study by 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].

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

| Variable                        | R²  | 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 | Standard range | –          | –       |
| Heart rate per minute during patient admission | –   | –              |         |

**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 surgery 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 neu- raxial 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].

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.jamsu.2021.01.034.

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