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Assessment of Optic Nerve Sheath Diameter in Patients Undergoing Epiduroscopy

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Background: Epiduroscopy is commonly used for the evaluation and treatment of low back pain. Saline with or without local anesthetic addition was used to visualize epidural space structure during this procedure. A rapid increase in epidural space pressure is transmitted into the spinal space to the optic nerve sheath. This study aimed to estimate the effects of epiduroscopy on optic nerve sheath diameter (ONSD) according to the volume of fluid using the ultrasonographic measurement of optic nerve diameter in adult patients.

Material/Methods: Sixty patients who had been treated for low back pain with epiduroscopy using low-volume (LV) or high-volume (HV) fluid application were enrolled into the study. Measurement of ONSD was performed before (T0) and immediately after epiduroscopy (T1), at 10 min (T2), and 20 min (T3) after the epiduroscopy.

Results: Both groups showed significant differences over time in ONSD (PGroup×Time=0.001). The HV group showed greater changes from T0 to T2 and T3 than the LV group in ONSD. However, in both groups, ONSDs at T2 and T3 were significantly larger than those with the highest values at T2 compared to T0.

Conclusions: Ultrasonography of ONSD presents a good level of diagnostic accuracy for identifying epidural hypertension. In the clinical decision-making phase, this may help physicians to be more cautious about volume when performing epidural injections to treat this disease.

MeSH Keywords: Injections, Epidural • Intracranial Hypertension • Optic Nerve Diseases

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Background

Epiduroscopy is widely used for diagnosis and treatment, especially for patients with lumbar disc herniation, because of its safety and effectiveness [1]. According to published evidence, complications are usually related to dural puncture and rise in epidural space pressure secondary to fluid injections [2]. However, the total volume of fluid used during the examination and of epidural space and intervention can differ among patients. Treatment with higher volumes can cause postprocedure visual impairment [3]. There are reports in the literature about the correlation between intracranial pressure (ICP) and the optic nerve sheath diameter (ONSD) [4]. Although direct ICP measurement from the brain parenchyma or the ventricle is accepted as the criterion standard for detection of intracranial hypertension, it is a rather complicated and invasive method [5]. Nowadays, ICP can be assessed via ONSD, which is noninvasively measured by ultrasonography, and it is an ideal technique for detecting intracranial hypertension [6]. Although perioperative visual loss has been attributed to the amount of epidural injectate, no previous study has investigated the effect of the volume of injectate used during epiduroscopy on ICP changes using ONSD measurement.

In this prospective observational study, we assessed the effect of low- and high-volume injectate on ICP with ultrasonographic measurement of ONSD in patients undergoing epiduroscopy for lumbar disc herniation.

Material and Methods

Patients

The study was approved by the ethics committee of the medical faculty of the Ordu University (2018/132) and written informed consent was obtained from the patients. Sixty adult patients undergoing epiduroscopy at Konya Training and Research Hospital for treatment of low back pain were enrolled. Although there is no recommendation for the maximum volume of injectate to use during epiduroscopy, we set 60 cc volume as a cut-off point according to published studies on related complications of epiduroscopy [7]. Therefore, the patients receiving 60 ml or more were assigned to the high-volume (HV) group and the others were assigned to the low-volume (LV) group. We excluded patients with spinal anomalies or infection in the sacral or lumbar region, coagulopathy, high ICP, or ophthalmic diseases.

Anesthesia

All patients were sedated with midazolam (0.03–0.3 mg kg – 1) (Dormicum, 50 mg ampule – 1, Deva Holding A.Ş., İstanbul, Turkey) combined with fentanyl (1–1.5 mcg kg – 1) (Fentanyl 100 mcg ampule – 1, Johnson & Johnson Company) and 4 L/min oxygen delivered by a face mask. All patients were monitored with electrocardiography, pulse oximetry (Sp02) noninvasive arterial blood pressure (NIBP), and end-tidal CO_2 ($EtCO_2$) measurement, as recommended by the American Society of Anesthesiology.

Epiduroscopy

Two experienced neurosurgeons from our hospital pain management team performed epiduroscopy. A 5-cm inclined 22-gauge block needle was inserted into the sacral epidural space after obtaing an X-ray image of the sacral region through the sacrococcygeal ligament. Small amounts of saline with 60 mmHg pressure were given through the catheter to obtain a proper visual image and to break down the adhesions. At the end of the procedure, 80 mg methylprednisolone and 10 mg bupivacaine in a 10 mL total volume were injected. The total volume of saline and local anesthetic used were noted.

