Retrospective Study

Evaluation of Increased Intracranial Pressure with the Optic Nerve Sheath Diameter by Ultrasound in Epiduroscopic Neural Laser Discectomy Procedures

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Background: In order to clarify the camera image and open the adhesions mechanically during epiduroscopy, saline is injected continuously in the epidural area. As a result, an increase in intracranial pressure is to be expected in theory. Increased intracranial pressure can be evaluated by measuring by optic nerve sheath diameter.

Objectives: This study was designed to evaluate the relationship between optic nerve sheath diameter measurements and intracranial pressure, after injecting fluid to the epidural area during epiduroscopy procedures performed in our clinic.

Study Design: Retrospective study.

Setting: Sakarya University Training and Research Hospital.

Methods: During the epiduroscopy procedure, pre and postoperative bilateral optic nerve sheath diameters were measured with an ultrasonography probe. With the patients' eyelids closed, the probe was placed on the orbita in the sagittal plane, measuring 3 mm posterior of the papilla.

Results: While there was a statistically significant difference between pre- and post-operative optic nerve sheath diameter measurements, there was no significant correlation with processing time, amount of fluid delivered, or fluid delivery rates.

Limitations: One of the limitations of this study is the retrospective collection of data. A second limitation is that repetitive measurements were not performed, instead of a single postoperative measurement.

Conclusion: We think more prospective randomized controlled studies are required to examine the increase in the diameter of the optic nerve sheath, which is an indirect indicator of increased intracranial pressure after epiduroscopy applications, in order to determine whether the pressure increase is associated with the rate of fluid delivery, the total fluid amount, or the processing time.

Key words: Epidural, epiduroscopic laser neural decompression, fluid volume, intracranial pressure, optic nerve sheath diameter, ultrasonography, rate.

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Epiduroscopic laser neural disc decompression (ELND) is an effective method in the treatment of intraspinal pathologies, such as herniated nucleus pulposus and pain-causing microscopic adhesions (1). During this procedure, disc decompression is provided by applying a holmium laser (Ho: YAG) from the sacral hiatus to the herniated disc, in the ventral epidural area. During this procedure, controlled saline is applied continuously to the epidural area (2). The advantage of performing the procedure with conscious sedation is that any epidural pressure increase that may occur in the patient can be evaluated with an intraoperative follow-up.

Epiduroscopic (spinal endoscopy) procedures increase epidural pressure as a result of intermittent or continuous fluid delivery to the epidural area. Intermittent or continuous infusion causes changes in cerebrospinal fluid (CSF), increasing CSF pressure. In addition to the amount of fluid delivered to the epidural area, the injection rate is stated to be more important than the volume, in terms of pressure increase (3). Increased intracranial CSF pressure expands the optic nerve circumference of the area toward the subarachnoid region and, thus, can lead to compression of the central retinal vein. In addition, it has been suggested that increased CSF pressure may cause a reflex increase in ophthalmic arterial pressure, as well as damage to capillaries by capillary rupture, thus, leading to venous collapse (2,4). Accordingly, it has been shown that the presence of increased CSF pressure can be indirectly indicated by optical disc measurement (5).

Evaluation of the optic nerve sheath diameter (ONSD) by ultrasonography (USG) has proven to be a reliable test for non-invasive diagnosis of increased intracranial pressure in neurocritical patients (6,7). The optic nerve is a tubular structure, approximately 5 cm long, whose intraorbital segment can be evaluated sonographically. Histologically surrounded by the same meningeal layers as the brain, the optic nerve can be observed as a hypoechoic structure, localized inside the optic nerve sheath. The optic nerve and sheath are located in the subarachnoid space, trabeculated together. Increased intracranial pressure is reflected in the optic nerve head. Due to the subarachnoid space the optic nerve periphery appears hyperechoic in USG (8). An increase in the ONSD is an indirect indication of hypertension, because changes in intracranial pressure have a direct effect on the peri-optic subarachnoid space diameter.

