original article

Evaluation of optic nerve sheath diameter in patients undergoing laparoscopic surgery in the Trendelenburg position: a prospective observational study

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BACKGROUND: The Trendelenburg position and pneumoperitoneum may cause cerebral edema and increased intracranial pressure. Non-invasive measurement of the diameter of the optic nerve sheath by ultrasonography can provide early recognition of intracranial pressure.
OBJECTIVE: Evaluate the optic nerve sheath diameter (ONSD) changes in patients who undergo laparoscopic surgery in the Trendelenburg position and make indirect conclusions about changes in intracranial pressure.
DESIGN: Prospective, observational
SETTING: Laparoscopic surgeries
PATIENTS AND METHODS: Patients aged 18-75 years who underwent laparoscopic surgery in the Trendelenburg position under general anesthesia were included in our study. The ONSD was measured four times: Immediately after tracheal intubation, in the neutral position (baseline value) (T0), 10 minutes after pneumoperitoneum and Trendelenburg position (T1), 60 minutes after pneumoperitoneum and Trendelenburg position (T2), and 10 minutes after the pneumoperitoneum is terminated and placed in the neutral position (T3).
MAIN OUTCOME MEASURES: Compare ONSD measured by ultrasonography at different times of surgery.
SAMPLE SIZE: 40
RESULTS: Arterial carbon dioxide pressure increased with laparoscopy and Trendelenburg position in parallel with ONSD measurements and decreased again after returning to the neutral position. It was still higher than the baseline value at the T3. There was also a significant difference[a] between the measurement made at the T2 and the measurement made at T1. This difference showed that the prolongation of the Trendelenburg time was associated with an increase in ONSD. At the end of the operation it was observed that the decreased statistically significantly (T3) 10 minutes after the pneumoperitoneum was terminated and the position was corrected. However, the ONSD was still higher at the end of the operation (T3) compared to the baseline value measured at the beginning of the operation (T0).
CONCLUSION: The ONSD increased in relation to Trendelenburg position and pneumoperitoneum. With these results, we think the ultrasonographic measurement of ONSD, a non-invasive method, can be used for clinical follow-up when performing laparoscopic surgery in the Trendelenburg position in cases requiring intracranial pressure

monitoring.
LIMITATIONS: There may be variations in the measurement of ONSD, even in the measurements of the same practitioner, as in all imaging with an ultrasonography device.
CONFLICT OF INTEREST: None.

Nowadays, surgeries that can be performed with the laparoscopic technique are preferred to the open technique because of the many advantages of laparoscopy. The advantages of laparoscopy are that it's a minimally invasive method, less bleeding, patient recovery is rapid with shorter hospitalization. Additionally, complications such as thromboembolism are much lower.[1,2] For the laparoscopic technique, the abdominal cavity must be inflated with carbon dioxide (insufflation), and for some surgeries, the upside-down position (Trendelenburg position) is required. Although laparoscopy has many advantages, its adverse effects on the respiratory, cardiovascular, and central nervous systems require special attention and approach from anesthesiologists.

Positive intra-abdominal pressure secondary to the pneumoperitoneum is transmitted to the lumbar venous plexus, and intracranial pressure is affected by decreased venous return. The (25-40 degree) upside-down position applied during the surgery increases the pressure of the cerebrospinal fluid. These effects may cause cerebral edema and increased intracranial pressure.[3,4] Laparoscopy should be used cautiously in patients with a baseline elevated ICP or head trauma.[5] Measurement of intracranial pressure during laparoscopic surgery is difficult, and direct monitoring with intracranial devices is often impossible. Measuring the optic nerve sheath diameter (ONSD) by ultrasonography has been developed as an alternative method for evaluating intracranial pressure.[6-8] The optic nerve is an extension of the central nervous system, surrounded by cerebrospinal fluid, and continues with the nerve sheath. The increase in intracranial pressure causes the optic nerve sheath to expand and grow in diameter (**Figure 1**). The ONSD which indicating intracranial pressure greater than 20 mm Hg, h[b]as traditionally been considered as 5 mm.[9] Therefore, measuring the ONSD by ultrasonography is considered a non-invasive, easy-to-apply, reproducible, and reliable method to evaluate intracranial pressure.[7] In the literature, various studies evaluate optic nerve diameter by ultrasonography in different surgeries.[10]