Measurement of ONSD

ONSD was performed by transorbital sonography by 2 investigators who were blind to the study protocol. Transorbital sonography was performed using an E-CUBE i7 ultrasound system (mechanical index, 0.2; thermal index, 0) using a linear 6–13 Hz probe (Alpinion Medical Systems, Seoul, Republic of Korea). To prevent eye damage, we placed a sterile shut-off gel and probed slightly without pressure on the eyelid. Ultrasonographic images of the field were obtained at the level of the optic nerve, and the ONSD image was captured 3 mm posterior to the optical nerve head (Figure 1). The optic nerve sheath was obtained in both eyes at each time interval: first (T0), immediately after epiduroscopy (T1), and at 10 min (T2) and 20 min (T3). The mean value of the 4 measurements was recorded as the ONSD at each time point. Heart rate (HR), NIBP, SPO2, and $EtCO_2$ were recorded separately at each time point.

Statistical analysis

The primary aim of this study was to assess the effect of low- and high-volume epidural injectate on ONSD of patients undergoing epiduroscopy. At least 28 subjects in each group were required to detect a 0.3-mm difference in ONSD measurements for clinically reliable results. We decided to include 60 patients with a power of 80% and a significance level of 5% for compensation of dropouts. We calculated the sample size according to a pilot study.

We performed multivariate observational analyses of all data. Descriptive statistics were given for the latent variables. Mean and standard deviation are given for continuous variables,

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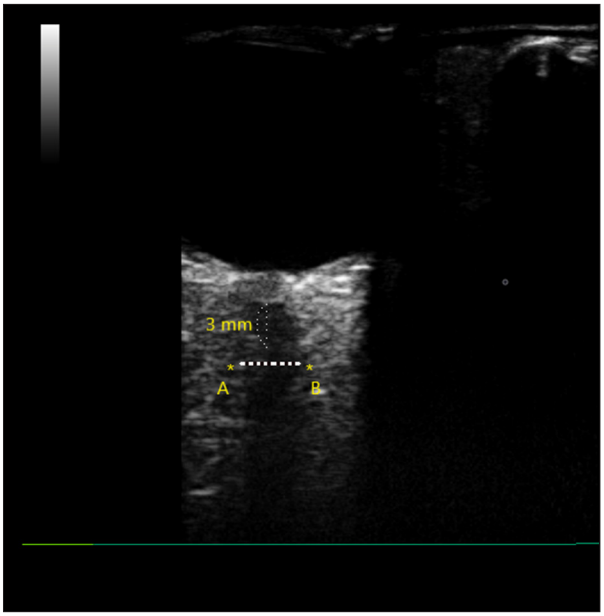

Figure 1. Measurement of optic nerve sheath diameter (ONSD) by ultrasonography. Axial images of the orbit were acquired in the plane of the optic nerve. ONSDs were measured 3 mm posterior to the optic nerve head (A-B).

and frequency and percentage are given for categorical variables. Mixed effects models were created for constant variables. Group, time, and group-time interaction were evaluated. The *t* test was used for the measurement of continuous variables between the 2 groups. When the group-time interaction was significant, least square means were compared. We used Statistical Analysis SAS (University Edition 9.4) software for data analysis. A value of p <0.05 was considered significant.

Results

All 60 patients completed the study. There was no significant difference between the 2 groups in terms of patient demographic data. Their characteristics are presented in Table 1. The operation times were significantly different between the 2 groups (p<0.001) (Table 1). There was no significant difference between the HV and LV groups in mean blood pressure (MAP), heart rate (HR), SpO2, or $EtCO_2$ throughout the epiduroscopy procedure (p>0.05) (Table 2).

The means of volume were 37.7±5.3 cc (LV group) and 64.9±2.9 cc (HV group). In group LV, ONSD values at T2 and T3 were significantly higher than at T0 (p<0.05, Figure 2), whereas in Group HV, ONSD values at T1, T2, and T3 were higher than basal ONSD values (p<0.001, Figure 2). The ONSD at T2 and T3 time points were significantly higher in Group HV (p<0.001, Figure 2) The ONSD values rose steadly and reached a maximum level at T2 in both groups. The degree of change between T0 and other measurement times were significantly different in each group, except for T1–T0 in group LV (results of the *post hoc* analysis are shown in Table 3). None of the patients had any complications after surgery.