In this study, we aimed to compare pre and post-operative USG-guided ONSD measurements in patients following ELND procedures.

Methods

In this retrospective study, epiduroscopic discectomies and/or adhesiolysis procedures performed between January 2017 and December 2017, in the Algology Clinic of the Anesthesiology and Reanimation Department, at the Sakarya University Training and Research Hospital, were retrospectively analyzed. After approval by the Ethics Committee of the Sakarya University Faculty of Medicine, patient information was obtained from the hospital's Karmed database program (Kardelen Software, Mersin, Republic of Turkey). Files were obtained from the hospital archive. Age, gender, weight, height, amount of saline used, duration of the operation, and bilateral pre- and post-operative ONSD data were acquired. Patients included in the study were aged between 18 and 65 years, had undergone conservative treatment, had lower back and/or leg pain for at least 3 months, had a scheduled ELND, and had no anamnesis of any ophthalmological disease. The criteria for exclusion included: patient refusal; patients with bleeding diathesis in laboratory tests; patients with any local or systemic infection; patients with pathology in the preoperative ophthalmological evaluation (cataract, glaucoma, macular degeneration, or diabetic retinopathy); patients with suspected clinical intracranial hypertension, headaches not responding to treatment, papillary edema, headache-related ophthalmoparesis, decreased visual acuity, headache-related vision loss, and situations, such as enucleation, that prevent the application of transorbital USG.

Venous access of 18-gauge (G) was opened and 1 gr ceftriaxone was administered to patients 1 hour before the procedure (Eqiceft, All-Drug, Turkey). They were then taken to the operating room. Bilateral ONSDs were measured with the USG probe (eSaote MyLab30Gold, Italy). Patients' eyelids were closed, then they were put in the supine position as the probe was placed on the orbita in the sagittal plane, measuring 3 mm posterior of the papilla (Fig. 1). Then, the intravenous administration of 0.9% saline infusion began. The patient underwent standard monitoring, such as electrocardiography, non-invasive blood pressure, pulse, and oximeter readings.

Aseptic conditions were achieved after the patient was placed in a prone position, and the intervention area was cleaned. Once the patient was covered with sterile set dressings, caudal region anesthesia was achieved with a 22 G Quincke spinal needle. After skin dilation, a trocar was inserted through the sacral hiatus. Epidurography, with a C-arm scope, showed that the trocar was in the midline. Tracking of procedure duration began as soon as the epiduroscopy catheter was inserted into the epidural space. The epiduroscopy catheter was guided through the anterior epidural space to the level of lumbar disc herniation and/or adhesions, after advancing through the trocar. During the procedure, saline was administered to the epidural area through the epiduroscope with a syringe. After imaging the herniated disc, the laser probe was directed into the disc, then the Ho: YAG was applied for decompression. The effectiveness of the procedure was demonstrated with an epidural opaque injection and the procedure was terminated by applying a lumbar epidural steroid injection (16 mg dexamethasone and 15 mg bupivacaine, 7–10 mL volume). All procedures were carried out by the first author (SGB). During the procedure, the total amount of fluid delivered to the epidural area was recorded (epidural saline, opaque substance, local anesthetic, and the steroid administered to the epidural space).

Optical Nerve Sheath Diameter (OSND) Measuring Technique

For measurement of the OSND, the position 3 mm back from the lamina cribrosa was preferred because this location is more sensitive to intracranial pressure changes according to anatomical studies (9,10). The optic nerve is seen as a hypoechoic linear structure localized between the 2 edges of the optic nerve sheath, while the subarachnoid space has a trabecular location, between the optic nerve and the optic nerve sheath, and has a hyperechoic appearance. The outer edges of the optic nerve sheath must be indicated by USG for an accurate measurement. If the image is not clear, imaging the central retinal artery within the optic nerve may be useful to determine the curvature areas and avoid erroneous measurement (11). The diameter of the hyperechoic tubular structure, which appears centrally in the space between the outer edges of the optic nerve sheath in both eyes, was averaged and recorded by making 3 consecutive measurements (Fig. 2).

