

Effects of Spinal and Epidural Anaesthesia on Brain Oxygenation in Lumbar Disc Surgery

Leyla Kazancıoğlu^{1*} Şule Batçık¹

1. School of Medicine, Recep Tayyip Erdoğan University, PO box 53020, Rize, Turkey

* E-mail of the corresponding author: leyla.kazancioglu@erdogan.edu.tr

Abstract

Aim: Due to the sympathetic blockage in spinal and epidural anesthesia applied in lumbar disc surgery, hemodynamic effects are different from each other and these effects may cause changes in cerebral oxygenation. In our study, we aimed to compare the effects of spinal and epidural anesthesia on brain oxygenation in patients undergoing elective LDS.

Material and Methods: ASA I-II, 50 patients were included in our study. Group S: (n = 25) 15mg(3ml) 5% isobaric bupivacaine intrathecal and Group E: (n = 25) 40mg(8ml) isobaric bupivacaine (5%), 70mg(3.5ml) lidocaine hydrochloride (2%), 75 µg(1.5ml) fentanyl and 3 ml saline were applied to lumbar epidural gap. The hemodynamic variables and bilateral regional cerebral oxygen saturation (rScO₂) of the patients were recorded with the Near-Infrared Spectroscopy (NIRS) method in the basal, supine position in the 5th, 10th minutes after the central block, 10th minute in the prone position and the patient was placed in the supine position again.

Results: In demographic data, hemodynamic parameters and periodic measurements in Group S and Group E, brain right and left hemisphere rScO₂ values (Group S: right hemisphere rScO₂ (basal) 69.7 ± 5.5, (60 minutes) 64 ± 7; left hemisphere rScO₂ (basal) 70.2 ± 5.1, (60 minutes) 64 ± 8, Group E: right hemisphere rScO₂ (basal) 71.6 ± 7.2, (60 minutes) 66.6 ± 5; left hemisphere rScO₂ (basal) 71.7 ± 7.3, (60 minutes) 66.8 ± 5), no statistically significant difference was found (p > 0.05).

Conclusion: Spinal and Epidural anesthesia affect rScO₂ in a similar way. Since epidural anesthesia causes a more balanced anesthesia, it can balance cerebral blood volume and oxygenation. This study may be a guide for studies evaluating the effects of spinal and epidural anesthesia on brain oxygenation, especially in geriatric patient groups.

Keywords: Lumbar disc surgery, Spinal anaesthesia, Epidural anaesthesia, Near-Infrared Spectroscopy (NIRS), Regional Brain Oxygenation Saturation(rScO₂)

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1. Introduction

Symptoms related to lumbar disc herniation (LDH) can decrease the quality of life and cause loss of labor. Although general anaesthesia and regional anaesthesia are used safely in lumbar disc surgery (LDS), which is frequently applied in neurosurgical surgery (Kusku 2014), regional anaesthesia applications are preferred more recently (Edgcombe et al. 2008; Babakhani et al. 2017). Decreased blood loss (Fernandez-Ordóñez et al. 2014), more successful hemodynamic balance (Chu et al. 2007; Davis et al. 1987) and decreased health cost (Deiner et al. 2014) are just a few of the reasons why regional anaesthesia is preferred.

In LDS, spinal or epidural anaesthesia can be preferred for different reasons. In spinal anaesthesia, while hypotension is a disadvantage, the duration of action is shorter than epidural anaesthesia (Jellish et al. 2003). It is known that the rate of neurological complications due to spinal anaesthesia is higher (Tezlaff et al. 1995; Agarwal et al. 2016; Hirose et al. 2016). Complications such as cardiac arrest, respiratory arrest, neuropathy, Cerebrospinal fluid leak, arachnoiditis, meningitis, headache, urinary retention limit spinal anaesthesia. In addition, in lumbar disc surgery, where spinal anaesthesia is applied, the motor and sensory block, which continues in the intraoperative and early postoperative period, delays the neurological examination that will ensure the detection of nerve damage. However, in lumbar disc surgery undergoing epidural anaesthesia, early neurological examination of the patients can be performed easily, since motor block is mostly absent.

