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Evaluation of intracranial pressure using optic nerve sheath diameter in patients undergoing thulium laser prostatectomy with spinal or general anesthesia

Turan Evran, Seher İlhan, İsmet Çopur

Department of Anesthesia and Reanimation, Faculty of Medicine, Pamukkale University, Denizli, Turkiye

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ABSTRACT

Aims: This study aims to evaluate optic nerve sheath diameter (ONSD) measurements as a non-invasive indicator of intracranial pressure in patients undergoing thulium laser prostatectomy (ThuLEP) under spinal or general anesthesia.

Methods: 44 patients aged 18-90 years were included in this prospective observational clinical study. Patients were randomly divided into general anesthesia and spinal anesthesia groups. ONSD measurements were made before, during and after surgery. Mann-Whitney U test, Wilcoxon signed rank test and Spearman chi-square test were used in statistical analysis.

Results: There was no statistically significant difference in preoperative, intraoperative and postoperative ONSD values between both groups. In patients who underwent general and spinal anesthesia, an increase in ONSD values was observed after anesthesia compared to the preoperative period.

Conclusion: ONSD measurement may be a useful, non-invasive technique for assessing intracranial pressure. This study showed that both anesthesia methods had similar effects on intracranial pressure. However, studies with a larger number of patients are needed to evaluate the effect of anesthesia management and surgical position on intracranial pressure.

Keywords: ThuLEP, optic nerve sheath diameter, anesthesia

INTRODUCTION

Benign growths of the prostate are the most common urological conditions in men, while malignant growths are the most common urological malignancies. Transurethral resection surgery is considered the gold standard treatment approach in the treatment of benign prostatic hyperplasia, the frequency of which increases with aging.[1] Thulium laser surgery is an enucleation-based method that started to be used in prostate surgery in 2010 and has gained popularity by offering less invasive alternatives.[2] The lithotomy position during this surgery in the lithotomy position during this surgery may lead to an increase in intracranial pressure. The fact that most of the patients undergoing this surgery are elderly with concomitant diseases and thus included in the fragile patient group highlights the need for intracranial pressure monitoring.

Although direct ventriculostomy is the gold standard in intracranial pressure measurement, it has limitations due to the fact that it is invasive and requires an experienced neurosurgeon. Intracranial pressure assessment can be performed more easily with other methods such as computed tomography (CT) and magnetic resonance imaging (MRI), but these methods also have their own limitations. CT evaluation may cause problems in repetitive evaluations due to the fact that it requires mobilization of the patient and contains radiation. Although MRI provides a high-quality image, it also has limitations such as requiring patient mobilization, taking a long time, patients' compatibility with the device is not good, and repetitive imaging takes a long time. Ultrasonography stands out in intracranial pressure measurement because it does not require patient mobilization, does not contain radiation, can be applied at the bedside, other physicians can also use it without the need for a specialist radiologist, and provides the possibility of frequent repeated imaging.[3]

The optic nerve is a continuation of the intracranial dura surrounding the subarachnoid space, and this feature causes it to expand with an increase in intracranial pressure. The optic nerve is a continuation of the dura surrounding the subarachnoid space. It expands with increases in intracranial pressure. When the intracranial pressure increases, the optic

Corresponding Author: Turan Evran, tevran@pau.edu.tr

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nerve sheath swells and becomes visible on ultrasound. Due to this feature, ultrasonography is an important point in the evaluation of intracranial pressure increase. Measurements of optic nerve sheath diameter (ONSD) by ultrasonography are compatible with measurements made by MRI, and ONSD values greater than 5 mm are associated with ICP intracranial pressure (ICP) values greater than 20 mmHg.[4] It has been stated that the evaluation of optic nerve sheath diameter by ultrasonography is a noninvasive, reliable method in intracranial pressure evaluation.[5,6]

The optic nerve sheath appears dark, linear, vertical on ultrasound and is about 3 mm behind the globe. The measurement is made from the place where the 3mm of the closed eyeball cuts the downward line perpendicular. It is recommended that at least two measurements are made and the average is taken to be evaluated with multiple measurements, since the sensitivity is higher than a single measurement.[7]