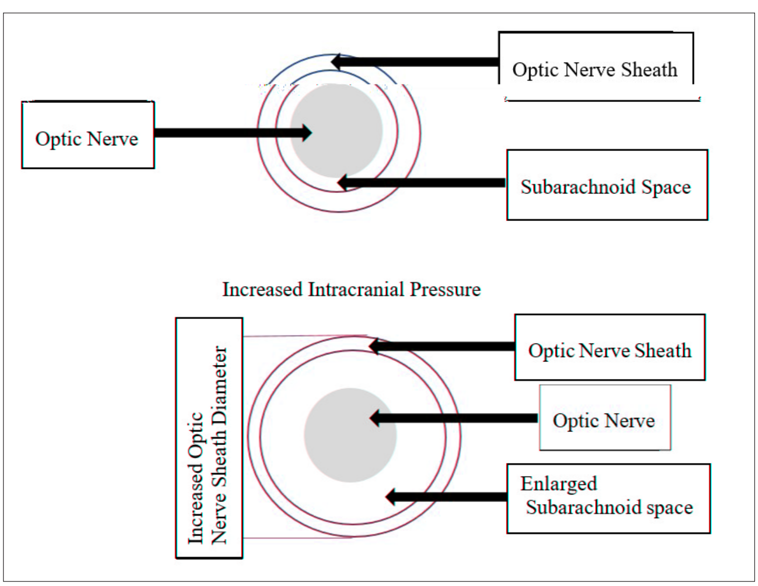

Figure 1. Optic nerve sheath diameter and increased intracranial pressure association.

In this study, we aimed to evaluate the ONSD changes in patients who undergo laparoscopic surgery in the Trendelenburg position. Our primary aim was to compare ONSD measured by ultrasonography at different times of surgery. Our secondary aim was to evaluate the correlation of these measurements with pH and carbon dioxide values in blood gas samples taken simultaneously.

PATIENTS AND METHODS

Approval for this study was obtained from the Istanbul Medipol University Clinical Research Ethics Committee with decision number 464 dated 10/06/2020. A registration was made on Clinical Trial.com After ethical approval was obtained (ClinicalTrials.gov Identifier: NCT04428229). Written, informed consent was obtained from the subjects.

Forty patients (aged 18-75) who underwent laparoscopic surgery in the Trendelenburg position under general anesthesia were included in our prospective observational study. Patients who received beta-blocker or diuretic therapy, had severe heart failure, had a diagnosis of diabetes with ocular or neurological complications, had undergone cardiac surgery, eye surgery, neurosurgery, or thoracic surgery, and had hydrocephalus, glaucoma, intracranial mass, and a history of stroke were excluded.

Twenty minutes before arrival in the operation room, patients were premedicated with midazolam (Dormicum, Deva). After the patients were taken to the operating room, electrocardiography, peripheral oxygen saturation, and non-invasive blood pressure were monitored. In anesthesia induction, (0.5 mg/kg) lidocaine (Arithmal 2%, Osel Pharmaceutical), (2-2.5 mg/kg) propofol (Propofol-Lipuro, B-Braun), (1.5-2 mcg/kg) fentanyl (Talinat, Vem Pharmaceuticals), and (0.6 mg/kg) rocuronium (Esmeron, MSD) IV were administered, and orotracheal intubation was performed. After intubation, both eyes were closed with a waterproof, transparent patch. Before the pneumoperitoneum, a nasogastric tube was inserted to decompress the gastrointestinal tract. (1.5–2%) sevoflurane (Sevorane, AbbVie) inhalation with a minimum alveolar concentration (MAC) value of (.8-1) in a 40% oxygen-air mixture and (.01-.1 µg/kg/min) IV remifentanil (Ultiva, Eczacıbaşı) were used to keep the anesthesia going. Mechanical ventilator settings were adjusted as tidal volume of (6-7 ml/kg), targeted maximum airway pressure of 30 cmH_2O, end-tidal CO_2 of (30-40 mm Hg), and PEEP of 5 cmH_2O. Invasive arterial pressure monitoring with radial artery cannulation and central venous pressure monitoring with right internal jugular vein catheterization were performed. If the pulse or mean blood pressure increased by 20% from the preoperative value, additional analgesia was provided with 1 mcg/kg bolus of fentanyl. IV (4-8 mg) of ondansetron (Zofer, Adeka İlaç) was administered to prevent postoperative nausea and vomiting. Surgical procedure was performed laparoscopically in the 30-degree Trendelenburg position. Pneumoperitoneum was achieved with a surgical trocar at (12–14 mm Hg) pressure. At the end of the surgery, the pneumoperitoneum was terminated, and the patients were moved from the Trendelenburg position to the neutral position. At the end of the operation, the patients with sufficient spontaneous respiration were transferred to the recovery unit after extubation. Patients with a modified Aldrete score of (9-10) were sent to the clinical service.

Measurement of optic nerve sheath diameter

ONSD was measured with ultrasound guidance using a 12 MHz high-frequency linear probe. Both eyelids were closed with a waterproof, transparent plaster. Before the measurement, ultrasonography gel was used to prevent artifacts caused by the air gap between the probe and the eyeball due to the convex structure of the eyeball (**Figure 2**). Measurements were performed by an anesthesiologist experienced in ocular ultrasonography. After the optic nerve sheath was visualized with the appropriate contrast difference and in the appropriate direction, 3 mm posteriorly, the eyeball was visualized (**Figure 3**). During the first measurement, three measurements were performed in the transverse plane of both eyes, and the mean value was calculated. When there was no difference between the two eyes, only the right eye was used for subsequent measurements. The average of the three measurements was recorded at each measurement time.

