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Araştırma makalesi / Research article

The impact of prone position on optic nerve sheath diameter

Prone pozisyonun optik sinir kılıfı çapına etkisi

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Abstract

Aim: The measurement of optic nerve sheath diameter is a reliable and non-invasive approach in determining increased intracranial pressure (ICP). We investigated the impact of prone position, a frequently used approach during surgery, on ICP in this present study.

Methods: Horizontal and vertical optic nerve sheath diameters for both eyes were measured by means of ultrasonography first immediately after intubation preoperatively and then when the patient has been placed in supine position prior to extubation postoperatively in a total of 60 patients scheduled for vertebral surgery in prone position in neurosurgical and orthopedic theatres. They were compared in terms of sex and duration as well as for left and right eye measurements.

Results: No significant differences were observed in terms of sex as well as right-left eye measurements in the patients. No changes were noted in optic nerve sheath diameter in the patients with shorter operative duration. However, there was a notable increase numerically in patients who had operation duration of over 240 minutes, although the difference was not established to be statistically significant.

Conclusion: Prone position was not associated with increased intracranial pressure in patients who undergo short or medium duration surgery. However, optic nerve sheath diameter is likely to increase in patients who undergo longer surgery. Therefore, care has to be taken in terms of elevated ICP in patients who remain in prone position for extended periods.

Keywords: Intracranial pressure increase, optic nerve sheath diameter, ultrasonography, prone position.

Öz

Amaç: Optik sinir kılıfı çapı ölçümü kafa içi basınç artışının tespitinde noninvaziv, güvenilir bir yöntemdir. Biz çalışmamızda, ameliyathane ortamında sık kullanılan prone pozisyonun kafa içi basıncına etkisini araştırdık.

Yöntemler: Prone pozisyonda vertebra operasyonu yapılacak toplam 60 beyin cerrahi ve ortopedi hastasının preoperatif indüksiyondan hemen önce ve postoperatif supine pozisyona alındığında ekstübasyondan önce ultrasonografi ile her iki gözde yatay ve dikey optik sinir kılıfı çapı ölçümlerini kaydettik. Cinsiyet, süre ve sağ göz- sol göz kıyaslamaları yapıldı.

Bulgular: Cinsiyet ve sağ göz- sol göz kıyaslamalarında fark gözlenmedi. Süre açısından kısa süren olgularda optik sinir kılıfı çapında değişiklik yoktu. 240 dakikadan uzun süren olgularda istatistiksel olarak anlamlı olmasa da nümerik olarak bariz artış gözlendi.

Sonuç: Prone pozisyonu kısa ve orta süreli operasyonlarda kafa içi basınç artışı yapmamaktadır. Ancak çok uzun süreli durumlarda optik sinir kılıfı çapı artma eğilimindedir. Bu nedenle çok uzun süre prone pozisyonda tutulan hastalarda kafa içi basınç artışı yönünden dikkatli olunmalıdır.

Anahtar Kelimeler: Kafa içi basınç artışı, optik sinir kılıfı çapı, ultrasonografi, prone pozisyon.

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Introduction

Intracranial pressure (ICP) is the positive pressure created by the cranial cerebrospinal fluid, cerebral blood volume, and the brain itself. It was first described by Monro in 1783 [1]. It is normally 5-15 mmHg [2]. The components creating the pressure compensate the alterations for one another under normal conditions. However, when the compensatory mechanism has been impaired, it leads to raised intracranial pressure (rICP) syndrome. A value of 25-30 mmHg is fatal [2].

While haematoma, tumour, and elevated cerebrospinal fluid level (increased production or decreased absorption) are the leading reasons, increased cranial blood volume (such as venous sinus thrombosis, hypercarbia induced elevated blood flow etc.) is also a frequent cause [3]. Furthermore, certain patient positions used during administration of anaesthesia have been established to have an impact on ICP [4]. While rICP syndrome could manifest itself with symptoms such as postoperative nausea, vomiting, papilledema or headache [5], we might also observe delayed postoperative recovery from general anaesthesia, postoperative delirium, impaired cognitive reactions, or, albeit rarely, neurological deficit [4].