LDS is often applied in the prone position. There are few publications about the effect of prone position or regional anaesthesia on cerebral tissue metabolism (Akakın et al. 2015). Studies about, prone position-related cerebrovascular hemodynamic changes (Hojlund et al. 2007), ureteroscopy under spinal anaesthesia (Scott et al. 1988), unilateral inguinal hernia surgery (Nicassio et al. 2010) and cesarean surgery under epidural anaesthesia

(Hojlund et al. 2012) under general anaesthesia in LDS have been evaluated previously.

Cerebral hemodynamic variables directly affect cerebral oxygenation. Oxygen saturation in the frontal region of the brain can be continuously measured noninvasively with the Near-Infrared Spectroscopy (NIRS) method. Regional anaesthesia methods applied in LDS may make hemodynamic changes due to sympathetic blockage. Cerebral blood flow is regulated automatically by cerebral autoregulation; however, if there is a decrease in blood pressure more than the lower limit of cerebral autoregulation, blood flow to the brain changes, and these changes may have an effect on cerebral oxygenation. Two different regional anaesthesia applications can cause different hemodynamic effects. Therefore, in this study, we aimed to compare the effects of spinal and epidural anaesthesia on brain oxygenation in patients undergoing elective LDS.

2. Material and Methods

Following RTEÜ Ethics committee approval (2016/4), 50 patients who underwent disc surgery for 1 or 2 levels of herniated lumbar disc in L4-5 and L5-S1 were included in the study. The exclusion criteria were as follows: age <18, age > 65, American Society of Anesthesiology risk score (ASA) > 2, multilevel spinal stenosis, coagulopathy, carotid artery disease (known stenosis or malformation), cerebral disease (cerebrovascular disease, intracranial lesion or increased intracranial pressure), localized infection, severe cardiac and liver disease, absolute and relative contraindication for regional anaesthesia. Informed volunteer consent was obtained from the patients and the study was carried out in accordance with the Helsinki Declaration. The patients were randomly divided into two groups as Group S (Spinal Anaesthesia) and Group E (Epidural Anaesthesia). The same surgeon and anesthesiologist were responsible for all patients included in the study.

3-derivation electrocardiograms, noninvasive blood pressure values, peripheral oxygen saturation (SpO₂) values, regional cerebral oxygen saturation (SpO₂) values and oxygen saturation (rScO₂) values of patients who were taken in the operating room without premedication and monitored with INVOS 5100C oximeter device, which electrodes were placed on both sides of the forehead (Somanetics, Covidien, Minneapolis, USA), were recorded in the basal, supine position at the 5th, 10th minute after the central block, at 10th minute at the prone position, and when the patient was taken back to the supine position. Spinal anaesthesia was applied in the operating room in a sitting position. After local anaesthesia (1% lidocaine 1ml), 15mg(3ml) 5% isobaric bupivacaine was administered to the subarachnoid space through a 25-gauge Quincke spinal needle from the intervertebral disc intervals in L3-4, L4-5.

Epidural anaesthesia was applied in the operating room under aseptic conditions, after local anaesthesia (1% lidocaine 2ml) from the patient's L3-4, L4-5 intervertebral disc space while the patient was in a sitting position. Epidural space was determined by applying air-resistance loss technique with the help of 18-gauge Tuohy needle 40mg (8ml) isobaric bupivacaine (5%), 70mg(3.5ml) lidocaine hydrochloride (2%), 75 µg(1.5ml) fentanyl and 3 ml saline were given to the epidural space as a single dose.