Parameters recorded simultaneously as the mea-

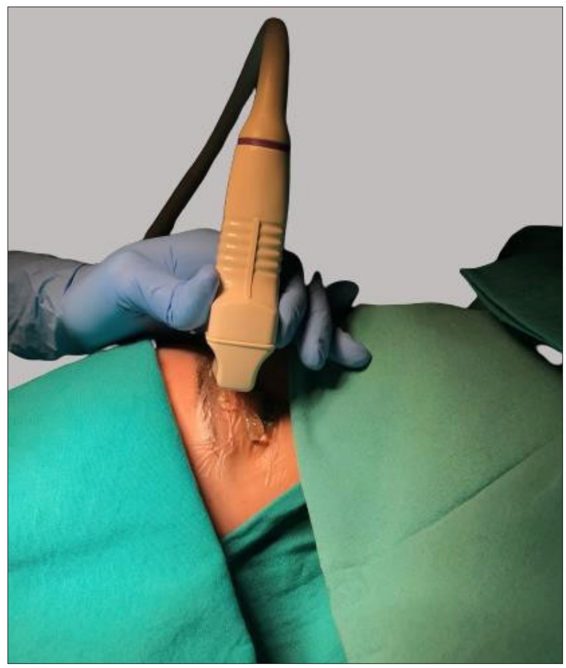

Figure 2. Imaging method of optic nerve sheath.

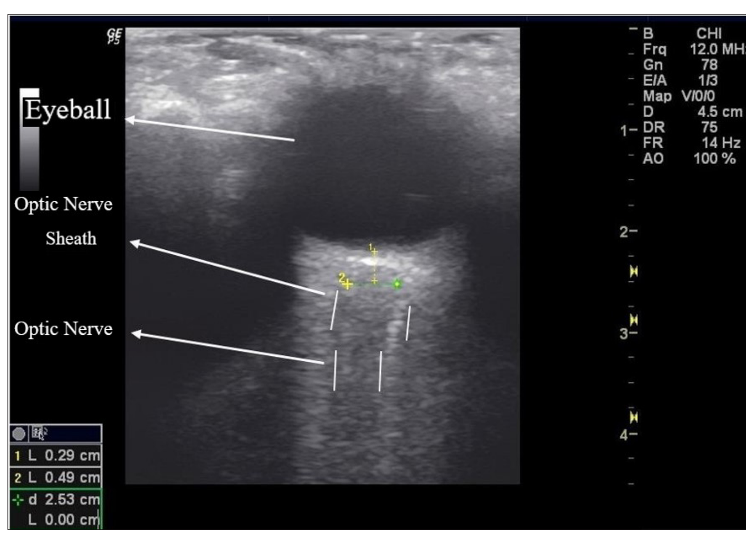

Figure 3. Ultrasonographic view of the optic nerve sheath.

surements were mean blood pressure, peripheral oxygen saturation, central venous pressure, tidal volume, airway pressures, end-tidal CO_2, intra-abdominal carbon dioxide pressure, blood pH, arterial carbon dioxide pressure, and blood lactate level.

The ONSD was measured four times.

T0: Immediately after tracheal intubation, in the neutral position (baseline value),

T1: 10 minutes following pneumoperitoneum and the Trendelenburg position

T2: 60 minutes after pneumoperitoneum and Trendelenburg position

T3: 10 minutes after the pneumoperitoneum is terminated and placed in the neutral position

Statistical analysis

As a result of the power analysis, for the 0.3 unit difference between the measurements to be significant, when the type 1 error (alpha error) was accepted as .05, the number of patients required to achieve 80% power was 36. Due to the losses that may occur during data collection, the study was started by planning 40 patients.

The statistical analysis of the obtained data was done with the IBM SPSS 16.0 program (Version 17.0. Chicago: SPSS Inc.). Statistical definitions were given as count and percentage (n, %) for categorical variables, and mean±standard deviation (minimum-maximum) for continuous variables. The results were assessed for normality with the Kolmogorov-Smirnov Test and equality of variance with the Mauchly test of sphericity and the Levene test. The data were analyzed using one-way and two-way repeated measure ANOVA followed by the Bonferroni test for between-group comparisons. When the Mauchly test was significant, normality and equality of variance were not violated in groups, the Greenhouse-Geisser adjustment was performed to determine the statistical significance of the factor (T0: Immediately after tracheal intubation, in neutral position (baseline value) T1: 10 minutes after pneumoperitoneum and Trendelenburg position T2: 60 minutes after pneumoperitoneum and Trendelenburg position T3: 10 minutes after the pneumoperitoneum is terminated and placed in the neutral position). A paired sample t test was used to compare ONSD values in groups according to operation time and Trendelenburg time.