All inhalation agents have a dose-dependent effect on increasing intracranial pressure by cerebral vasodilation. Propofol has an effect on reducing intracranial pressure. Hypotension and CSF Cerebrospinal fluid (CSF) leakage due to spinal anesthesia cause intracranial pressure reduction.[7] Thulium laser prostatectomy (ThuLEP) surgery is performed in the lithotomy position. Since the legs are lifted in the lithotomy position, venous return increases, causing an increase in cardiac output. It also causes a moderate increase in intracranial pressure due to an increase in cerebral venous return.[8]

ThuLEP surgery can be performed under general anesthesia and spinal anesthesia. Since the majority of patients are elderly, monitoring of intracranial pressure is even more important. For this reason, we aimed to evaluate the optic nerve sheath diameter with USG as a noninvasive method to study the effects of anesthesia on the intracranial pressure of patients in this surgery and to find the appropriate form of anesthesia.

METHODS

April 2023 to February 2024 was held at Pamukkale University Faculty of Medicine Hospital. This study is a prospective, observational clinical study. Study protocol Pamukkale University Non-interventional Clinical Researches Ethics Committee (Date: 19.03.2024, Decision No: 341787) was approved by. All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

The study included patients who underwent TURP surgery, aged 18-90, with ASA (American Society of Anesthesiologists) classifications I, II, or III. All participants were provided with the necessary information and gave written informed consent. Patients with neurological diseases, intracranial space-occupying masses (such as tumors or abscesses), a history of cerebral hemorrhage or infarction, acute or chronic eye-related diseases (such as optic nerve inflammation or cataracts), a diagnosis of any such conditions, a history of eye surgery, those using drugs known to affect intraocular pressure (such as beta-blockers, calcium channel blockers, nitrates, or statins), and those allergic to any of the study drugs were excluded from the study. Patients who did not give consent to participate in the study, withdrew their consent, and experienced data loss during follow-up were also excluded from the study.

The general anesthesia and spinal anesthesia methods were determined by random selection in the patients enrolled in the study. The patients were grouped into spinal group (GS) and general anesthesia group (GGA). All patients underwent standard anesthesia monitoring [ECG, non-invasive blood pressure, peripheral oxygen saturation ($SpPO_2$)] and intravenous isolyte S balanced crystalloid fluid was started by opening the vascular tract. For spinal anesthesia, GS patients were given 15 mg of heavy bupivacaine at the L3-L4 level. For general anesthesia, GGA patients were intubated following induction with propofol (2 mg/kg), rocuronium (0.6 mg/kg), and fentanyl (2 mcg/kg). 2% sevoflurane, 40% O2/60% air distribution was made (GE DATEX OHMEDA AVANGE CS2 USA, USA). In the mechanical ventilation volume control mode, the tidal volume was adjusted to 8 mg/kg, respiratory frequency; between 12-14, the end-of-breath Decarbonization level was adjusted to 35-40 mm/hg. In the mechanical ventilator volume control mode, the initial settings were a respiratory rate of 12-14 breaths per minute and a tidal volume of 8 ml/kg. The respiratory frequency was adjusted to maintain an end-tidal carbon dioxide pressure between 35-40 mmHg.

All patients underwent ONSD measurement (T0) before spinal or general anesthesia was applied in the operating room and this value was accepted as the baseline ONSD value. Subsequent ONSD measurements were performed after spinal or general anesthesia was applied to the patient and the patient was placed in the lithotomy position (T1) and after the patient was placed in the supine position at the end of the operation (T2). The ONSD measurement was transorbitally positioned with an ultrasound linear probe (GE LOGIQ-E, USA). Before the measurement, the patient was asked to close his eyes and not to move. The ultrasound linear probe on the closed eye was slightly placed on the eyelid so as not to create pressure on the patient's eye. The length of the line showing the optic nerve sheath diameter cutting the line drawn 3 mm down from the lower edge of the eyeball seen on ultrasound at a right angle was measured and recorded. The optic nerve sheath diameter was measured twice transorbitally vertically and horizontally from both eyes in the first measurement and the averages were taken. Blood was taken for sodium and hemoglobin values at T0 and 2. Demographic data of the patients, body-mass index (BMI), duration of operation, sodium and hemoglobin values measured in T0 and T2 were recorded. Isotonic sodium chloride solution (0.9% NaCl) was used as irrigation fluid in all patients and the amount of solution used during the operation was recorded.