Following the injection in both groups, patients were placed in supine position and their heads were raised 30 degrees. Patients' sensory block level was evaluated by needle immersion method (pinprick test). In addition, motor block was evaluated with the modified Bromage Scale (0 = no motor block, 1 = no flexion from the hip, 2 = no flexion from the knee, 3 = no ankle or foot movement). When the sensory block reached the level of T10 dermatome, patients were placed in prone position and surgical operation was started. The sensory and motor block levels of the 2nd, 5th, 10th, 15th and 20th minutes after spinal and epidural injection were evaluated.

If the critical heart rate (HR) is <45 beat/minute, 0.5mg of atropine intravenous (IV) if mean arterial pressure (MAP) <60 mmHg, 10mg ephedrine iv and oxygen support in the facial mask was increased if peripheral oxygen saturation (SpO₂) <90%.

2.1 Statistical Analysis

SPSS software (version 22.0) was used for analysis. The suitability of the data to normal distribution was examined using the Kolmogorov-Smirnov test. Parametric data are expressed as mean ± standard deviation. Categorical data were expressed as numbers and percentages (%). Student's t-test was used for comparison between groups, Paired-t test was used for comparison within the group, and Chi-square test was used to compare categorical data, and p values under 0.05 were considered significant.

3. Results

The data of 50 patients who underwent LDS were analyzed. There were no statistically significant differences

between the two groups in terms of demographic data such as gender, ASA, age, height, weight and body mass index (Table 1) and hemodynamic parameters (HR, MAP and SpO₂) ($p > 0.05$).

There were several side effects due to anaesthesia in Groups S and E. In group S, in the 5th minute of spinal anaesthesia in 4 patients, a decrease of more than 20-30% of the MAP basal value was accompanied by a decrease in HR and a 30% reduction in the right and left hemisphere rScO₂ values at the same time. 10-15mg ephedrine was administered intravenously to patients. After reaching the normal values of MAP within 2-3 minutes, the right and left hemisphere rScO₂ values of the brain reached 85% of their baseline value. At the end of the operation, no pathology was found in patients whose cognitive functions were evaluated by mini mental state test in the recovery unit. Nausea occurred in two patients in Group S and one patient in Group E. No patients in either group were given additional sedatives or analgesics outside the standard regimen (Table 2).

There was no statistically significant difference in the right and left hemisphere rScO₂ values in the periodic measurements between Group S and Group E ($p > 0.05$) (Table 3).

Table 1. Distribution of demographic characteristics

	Grup (n=25)	S Grup (n=25)	E
Gender (M/F)	14/11	13/12	
ASA(I/II)	13/12	13/12	
Age (year)	50±10,75	52±11,15	
Weight (kg)	78,44±15,22	81,24±12,33	
Height (cm)	169,44±9,60	171,2±8,72	
Body Mass Index (kg/m ²)	29,08±4,82	28,94±3,48	

Values are presented as Mean±Standard Deviation or n (%).

Grup S: Spinal Anaesthesia, Grup E: Epidural Anaesthesia

Table 2. Intraoperative and postoperative complications

	Grup (n=25)	S Grup (n=25)	E
Hypotension	4	0	
Bradycardia	2	0	
Nausea / Vomiting	2	0	
Urinary retention	1	1	
Neurological complication	0	0	
Headache	0	0	

Table 3. Cerebral oximetry values of groups (%)

	Left Cerebral Hemisphere			Right Cerebral Hemisphere		
	Grup S (n=25)	Grup E (n=25)	P	Grup S (n=25)	Grup E (n=25)	P
Pre - anaesthesia	70.2± 5.1	71.7± 7.3	0.40	69.7± 5.5	71,6± 7.2	0.30
Post-central block Supine 5th min.	66.2±6.6	70 ± 7.6	0.76	66±6.7	70± 7.4	0.06
Post-central block Supine 10th min.	65.7 ± 6	67.8 ± 7.8	0.30	65.4± 5.8	68± 7.7	0.18
Post-central block Prone 10th min.	64.3 ± 5	66.6 ± 8	0.25	64.2± 5.3	66.5± 8	0.24
Post-central block Prone 20th min.	64.6± 6	66 ± 7.1	0.51	64.7 ±5.3	65.7 ±7.7	0.64
Post Operation Supine	64 ± 8	66.8 ± 5	0.72	64 ± 7	66 ± 5	0.59

Values are presented as Mean±Standard Deviation or n (%).