Correlations between variables were calculated with appropriate correlation coefficients, depending on the type of data and the availability of certain assumptions. The relationship between ONSD measurements and other recorded parameters and their statistical significance were calculated by Pearson's test. The statistical significance limit was accepted as .05.

Table 1. Demographic data and surgery information.

Male/Female	14/24
ASAI/ASAII	16/22
Age (year)	53.7 (13.3), 27-75
Body mass index (%)	27.6 (5), 20.3- 44
Trendelenburg time (minutes)	146 (72.7), 60- 375
Operation time (minutes)	186.8 (83.8), 70-400
Anesthesia time (minutes)	236.5 (95.4), 90-470

Data are mean (standard deviation) or median (25th-75th percentile) for continuous data and number (percentage) for categorical data. ASA: American Society of Anesthesiologists

Table 2. Optic nerve sheath diameter and respiratory parameters.

	T0	T1	T2	T3	*P*
ONSD (cm)	.48 (.04)	.52 (.05)	.53 (.04)	.50 (.04)	**<.001**
$PaCO_2$ (mm Hg)	31.7 (3.6)	36.1 (2.7)	39.1 (4.05)	37.3 (3.8)	**<.001[a]**
pH	7.4 (.04)	7.3 (.04)	7.35 (0.04)	7.37 (.04)	**<.001[a]**
Lactate (mmol/L)	.80 (.30)	.89 (.34)	.92 (.35)	.94 (.37)	**.009**
pPlato (cmH_2O)	16.26 (3.3)	27.2 (6.7)	26.6 (6.06)	18.42 (3.7)	**<.001[a]**
Ppeak (cmH_2O)	17.63 (3.22)	29.2 (5.7)	29.1 (5.2)	19.7 (3.7)	**<.001[a]**
TV (mL)	506.97 (60.2)	499.2 (54.2)	501.1 (51.5)	511.3 (50.9)	**.025**

Repeated measure ANOVA, [a]Greenhouse-Geisser. T0 - Immediately after tracheal intubation, in neutral position (baseline value) T1: 10 minutes after pneumoperitoneum and Trendelenburg position T2: 60 minutes after pneumoperitoneum and Trendelenburg position T3: 10 minutes after the pneumoperitoneum is terminated and placed in the neutral position, Arterial partial pressure of carbon dioxide, pPLATO=Plato pressure, PpEAK=Peak pressure, TV=Tidal volume, ONSD: Optic nerve sheath diameter.

RESULTS

Since the operation was continued with the open technique in 2 of the 40 patients included in the study, these patients were not included in the evaluation. Of the 38 patients included in the study, 14 were male, and 24 were female. In the evaluation performed before anesthesia, 22 patients were evaluated as ASA I and 16 as ASA II (**Table 1**).

The ages of the patients included in the study (ranged from 27 to 75 years), with a mean of (53.7 [13.3]) years. Their body mass indexes were (between 20.30 and 44.00 kg/m^2), with a mean of (27.5 [5.09]) kg/m^2. Total laparoscopic hysterectomy was performed in 19 patients, and colectomy was performed in 19. The patient's comorbidities, such as coronary artery disease, hypertension, and diabetes mellitus, were recorded.

Arterial carbon dioxide pressure ($PaCO_2$) increased with laparoscopy and Trendelenburg position (F [2.183, 80.771]=45.721, *P*<.001, $PaCO_2$ increased by 4.447 between T0 and T1 (*P*<.001) and then increased by an additional 3.026 between T1 and T2 (*P*<.001) in parallel with ONSD measurements and decreased again after returning to the neutral position but this was not statistically significant ($PaCO_2$ decreased by 1.816 between T2 and T3 (**Table 2**). $PaCO_2$ was still found to be higher than the baseline value 10 minutes after being in the neutral position ($PaCO_2$ increased by 5.685 between T0 and T3 (*P*<.001). This change is shown in **Figure 4**. The patients' ONSD values measured at the specified times are shown in the graph in **Figure 5**.