Results

As a result of scanning the hospital database, 84 patients were included in the study. Age, ENLD duration, amount of saline used, and pre- and post-operative right and left ONSD measurements are shown in Table 1. The pre- and post-operative ONSD measurements were 6.32 mm and 6.65 mm, respectively, for the right (R) eye, and 6.35 mm and 6.66 mm for the left (L) eye.

As a result of the applied Pearson correlation analysis, no significant relationship was found between the ONSD measurements, processing time, and fluid delivery rate ($P < 0.05$, Table 2). As a result of the dependent sample t-test applied, there was no statistically significant difference between preoperative measurement values and postoperative values ($P < 0.05$). Accordingly, postoperative ONSD measurement values for the right and left eyes were statistically significantly higher than preoperative ONSD measurement values ($P < 0.05$, Table 3).

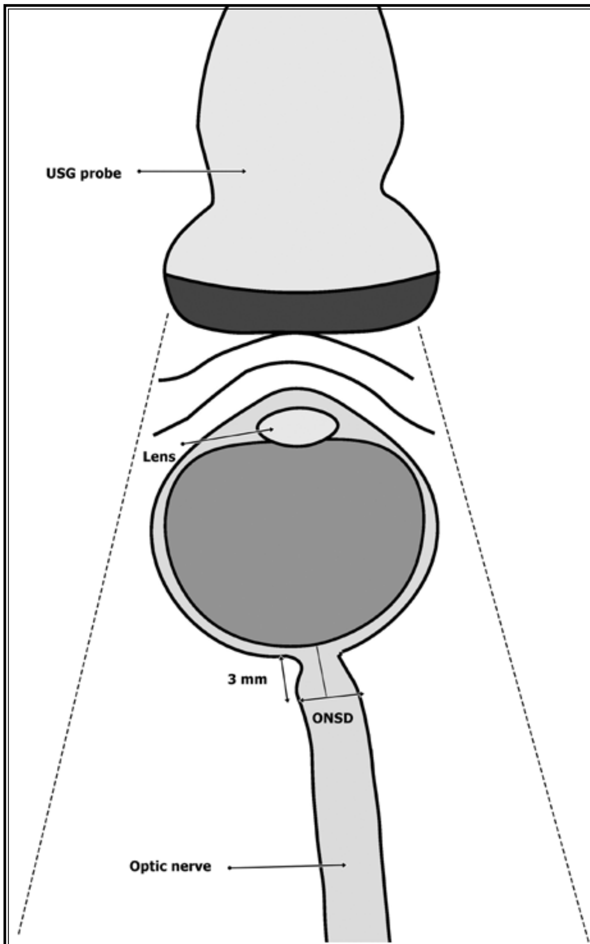

Fig. 1. *ONSD measurements were performed before and after epiduroscopy of 84 patients. 3 mm posterior of lamina cribrosa was preferred for ONSD measurement with USG.*

Fig. 2. *Ultrasound image of the optic nerve sheath diameter (ONSD) evaluation. ONSD is measured 3 mm posterior to the glob of the eye.*

Table 1. *Descriptive statistics.*

	Mean	Std. Deviat.	Min	Max
Age	46.83	13.197	18.0	78.0
Duration (min.)	11.88	3.703	6.0	24.0
Saline used (mL)	95.53	29.430	45.0	175.0
Saline Injection Rate (mL/min)	8.24	2.174	3.8	15.0
Preop ONSD-R	6.32	0.882	4.1	8.2
Preop ONSD-L	6.35	0.840	4.5	8.1
Postop ONSD-R	6.65	0.955	4.6	8.4
Postop ONSD-L	6.66	0.954	4.5	8.5

Table 2. *The relationship between preoperative - postoperative right-left ONSD values and ELND duration, liquid given, and liquid/duration ratio.*