Grup S: Spinal Anaesthesia, Grup E: Epidural Anaesthesia

4. Discussion

LDS is applied under general anaesthesia or regional anaesthesia (Smith et al. 1995; Schuster et al. 2005; Kahveci et al. 2014). Due to the sympathetic blockage that occurs in spinal anaesthesia, heart rate and blood pressure are lower than general anaesthesia (Jellish et al. 1996; Uluş et al. 2015; Smrcka et al. 2001; Ustalar et al. 2014). In patients undergoing spinal anaesthesia, a simultaneous decrease in cerebral oxygenation, which is measured by NIRS method with bradycardia and hypotension, has been reported (Nicassio et al. 2010). In addition, in a study conducted in elective cesarean section with spinal anaesthesia, negative symptoms such as hypotension (69%) and nausea and vomiting (44%) were observed. In this study, it was found that maternal regional cerebral blood volume and oxygenation values measured by NIRS method were lower than basal value simultaneously with hypotension. It has been stated that this may be the beginning of adverse events such as cerebral hypoperfusion and brainstem ischemia (Auroy et al. 2002). In our study, although there was no statistically significant difference in right and left rScO₂ values in both groups, the decrease in rScO₂ secondary to hypotension seen in 4 patients in Group S may indicate that epidural anaesthesia is preferable in the risky group of patients. In a study evaluating the effects of general anaesthesia on the supine and prone position in cerebral oxygenation in lumbar spine surgery, there was a decrease in bilateral regional cerebral oxygen saturation as well as a decrease in heart rate and mean arterial pressure in comparison to the supine values in the 30th and 60th minutes after repositioning the prone position and it was stated that cerebral oxygen values reached normal values in the supine position at the 90th minute of the prone position. The reason for this decrease in cerebral oxygen saturation has been linked to the sympatholytic effects of general anesthetic drugs (Kakiuchi 1997). In our study, no significant difference was found in cerebral oxygenation in the comparison of spinal and epidural anaesthesia in supine and prone position within and between groups.

Denier et al. (Bonica et al. 1966) stated that patients over the age of 68 who underwent non-cardiac (general, spinal, urological, etc.) surgery under general anaesthesia developed 2 times more mild cerebral desaturation in the prone position than in the supine position. They reported that this cerebral desaturation may be due to artery flow occlusion and venous congestion as a result of the foam head and misplaced iliac crest support, although the head position is optimal. Thus, they stated that cerebral desaturation developed by increase of intracranial pressure and decrease of brain perfusion pressure. In other studies (Meyer et al. 2010; Williams 2002), they associated cerebral desaturation with decreased stroke volume and cardiac output due to V. cava inferior compression. Since our study is under regional anaesthesia, we think that the cerebral desaturation developing in our patients is related to the venous ponding and decrease in cardiac output due to sympathetic blockage.

There were two potential limitations in this study. The first is to exclude patients with cerebrovascular disease

from the study. Since we compared two different regional anaesthesia techniques, we could evaluate the effects of these patients on brain oxygenation. The second was that the duration of LDS surgery was a bit short to assess the effects of brain oxygenation in the supine and prone position. Longer-term operations could also be evaluated more clearly.

5. Conclusions

Spinal and Epidural anaesthesia affect rScO₂ in a similar way. However, in spinal and epidural anaesthesia, hemodynamic parameters due to sympathetic block may change and this may affect cerebral oxygenation. Since epidural anaesthesia causes a more balanced anaesthesia, it can balance cerebral blood volume and oxygenation. This study may be a guide for studies evaluating the effects of spinal and epidural anaesthesia on brain oxygenation, especially in geriatric patient groups.

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