Statistical Analysis

GraphPad Prism 19 program was used to calculate the sample size. In this study, with an alpha of 0.05, a beta of 0.10, and 1-beta of 0.90, it was decided to include 22 individuals in each group. The power of the test was found to be 0.90681. Data were analyzed using SPSS 25.0 software (IBM SPSS Statistics 25, IBM Corp., Armonk, NY). Continuous variables were presented as mean±standard deviation, and categorical variables were presented as number and percentage. Parametric test assumptions were not met. Mann-Whitney U test was used to compare differences between groups forcontinuous variables. Wilcoxon signed-rank test was used for within-group changes over time. Spearman chi-square test was used for comparisons between categorical variables and groups. In all analyses, $p<0.05$ was considered statistically significant.

RESULTS

A total of 60 patients underwent transurethral prostate resection with ThuLEP. 18 Patients who did not meet the inclusion criteria were excluded from the study. 44 patients who met the inclusion criteria were randomly selected and divided into two groups GS and GGA. The mean age of the patients was 67.80±7.95 years, and the mean age of the Group (69.95±8.55) was significantly higher than GGA (65.64±6.83) (p=0.043). The duration of surgery was significantly longer in Group GGA (147.68±47.65 min) compared to Group GS (118.77±36.38 min) (p=0.040). BMI, amount of irrigation fluid used, ASA scores were similar in both groups (Table 1). When the additional diseases of the patients were examined, 13 of them had HT, 12 of them had DM and 7 of them had coronary artery disease.

Table 1. Demographic data

		GGA (n=22)	GS (n=22)	p	Total
Age (years)		65.64±6.83	69.95±8.55	0.043	67.80±7.95
BMI		26.76±3.68	26.56±2.84	0.999	26.66±3.25
Solution (ml)		52090.9±33043	40.681.8±18237	0.404	46386±26999
	1	0	3 (%13.6)		3 (%6.8)
ASA score	2	16 (%72.7)	13 (%59.1)	0.191	29 (%65.9)
	3	6 (%27.3)	6 (%27.3)		12 (%27.3)

GGA: General anesthesia group, GS: Spinal group, BMI: Body-mass index, ASA: American Society of Anestehesiology

The ONSD values were similar between the groups at all time intervals (p>0.05). In the intra-group evaluation, both right and left ONSD values significantly increased in T1 and T2 measurements compared to T0 measurement (p<0.05). The Na values measured at T0 and T1 times were similar in both groups. The group GGA T1 Hgb (12.24±1.71) was significantly lower compared to the T0 Hgb value (13.78±1.52) (p<0.00). The group GGA T1 Hgb (11.82±2.46) was significantly lower than the T0 Hbg value (13.13±1.99) (p<0.00). Although both Hgb value decreases were statistically significant, they were not clinically significant. The changes in the Hgb values were similar in the intergroup comparison (p>0.05) (Table 2).

Table 2. Optic nerve sheath diameter measurement over time

		GGA (mean±**SD**)	GS (mean±**SD**)	p*
	T0	0.473±0.03	0.470±0.04	0.777
ONSD (right) (mm)	T1	0.534±0.05	0.541±0.05	0.589
	T2	0.546±0.06	0.549±0.06	0.716
p**		0.001	0.030	
	T0	0.470±0.03	0.472±0.04	0.934
ONSD (left) (mm)	T1	0.536±0.06	0.536±0.06	0.787
	T2	0.548±0.07	0.541±0.06	0.972
p**		0.000	0.048	
Hemoglobin (g/dL)	T0	13.78±1.52	13.13±1.99	0.139
	T2	12.24±1.71	11.82±2.46	0.806
p**		0.000	0.000	
Na (mEq/L)	T0	139.77±2.51	138.77±2.81	0.237
	T2	139.14±2.17	137.45±2.74	0.032
p**		0.129	0.148	

GGA: General anesthesia group, SD: Standard deviation, GS: Spinal group, ONSD: Optic nerve sheet diameter, Na: Sodium, p*: Mann Whitney U test, p**: Wilcoxon test

DISCUSSION

In this study, we evaluated the relationship between optical ONSD measurements and an indirect increase in intracranial pressure and the applied anesthesia method in patients undergoing prostate resection with Thulium Laser in the lithotomy position. Dec. The study results showed that under spinal or general anesthesia, ONSD increased in the lithotomy position compared to preoperative values. At the end of the surgery, the ONSD measured in the supine position was found to be high compared to the initial value. Similar ONSD value increase was found in both anesthesia methods.