The measurement of ICP can be carried out by using invasive or non-invasive approaches. While external ventricular drain (EVD) has been established to be the golden standard for ICP measurement [5], it could lead to haemorrhage, and poses a risk in terms of infection in patients monitored for longer periods [6]. It is also possible to perform a reliable and quick ICP measurement by means of Computed tomography (CT), Magnetic resonance imaging (MRI) or Ultrasonography (USG) non-invasively. A number of studies demonstrated the reliability and efficiency of non-invasive measurement through ocular sonography [6, 7]. The measurement of optic nerve sheath diameter (ONSD) is a non-invasive reliable method well-correlated with ICP [4]. The retrobulbar segment of the optic nerve is surrounded by a subarachnoid space that can expand as a result of elevated cerebrospinal fluid pressure.

Although it was claimed that Trendelenburg position led to elevated ICP [7], we have come across few studies demonstrating that prone position singularly having an impact on the increase of the optic nerve sheath diameter.

Prone position is one of the most effective approaches utilized nowadays during the pandemic in management of COVID-19 patients. The increases in ICP and optic nerve sheath diameter have gained greater significance during the pandemic as patient monitoring time on average is 16-24 hours and following a short duration in supine position patients are returned to prone position.

In this study, we aimed to investigate the impact of prone position on ONSD and consequently on ICP.

Material and methods

This prospective observational study was initiated following the approval of the local ethics committee of the University of Health Sciences, Prof.Dr. CemilTaşçıoğlu City Hospital (dated 17.12.2019 / protocol no.1518). A written informed consent was obtained from all patients. The study was conducted in accordance with the Helsinki declaration.

Patient population

A total of 60 patients scheduled for elective vertebral surgery in prone position in neurosurgical and orthopedic theatres were enrolled in the study.

Inclusion Criteria: Aged 18-70 years, scheduled for elective surgery in prone position, surgery time of minimum 1 hour, American Society of Anesthesiologists (ASA)physical status classification I-II-III and consent to be enrolled in the study.

Exclusion Criteria: Patients with a history of ophthalmic surgery, glaucoma, diabetic retinopathy, cataract, retinal detachment, advanced-stage lung disease and advanced-stage cerebral disease as well as those not willing to be enrolled in the study and those who were established to be ASA IV or higher were excluded.

As intrathoracic pressure increase would lead to an increase in intracranial pressure[8], patients with elevated peak pressure intraoperatively were also planned to be excluded.

Anaesthesia protocol

The patients were premedicated 30 minutes prior to surgery with 0.05 mg/kg i.m. midazolam. Following routine hemodynamic monitorization (Electrocardiography-ECG-, non-invasive blood pressure, pulse oximetry), bispectral index pads were placed in the right and left frontal region to record baseline values. Patients were administered with 2.5 mg/kg i.v. propofol and 0.6 mg/kg i.v. rocuronium to induce anaesthesia. Meanwhile,1 μg/kg i.v. fentanyl was administered. Orotracheal intubation was performed. During the anaesthetic procedure, bispectral index values were kept between 40 and 60 by administering sevoflurane (Minimum alveolar consentration= 0.8-1.0) and remifentanil infusion (0.03-1.0 μg/kg i.v.). To maintain myorelaxation, 0.1 mg/kg i.v. rocuronium was administered every half an hour. Volume-controlled ventilation was utilized during operation. Tidal volume was set at 8 ml/kg (ideal body weight) and I/E rate was 1/2. The frequency of ventilation was set at 10-15/min to keep end tidal carbon dioxide ($EtCO_2$) within normal range. Positive end expiratory pressure (PEEP) was set at 5 mmHg. Hypotonic and hypertonic liquids were avoided. In addition to demographical values, type and duration of surgery as well as values recorded during operation were noted for further assessment.