When the measurements of ONSD were compared, the measurement performed at the 10th minute of the Trendelenburg position (T1) was statistically significantly higher than the measurement performed before the pneumoperitoneum in the neutral position (T0) (F [3, 111]=105 979, *P*<.0001, ONSD increased by 0.039 between T0 and T1 (*P*<.001)). There was also a significant difference between the measurement made at the 60th minute of the Trendelenburg position (T2) and the measurement made at the 10th minute of the Trendelenburg position (T1) (ONSD increased by 0.011 between T1 and T2 (*P*=.005). This difference showed that the prolongation of the Trendelenburg time was associated with an increase in ONSD. The ONSD increased as the pneumoperitoneum and Trendelenburg time increased. At the end of the operation, it was observed that the ONSD decreased statistically significantly (T3) 10 minutes after the pneumoperitoneum was terminated and the position was corrected (ONSD decreased by 0.031 between T2 and T3, *P*<.001). However, the ONSD was still higher at the end of the operation (T3) compared to the baseline value measured at the beginning of the

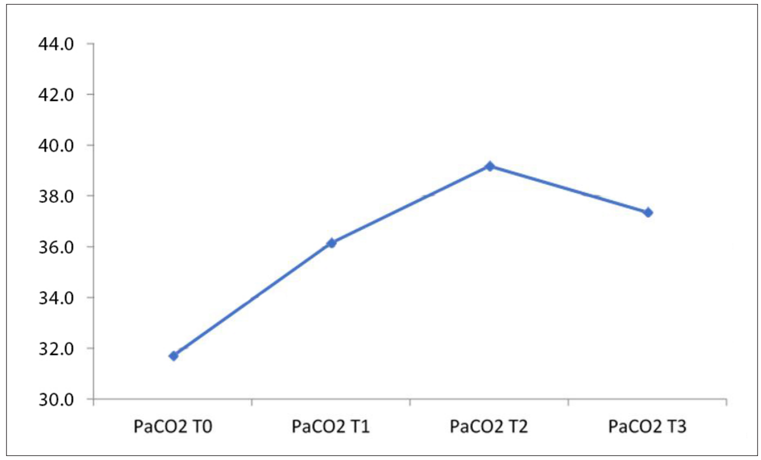

Figure 4. $PaCO_2$ values.

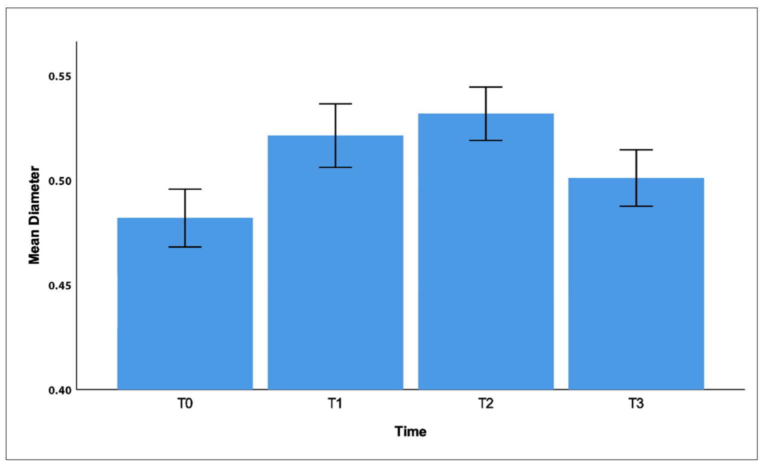

Figure 5. Optic nerve sheath diameter measurements.

Table 3. Pairwise comparisons of optic nerve sheath diameter values.

	Mean difference	*P*
T0-T1	-.039	**<.001**
T0-T2	-.050	**<.001**
T0-T3	-.019	**<.001**
T1-T2	-.011	**.005**
T1-T3	-.020	**<.001**
T2-T3	.031	**<.001**

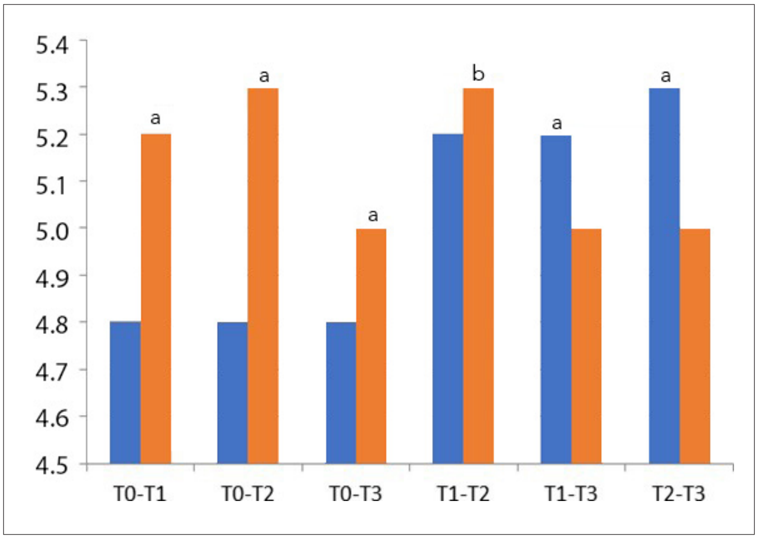

Figure 6. Optic nerve sheath diameter measurements comparisons: T0 - Immediately after tracheal intubation, in neutral position (baseline value) T1 - 10 minutes after pneumoperitoneum and Trendelenburg position T2 - 60 minutes after pneumoperitoneum and Trendelenburg position T3-10 minutes after the pneumoperitoneum is terminated and placed in the neutral position: [a]*P*<.001; :[b]*P*<.005.