Optical nerve sheath diameter measurement using ultrasonography is a very sensitive method for measuring intracranial pressure. It helps to establish a strong relationship with the evaluation of intracranial pressure as well as invasive gold standard methods. Inhalation anesthetics increase intracranial pressure with cerebral vasodilation, while spinal anesthesia causes a decrease in intracranial pressure due to csf leakage and systemic hypotension.[6] ThuLEP surgery, which is used for the treatment of benign and malignant growths of the prostate, is performed in the lithotomy position and intracranial pressure increases due to an increase in venous return. Evaluation of intracranial pressure is of more importance in elderly patients. For this reason, the change of intracranial pressure was evaluated with the form of anesthesia to be selected in this surgery.

In our study, the average age in the spinal anesthesia group was found to be statistically significantly higher than the general anesthesia group with 69.95. The average age in the general anesthesia group was 65.64 and both groups were in the geriatric age group. Therefore, this statistical significance does not constitute a clinically significant difference. The duration of surgery under general anesthesia was found to be longer than in the spinal anesthesia group. This situation can be explained by the fact that the time elapsed until the patient is put to sleep and put in position in the general anesthesia group is shorter in the spinal anesthesia group, and the patient's recovery time after the end of the operation in the general anesthesia group is not in the spinal anesthesia group. This situation can be explained by the fact that the time spent intubating and positioning the patient in the general anesthesia group is not present in the spinal anesthesia group, and there is no need to wait for extubation at the end of the operation in the spinal anesthesia group.

There was no statistically significant difference between the general anesthesia and spinal anesthesia groups in terms of ONSD for both eyes during the preoperative, intraoperative, and postoperative periods. In both groups, ONSD was found to be significantly higher in the intraoperative and postoperative periods compared to the preoperative period. We think that performing the surgery in the lithotomy position causes increased ONSD values in both groups. Kim at al.[6] showed that in a study comparing sevoflurane and propofol anesthesia, ONSD increased in the sevoflurane group and there was no increase in the propofol group. The study of Lee et al.[9] showed no difference in intracranial pressure and optic nerve diameters between the choice of propofol-based anesthetic and the choice of sevoflurane-based anesthetic in gynecological surgery performed in the trendelenburg position. They showed that optic nerve sheath diameters increased in both groups after trendelenburg position and after abdominal insufflation.

They have shown that optic nerve sheath diameters increase as the surgery period progresses in patients who have undergone lower extremity surgery under spinal anesthesia.[10] This study supports the findings of increased ONSD under spinal anesthesia as observed in our study. In a study conducted by Gönen et al.[11] On pediatric patients, they showed that caudal injection is safe to increase intracranial pressure. Since the amount of anesthetic drug given in this study is at very low doses, we think that it will not be enough to compare the result with the intrathecal dose administered in our study. Postoperative hemoglobin values were found to be statistically significantly lower in both groups compared to the preoperative period. We think that the absorption of the fluid used for bladder flushing and the related dilutional hemoglobin decrease may occur during ThuLEP surgery. There was no significant difference between preoperative and postoperative sodium values in both groups. Although lower sodium values were observed in the spinal anesthesia group in the postoperative period, there was no clinically significant increase.

In our study, there was no difference between spinal anesthesia and general anesthesia in terms of increasing the optic nerve sheath diameter, and it was thought that the increase in both groups may be due to the lithotomy position. We think that the small number of patients may cause the results of our study to come out in this way. We think that optic nerve sheath diameter change should be evaluated under spinal anesthesia and general anesthesia in a larger patient population.

CONCLUSION

ONSD measurement may be a useful noninvasive technique for assessing intracranial pressure. In our study, spinal and general anesthesia setup in ThuLEP surgery did not make a difference in terms of intracranial pressure change, and ONSD increased in the lithotomy position in the postoperative and intraoperative periods compared to the preoperative period. We think that the effects of surgical position on ICP may be important for patients at risk, but more studies with higher patient numbers are necessary to evaluate the effects of anesthesia management on intracranial pressure and ONSD.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of Pamukkale University No Interventional Clinical Researches Ethics Committee (Date: 19.03.2024, Decision No: 341787).

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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