Ocular sonography

Optic nerve sheath diameter (ONSD) was measured by means of ultrasonography by a trained researcher. After the patients were intubated in supine position and were stabilized, their eyes were closed, and a thin layer of gel was applied on their upper eye lids. A Mindray M5 system was used for the measurements. A linear probe at 7.5 MHz was placed on the eyelid without applying pressure. Optimal contrast between retrobulbar echogenic fat tissue and vertical hypoechoic band was achieved by adjusting the probe at an angle. The diameter of the hypoechoic structure was measured 3 mm posterior to optic disc in the image as shown in Figure 1. Vertical and horizontal measurements were performed in both eyes, and mean values were calculated for analyses. Although a cut-off value varying between 4.8 and 5.9 mm was used in different studies [9], a mean ONSD value of >5 mm was taken as positive in favor of ICP in our study[10,11]. Since it was not possible to carry out ONSD measurements when patients were in prone position during surgery, measurements were repeated and recorded at conclusion of surgery when patients were placed in supine position. It was planned that the patients with elevated values would be reassessed in the post-anaesthesia care unit at 30 minutes postoperatively. If the values were observed to be elevated again, they would be referred for further examination and consultation in terms of rICP.

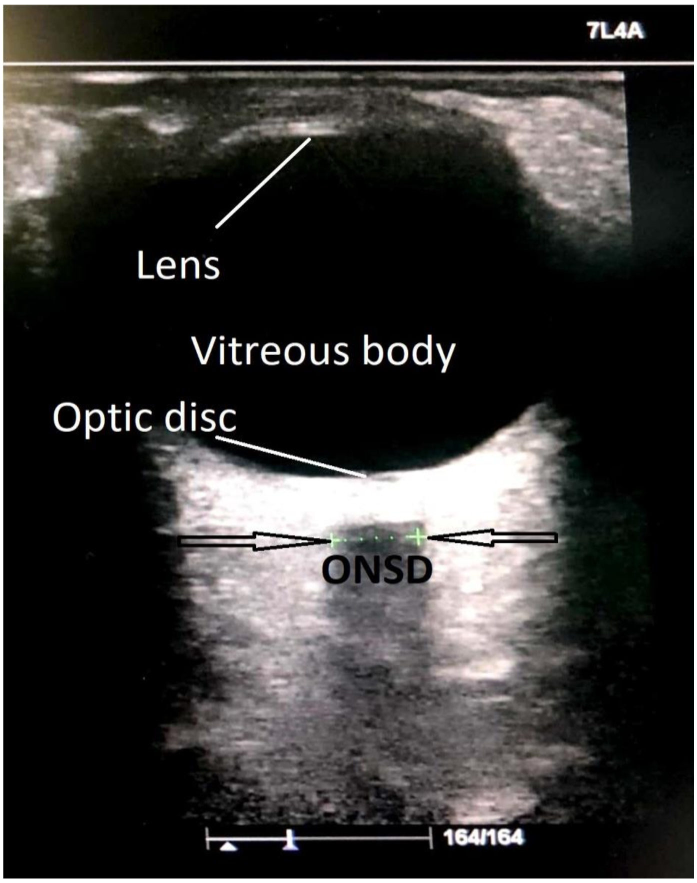

Figure1. Optic nerve sheath diameter measurement.

Statistical analysis

SPSS 20.0 was used for statistical analyses. Categorical variable frequencies of data were expressed numerically and in percentages, while continuous variables were given as mean and standard deviation. Kolmogorov-Smirnov test revealed that data distribution was not normal. As a result, a non-parametric test (Mann-Whitney U) was employed. Statistical significance was set at $p<0.05$. Comparisons were made in terms of sex, surgery duration (over or under 240 minutes) andright-left eye. Pearson Correlation as well as 2-tailed significance test were performed.