Discussion

We evaluated the effect of injectate volume used during epiduroscopy on ONSD in patients undergoing epiduroscopy for low back pain. Fluid injection during the epiduroscopy procedure resulted in an increase in ONSD, which did not reach the baseline even after 20 min in both high- and low-volume groups of patients. The highest ONSD value was observed 10 min after epiduroscopy in both groups. In addition, the high-volume injectate group had significantly higher ONSD values at 10 and 20 min after epiduroscopy.

The expandable subarachnoid space surrounds the optic nerve. Therefore, a change in ICP can increase ONSD by releasing cerebrospinal fluid (CSF) from the intracranial hole into the perineural subarachnoid space surrounding the optic nerve. According to previous studies on the relationship between ONSD and CSF pressure, ONSD is linearly associated with ICP [4,8]. Several

Table 1. Subject characteristics and operative data.

Demographic data	HV (n=30)	LV (n=30)	p-Value
Age (months)	54.30 (±10.24)	56.33 (±10.64)	0.454
Height (cm)	163.07 (±9.84)	163.20 (±8.26	0.955
Weight (kg)	76.27 (±13.03)	75.60 (±13.03	0.836
Body mass index (kg/m^2)	29.75 (±4.35)	28.94 (±4.06)	0.463
ASA physical status (I/II)	30/2	30/2	0.611
Operation time (min)	17.23 (±3.23)	21.33 (±5.33)	<0.001*

Values are presented as mean (SD) or number of subjects. HV – high volume; LV – lov volume, * *p*<0.001.

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Table 2. The differences between the two groups in the same time interval.

Times	HV N=30		LV N=30		Adjusted *p* value
Heart rate (beats/min^{-1})					
T0	78	(10)	75	(13)	0.4054
T1	78	(14)	74	(11)	0.1605
T2	72	(10)	72	(12)	0.9731
T3	70	(8)	69	(11)	0.9193
Mean arterial pressure (mmHg)					
T0	104	(14)	102	(19)	0.6862
T1	102	(18)	99	(16)	0.5041
T2	93	(16)	96	(13)	0.4466
T3	90	(16)	90	(14)	0.9752
Oxygen Saturation (%)					
T0	97	(1)	97	(2)	0.9554
T1	97	(2)	96	(2)	0.4023
T2	96	(2)	96	(2)	0.4344
T3	96	(2)	96	(2)	0.8669
$EtCO_2$ (mmHg)					
T0	31	(4)	31	(4)	0.7681
T1	29	(4)	31	(4)	0.1058
T2	30	(3)	32	(5)	0.0938
T3	30	(4)	32	(4)	0.0779

Values are presented as mean (SD). Adjusted *P*-value indicates the Bonferroni-corrected *P*-value. $EtCO_2$, level; T0 – before epiduroscopy; T1 – immediately after epiduroscopy; T2 – 10 min; T3 – 20 min; after epiduroscopy. HV – high volume; LV – lov volume.

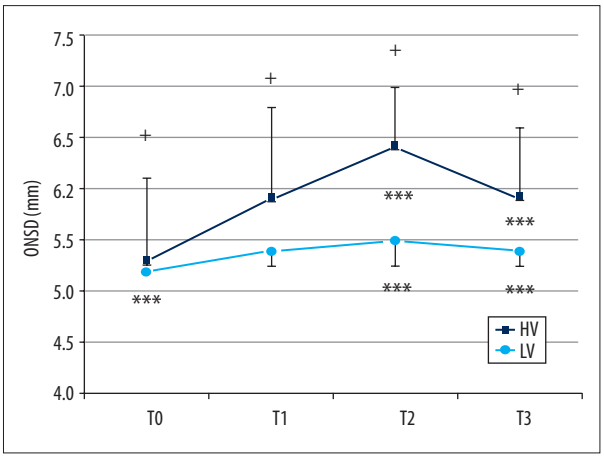

Figure 2. Changes in optic nerve sheath diameter (ONSD). Values are expressed as mean (SD). *** The two groups showed significant differences in changes in ONSD according to time in the linear mixed model (corrected for age, body mass index, end-tidal carbondioxide levels, *p* Group_T2 and T3 Time *p<0.05* ***). Each group showed significant differences in changes in ONSD of T0–T2 (LV), *(p<0.05 ***)*/T0–T3(LV), *(p<0.05 ***)* and in ONSD of T0–T1 (HV), *(p<0.001 +)*/T0–T2 (HV), *(p<0.001 +)*/T0–T3(HV), *(p<0.001 +)*. T0 – before epiduroscopy; T1 – immediately after epiduroscopy; T2 – 10 min. after epiduroscopy; T3 – 20 min. after epiduroscopy.