		Time (min)	Liquid Used (mL)	Liquid/Duration Ratio (mL/dk)
Preop ONSD-R	r	-0.042	-0.231	-0.210
	P	0.706	0.035*	0.056
Preop ONSD-L	r	-0.028	-0.160	-0.139
	P	0.804	0.145	0.207
Postop ONSD-R	r	0.095	-0.106	-0.208
	P	0.390	0.337	0.057
Postop ONSD-L	r	0.089	-0.102	-0.210
	P	0.422	0.357	0.055

*: $P < 0,05$ **: $P < 0,01$ ***: $P < 0,001$

Table 3. *Comparison of preoperative and postoperative right-left ONSD values*

	Mean	Std. Deviat.	t	P
Preop ONSD-R	6.32	0.882	-5.155	0.000***
Postop ONSD-R	6.65	0.955		
Preop ONSD-L	6.35	0.840	-3.460	0.001**
Postop ONSD-L	6.66	0.954		

*: $P < 0,05$ **: $P < 0,01$ ***: $P < 0,001$

No complications (including headaches) were observed in these patients during the intra and postoperative period.

Statistical Analysis

Data were completed by transferring to the IBM SPSS Statistics 23 program. While evaluating the study data, parametric tests were used because of the distribution of the sample mean for $n \to \infty$, according to the numerical variables, the law of large numbers. Frequency distribution is given for categorical variables and descriptive statistics (mean, standard deviation, minimum, maximum) are given for numerical variables. A dependent sample t-test was used to examine the difference between pre- and post-operative values and Pearson correlation analysis was used to examine the relationship between 2 numerical variables. A value of $P < 0.05$ was considered significant.

Discussion

Applications used on some neurological treatment tables, such as intraventricular drainage and intracranial pressure sensors, can increase intracranial pressure and are quite invasive. In cases where there is no contraindication, such as an intracranial mass or bleeding diathesis, measurement is made by connecting a manometer to the lumbar puncture needle to show the increase in intracranial pressure. As a newer and less invasive method, we can provide indirect information about intracranial pressure with ONSD measurements using USG. According to the current literature, several studies have been published evaluating ONSD by using USG in idiopathic intracranial hypertension (7,12,13). We know that the ONSD value, which reflects the increased intracranial pressure value, is significantly more popular when comparing patients with no intracranial pressure increase and patients with idiopathic intracranial hypertension. The optimal ONSD cut-off value is 6.3 mm. Patients with an ONSD above this value are 11 times more likely to have intracranial hypertension than patients below 6.3 mm (14). The cut-off value (4.8 – 6.3 mm) observed in this study was considerably higher than previous studies reported (7,15,16). In a study published in 2019, it was stated that the cut-off value was 6.3 mm (5.2 – 6.3 mm) (17). In this study, measurements were 6.32 ± 0.88 mm for the right eye and 6.35 ± 0.84 mm for the left eye, while the cut-off value was 9 mm (4.1 – 8.2 mm). In cases of such high cut-off values, Del Saz-Saucedo, et al, (14) recommend that each center should take responsibility for validation of the ultrasonographic evaluation of ONSD to determine intracranial pressure on its behalf, as in any diagnostic technique. There are many factors determining correct ONSD assessment, such as the operator's experience, location, spatial resolution of USG, and presence of image inaccuracies. We agree with comments by Del Saz-Saucedo, et al, (14) for the reasons explained above and in the light of the results obtained from the scientific literature.