Table 4. Optic nerve sheath diameter values in groups according to operation time and Trendelenburg time.

Time	Group	N	ONSD (cm)	*P*
T0	OT ≤ 150	17	.49 (.05)	.521
	OT > 150	21	.48 (.04)	
T1	OT ≤ 150	17	.53 (.05)	.392
	OT > 150	21	.52 (.04)	
T2	OT ≤ 150	17	.54 (.04)	.487
	OT > 150	21	.53 (.04)	
T3	OT ≤ 150	17	.51 (.05)	.317
	OT > 150	21	.50 (.04)	
T0	TT ≤ 120	19	.49 (.05)	.403
	TT > 120	19	.48 (.04)	
T1	TT ≤ 120	19	.53 (.05)	.163
	TT > 120	19	.51 (.04)	
T2	TT ≤ 120	19	.54 (.04)	.365
	TT > 120	19	.53 (.04)	
T3	TT ≤ 120	19	.51 (.04)	.226
	TT > 120	19	.49 (.04)	

Mean (standard deviation) for ONSD. OT: Operation Time (minutes); TT: Trendelenburg time (minutes).

operation (T0) (ONSD increased by 0.019 between T0 and T3, *P*<.001) (**Table 3, Figure 6**).

The comparison of ONSD in groupings according to operation time and Trendelenburg time is shown below (**Table 4, Figures 7 and 8**). Longer operation time or longer Trendelenburg position did not affect the rate of return of the enlarged optic nerve sheath to baseline values (F [3, 108]=0.337, *P*=.798); F [3, 108]=1.112, *P*=.347), respectively. Although the increase in ONSD was parallel with the prolongation of time T0, T1, T2, and T3 ONSD values were not correlated with the operation time (*P*=.819, *P*=.927, *P*=.994, *P*=.792, respectively) and Trendelenburg time (*P*=.586, *P*=.991, *P*=.823, *P*=.957, respectively).

DISCUSSION

In our study, we aimed to observe whether there is an increase in the ultrasonographic measurement of ONSD in patients who underwent laparoscopic surgery in the Trendelenburg position, and indirectly to comment. According to our results, it was determined that ONSD increased in relation to Trendelenburg position and pneumoperitoneum.

Intracranial pressure measurement techniques are essential for monitoring patients with potential brain injuries or disorders. Invasive methods, such as intraventricular catheter, intraparenchymal, epidural sensors, involve direct insertion into the brain tissue or the outer layer of the brain, providing highly accurate readings. intraventricular catheter is the gold standard measurement method.[11] Non-invasive techniques, on the other hand, offer less risk and include transcranial Doppler ultrasonography, which uses sound waves to measure blood flow velocity in the brain's major arteries; tympanic membrane displacement, which gauges pressure changes transmitted through the ear; and near-infrared spectroscopy, which assesses oxygenation levels in brain tissue by measuring light absorption.[12] Studies show that ONSD is a non-invasive but reliable method for interpreting intracranial pressure.[13,14] ONSD measurement with USG guidance. It enables repeatable measurements at the bedside and has a shorter learning curve compared to other methods. While its sensitivity for detecting increased intracranial pressure is high, other conditions that may influence the diameter should also be considered. In a meta-analysis of six studies that included 231 patients in total and were performed for the measurement of intracranial pressure, ultrasonographic measurement of ONSD was found to be a safe and usable method with a sensitivity of .90 and a specificity of .85.[15] Our study aimed not to show the relationship between ONSD and intracranial pressure. As a result of the study, it was determined that ONSD increased in relation to position and pneumoperitoneum. It was also important that the values measured at the 10th minute after the position was corrected and the pneumoperitoneum was terminated were close to the baseline values but were still higher than the first measurement. There was no correlation between the vital signs of the patients recorded and the ONSD measured at all measurement times. The increase in $PaCO_2$ values according to the measurement times and the increase in ONSD were similar, and this suggests that hypercarbia caused by position and laparoscopy may also contribute to the increase in ONSD.

The increase in intracranial pressure is considered the most important cerebrovascular effect caused by using the pneumoperitoneum and Trendelenburg position together.[16] The most reliable method for evaluating intracranial pressure is measurement with invasive intracranial devices. However, it is almost impossible to use this method during laparoscopic surgery due to severe complications such as bleeding, infection, and device failure.[13] The best way to reliably measure intracranial pressure is to insert an invasive ventricular catheter;[17] however, the fact that it is a specialist application and the risks of serious complications limit the use of this invasive method, especially in cases other than neurosurgery.[15] However, these patients may still have increased intracranial pressure, and a non-invasive, easy-to-use, and inexpensive method is needed to detect this increase. ONSD measurement using ocular ultrasonography is a non-invasive, reproducible method defined in recent years for evaluating intracranial pressure.[18] Previous studies have shown that this method can recognize increased intracranial pressure and is reliable.[15,17,19] We also think that regular ONSD measurements can be used in the early diagnosis of increased intracranial pressure in patients undergoing laparoscopic surgery in the Trendelenburg position.