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Table 3. Changes in optic nerve sheath diameter (ONSD) between time points.

Simple effect level	Time (mean diameter value mm)	Time (mean diameter value mm)	Adj p
LV	T0 (5.2)	T1 (5.7)	0.3678
LV	T0 (5.2)	T2 (5.7)	0.0032*
LV	T0 (5.2)	T3 (5.4)	0.0030*
LV	T1 (5.7)	T2 (5.7)	0.3678
LV	T1 (5.7)	T3 (5.4)	0.3547
LV	T2 (5.7)	T3 (5.4)	1.0000
HV	T0 (5.3)	T1 (6.3)	<.0001**
HV	T0 (5.3)	T2 (6.2)	<.0001**
HV	T0 (5.3)	T3 (6.0)	<.0001**
HV	T1 (6.3)	T2 (6.2)	0.0934
HV	T1 (6.3)	T3 (6.0)	0.4083
HV	T2 (6.2)	T3 (6.0)	0.9422

Values are presented as mean (SD). Adjusted *p*-value indicates the Bonferroni – corrected *p*-value. HV – High volume; LV – lov volume. * $p<0.05$; ** $p<0.001$.

published studies have shown that ultrasound measurement of ONSD is correlated with ICP, and showed that ultrasound-guided measurement of ONSD is a useful method for monitoring [9,10]. Kimberly et al. showed a correlation between ONSD values measured by ultrasonography and ICP values measured by invasive methods. The injected fluid volume led to a rise in epidural pressure, and this increase in epidural pressure translated into the subarachnoid space to the optic nerve sheath. However, the amount of fluid administered through epiduroscopy is case-specific and not determined before the procedure [5]. Therefore, it is difficult to set a particular cut-off point for the volume of injectate. The results of the present study show that injectate volume greater than 60 cc can lead to greater increases in ICP compared to lower volumes [7]. In addition, our results suggest that high-volume fluid treatment can lead to neurological deterioration, particularly in patients with undiagnosed intracranial compliance.

In patients experiencing visual impairment after epiduroscopy, a clear definition of the amount of fluid pumped and the resulting visual impairment is not defined. However, it is clear that the amount of injected fluid affects the temporary increase in ICP, which might be a possible cause of visual impairment. Our results do not show the maximum volume that can be added during epiduroscopy [3]. Also, the compliance of the brain affects translation of volume on the ICP; therefore, the treatment threshold for ICP may change according to patient age and co-morbidities [11,12]. Our findings show that epiduroscopy requires careful attention when using both high volume and low volume, especially in patients with intracranial pathologies or risk factors associated with increased ICP.

Despite previous studies that examined ONSD among patients with and without existing high ICP, little is known about how fast ONSD reflects acute differences in ICP. In these studies, the pressure measured from the epidural space has been accepted to reflect the changes in ICP [6,13]. Intracranial and epidural pressures have been shown to peak immediately after epidural injection and subsequently decrease [4,14]. In our study, patients treated with epidural injectate volumes greater than 60 ml had significant increases in ONSD values immediately after the procedure compared to baseline values. At these time points,there were also significant differences between the 2 groups. The low-volume group of patients also showed higher ONSD values after epiduroscopy. All the patients requiring epiduroscopy must be evaluated individualy according to comorbid diseases, if any.

This study has some limitations. The first limitation is the statistically different operation time, but we measured the ONSD at specified time points, and challenges in the management of patients in the high-volume fluid group would mostly prolong the duration of surgery. The second limitation is that the epidural injection pressure was set at 60 mmHg in our patients; therefore, we did not determine the effect of high-pressure injectate on ONSD. The third is that we did not measure the body temperature of patients. The resistance rates of the surfaces

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change with the temperature, and the surface resistances in the liquid and air mass also change. Thus, temperature and pressure can affect each other in a reverse or linear ratio [15].

Conclusıons

We found that the volume of injectate used during epiduroscopy affects ONSD in patients undergoing epiduroscopy for low back pain. However, the significant rise in ONSD in the LV group shows that ICP can be significantly increased even, after epiduroscopy, with low-volume injectate. Therefore, measurement of ONSD as a method of noninvasive intracranial pressure monitoring is preferrable due to its safety and availibility.

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