Using a different methodology, Beyaz, et a (2) reported that the liquid used in ELND procedures (at an average volume and rate of 107.25 mL (45 – 180 mL) and 8.33 ml/min, respectively) had no effect on postoperative intraocular pressure, optic disc diameter, reasonable thickness, and peripapillary retinal nerve fiber layer (RNFL) thickness. Their study also found that the ophthalmic complications, which are stated to be related to this method, are safe when using fluid at the specified amount and speed (2). Our study was performed with the same method and no complications were found by administering fluid at a rate of 8.24 mL/min (3.8 – 15 mL/min). Another important issue was the amount of fluid delivered to the epidural area. Although the mean amount of saline (95.53 mL [45 – 175 mL]) given to the epidural area caused an increase in intracranial pressure, it was found to be in safe limits, since it did not cause any clinical symptoms. Beyaz, et al (2) performed optimal coherence tomography (OCT) measurements after ENLD procedures. In these circumstances, it may be difficult for patients to adapt to OCT measurements. OCT measurements should be taken post-operatively, when patients are in a sitting and fixed position. However, considering the sacral hiatus and postoperative pain associated with these procedures, the reliability of these measurements can be questioned. In addition, these measurements may not be considered reliable because patients were given sedative drugs. In this study, in which ONSD is measured with USG, the measurement is quick and easy. When the patient was taken from the prone position to the supine position after the ENLD procedure was performed at the bedside without having to take the patient to another measurement room. It is also advantageous in terms of reliability, as it does not need to pass the sedation effect. When these 2 observations are evaluated together, we can say that after the ENLD procedures, USG-guided ONSD values increased. Pressure returned to normal levels after 1 to 2 postoperative hours and the epidural area tolerated these amounts of fluid.

A study by Tire, et al (17) measured ONSD at 3 different times after epiduroscopy procedures (immediately postoperatively, and at 10 and 20 minutes after procedure). During epiduroscopy, patients were grouped in either a high-volume group (patients who received 60 mL or more of fluid) or in a low-volume group (patients who were given less than 60 mL of fluid). The study compared the low-volume group (with 37.7 ± 5.3 mL) with the high-volume group (with 64.9 ± 2.9 mL) and found the ONSD values in the high-volume group were higher than the preoperative values at 10 and 20 minutes after the operation. The results of this study and our study are different because, as Gill and Heavner (3) stated, the most important factor is the rate of fluid delivery into the epidural space, followed by the volume of the fluid delivered. In their study, disregarding and not interpreting the rate of administration accordingly, significantly affected the results considerably. Looking at the operation times in the study by Tire, et al (17), we can see that fluid was given at an average rate of 2–3 mL/min (17.23 ± 3.23 minute operation time in the low-volume group; 21.33 ± 5.33 minute operation time in the high-volume group). It is not possible to increase the pressure at these speeds and the results are inconsistent. In this case, how the operation time is calculated becomes very important. In our study, we started the time from the moment the epiduroscopy catheter was inserted into the epidural space in the ENLD procedure. Operation preparation stages were not included. In addition, the study does not identify which cases were performed by epiduroscopy. Operation times will, of course, change according to the type of operation performed. Epiduroscopy has become a general definition for a range of procedures. The purpose of the epiduroscopy, route of administration, and its place in treatment are changing and improving day by day. When the first studies on epiduroscopy were carried out, only the posterior epidural area was reached by the epiduroscopy method, while anatomical structures were displayed and pathological structures were distinguished. More recently, fibrotic structures and adhesions occurring in the posterior epidural area have been treated in patients with failed back surgery syndrome (1,18,19).

Limitations

The most striking aspect of our study is that a single epiduroscopy technique is performed by the same person. This ensures reliability in transaction results. One of the limitations of our study is the retrospective collection of data. A second limitation is that repetitive measurements were not performed, instead of a single postoperative measurement.

Conclusion

As a result, we conclude that the fluid used in ENLD procedures (at an average volume and rate of 95.53 mL and 8.24 mL/minute, respectively) increases ONSD, and can, therefore, indicate increased intracranial pressure. However, this can be tolerated without causing any complications and is safe to be used at these speeds and amounts. We think there is a need for randomized, controlled studies to be performed, using a method that can monitor eye measurements throughout the operation, together with the amount of fluid delivered to the epidural area, and the rate at which it is delivered.

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