Contrary to other surgical procedures, an increase in arterial carbon dioxide pressure may be one of the factors causing an increase in intracranial pressure in surgeries where laparoscopy and Trendelenburg position are used simultaneously.[20] Cerebral blood flow increases by (1.8 mL/100 g/min) for every 1 mm Hg increase in carbon dioxide pressure in arterial blood, thus increasing intracranial pressure.[21] In our study, there was an increase in arterial carbon dioxide values measured after pneumoperitoneum was created compared to those measured after anesthesia induction. This increase may have partially contributed to the increase in intracranial pressure. On the other hand, the fact that the measured partial carbon dioxide pressure values are in the normocarbia range suggests that this contribution will be minimal.

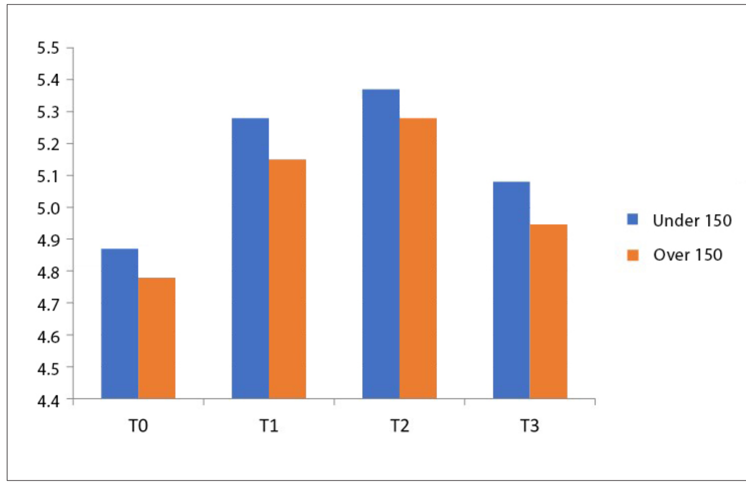

Figure 7. Optic nerve sheath comparison according to operation time T0 - Immediately after tracheal intubation, in neutral position (baseline value) T1 - 10 minutes after pneumoperitoneum and Trendelenburg position T2 - 60 minutes after pneumoperitoneum and Trendelenburg position T3 – 10 minutes after the pneumoperitoneum is terminated and placed in the neutral position

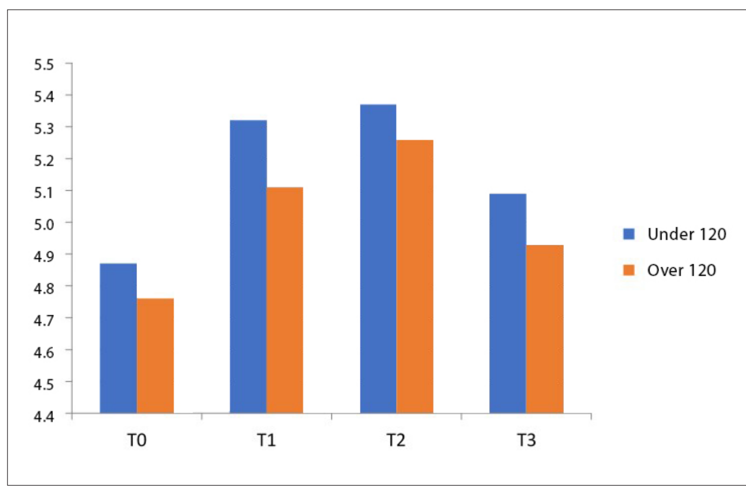

Figure 8. Optic nerve sheath comparison according to Trendelenburg time T0 - Immediately after tracheal intubation, in neutral position (baseline value) T1 - 10 minutes after pneumoperitoneum and Trendelenburg position T2 - 60 minutes after pneumoperitoneum and Trendelenburg position T3 – 10 minutes after the pneumoperitoneum is terminated and placed in the neutral position

A study by Halverson et al showed that pneumoperitoneum can increase intracranial pressure with a direct physical effect, independent of the partial pressure of arterial carbon dioxide.[22] In this animal study, the mechanism of the increase in intracranial pressure was suggested to be disruption of cerebrospinal fluid drainage at the level of the lumbar venous plexus due to the increase in intra-abdominal pressure. This study also showed that the Trendelenburg position could exacerbate the increase in intracranial pressure. Similar data obtained in our study supports the conclusion that position and pneumoperitoneum cause an increase in intracranial pressure.

Volatile anesthetics create a vasodilator effect by acting on vascular smooth muscle.[23] When the volatile anesthetic concentration is above 1 MAC, this vasodilator effect is more pronounced and increases cerebral blood flow with the effect of cerebral vasodilation.[24] With increased blood flow, an increase in intracranial pressure may occur. Since volatile anesthetics were also used in our study, the anesthesia method may have contributed to the increase in ONSD independent of pneumoperitoneum and Trendelenburg. However, the effect of volatile anesthetics was standardized by using the same MAC levels in all our patients.

The ONSD, which indicates high intracranial pressure, has traditionally been accepted as 5 mm.[9] Geeraert et al reported that the ultrasonographically measured diameter of the optic nerve sheath is related to the intracranial pressure measured with the help of an invasive catheter, and a pressure greater than 5.8 mm reflects a pressure higher than 20 mm Hg that requires treatment.[16] However, no clear value is mentioned in the books regarding the normal values of ONSD, and the authors take different values as limit values. In a study by Amini et al in patients with cerebral hemorrhage, 5 mm was accepted as the value indicating that the intracranial pressure is above 20 mm Hg.[4] In another study on 134 Korean patients, 5.5 mm was accepted as the value reflecting the increased intracranial pressure.[25] In a study conducted in Italy in 2014, when 53 patients with cerebral hemorrhage and 53 control group patients were evaluated, 5.2 mm was accepted as the limit value showing intracranial pressure above 20 mm Hg.[18] As a result of these studies, it is seen that more studies are needed to clarify the ONSD, which indicates increased intracranial pressure. In order to be less affected by this uncertainty in our study, we evaluated the intraoperative changes in ONSD instead of using a specific cutoff value when interpreting our data. We observed that the ONSD increased at the 10th minute compared to the baseline value in patients who underwent laparoscopic surgery in the Trendelenburg position. We observed that the values measured at the 60th minute increased significantly compared to the baseline and the 10th minute. Although the values measured 10 minutes after the patients were placed in the neutral position at the end of the operation decreased significantly, they were still statistically higher than the baseline values. The mean ONSD measured in our study was less than 5.8 mm. A value above 5.8 mm was measured in only three patients, and, with this result, we hypothesized that most patients undergoing laparoscopic surgery in the Trendelenburg position did not have intracranial pressure above 20 mm Hg. On the other hand, in a study by Josephs et al, it was observed that there was a significant increase in intracranial pressure from (22.6 mm Hg to 27.4 mm Hg) after pneumoperitoneum in animals with intracranial damage.[26] Therefore, it should be kept in mind that there may be a significant increase in intracranial pressure when performing laparoscopic surgery in the Trendelenburg position in patients with intracranial pathology.

This study has some limitations. One of them is that, although less than other methods, ocular ultrasonography requires experience. Tayal et al, in their study, showed that physicians without previous ocular ultrasonography experience needed more than 25 imaging experiences to obtain an adequate optical sheath diameter image.[27] The clinician who measured in our study made optic nerve diameter measurements on more than 30 patients before the study, and the study was started after a radiologist stated that it was sufficient. As a second limitation, there may be variations in the measurement of ONSD, even in the measurements of the same practitioner, as in all imaging in the ultrasonography device. As Ballantyne et al reported, ultrasonographic measurement of ONSD is a learnable and reproducible method, and the applicator variation is .2–.3 mm).[28] This variation has been accepted as a natural consequence of the ultrasonography device.

It would be more accurate to measure the patient's ONSD before starting tracheal intubation for the patient's initial ONSD value. However, we thought that measuring ONSD in an awake patient would be uncomfortable for the patient. After induction of anesthesia, there was insufficient time to measure ONSD before intubation. Therefore, we to preferred measure the baseline value immediately after tracheal intubation.

Even if we have reached a sufficient number of samples according to the power analysis result, it is a fact that studies with higher numbers and more advanced variables are needed. Considering that there may be fluctuations in intracranial pressure during surgery and variations that may arise from the ultrasonography device, it is seen that studies involving more participants are needed. Even if there is no clear connection between ONSD variations and age, in future studies we suggest having more homogenous groups for age, sex and previous disease to give more strength to the results of the study.[29]

In conclusion, we found that ONSD increased in relation to position and pneumoperitoneum. We showed that the postoperative measurement results at the 10th minute after the position was corrected and the pneumoperitoneum was terminated were still higher than the first measurement, although they approached the basal values. With these results, we think the ultrasonographic measurement of ONSD, a non-invasive method, can be used for clinical follow-up when performing laparoscopic surgery in the Trendelenburg position in cases requiring intracranial pressure monitoring.

Ethics approval and consent to participate

This study has been approved by Istanbul Medipol Ethics and Research Committee (10/06/2020, no 464). Written informed consent was obtained from the participants. All methods were carried out in accordance with relevant guidelines and regulations.

Availability of data and material

The datasets generated and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

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