Results

A total of 60 patients underwent measurements. As shown in Table 1, no statistically significant differences were observed in the group in terms of demographical data, including sex. Pulse, Oxygen saturation-SpO2-, mean arterial pressure and EtCO2 values were within normal range in the patients.

The difference in the numbers of male and female participants was not statistically significant in the group (p=0.722). Postoperative comparison of right and left eyes in terms of ONSD values independent of any variables (age, sex, duration) revealed a p value of 0.431, which was not statistically significant ($p>0.05$). Furthermore, as seen in Table 2, no significant differences were observed in terms of preoperative and postoperative ONSD values in either eye in the patients.

When evaluated in terms of surgery duration, postoperative measurements of the patients undergoing surgery for over 240 minutes revealed p values of 0.57 and 0.07 for the right and left eyes, respectively, in Table 3. The differences were not statistically significant. However, a numerical increase was noted in mean postoperative ONSD values. As seen in Figure 2, we observed that as the duration of surgery increased, ONSD values tended to increase as well.

Table 1. Demographic data.

	Mean±SD
Age	50.57±12.7
Height (cm)	168±8.3
Weight (kg)	74.6±11.2
Pulse (/min)	75.8±9.6
SpO_2 (%)	99.0±0.5
Mean Arterial Pressure (mmHg)	77.68±5.1
$EtCO_2$ (mmHg)	31.48±1.2
	n(%)
Gender	
• Male	31 (51.7%)
• Female	29 (48.3)
ASA	
I	27(45%)
II	26(43.3%)
III	7(11.7%)

SpO_2: Oxygen saturation, $EtCO_2$: end tidal carbon dioxide, ASA: American Society of Anesthesiologists, SD: standard deviation.

Table 2. Preoperative and postoperative ONSD values.

	Preoperative	Postoperative	
n=60	Mean±SD	Mean±SD	p values
Right eye (mm)	4.34±0.49	4.38±0.48	>0.05
Left eye (mm)	4.41±0.48	4.43±0.45	>0.05

ONSD: optic nevre sheath diameter, SD: standard deviation.

Table 3. ONSD values for patients undergoing longer surgery and results of statistical analyses.

	Preoperative	Postoperative	
n=16	Mean±SD	Mean±SD	p values
Right eye (mm)	4.22±0.42	4.42±0.50	0.56
Left eye (mm)	4.16±0.47	4.59±0.49	0.07

ONSD: optic nevre sheath diameter, SD: standard deviation.

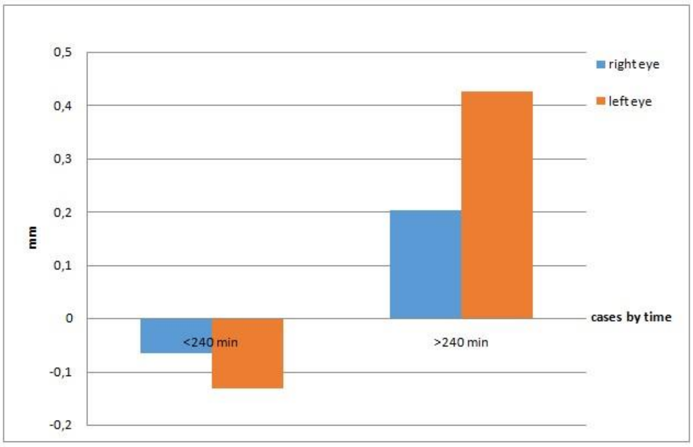

Figure 2. Time-related graph of the postoperative change of ONSD (Figures show the difference between postoperative and preoperative measurements)

Discussion

Surgical prone position is an approach frequently used in various surgical operations. We observed that prone position did not have an impact on ONSD in surgical durations of 60 – 240 minutes in our study.

Increase in ICP in patients under anaesthesia is attributable to several factors such as anaesthetic agents, mean arterial pressure, elevated central venous pressure and blood CO2 level. The patients were administered the same anaesthetic agents by making adjustments depending on weight to ensure standardization in our study. Remifentanil infusion was used to maintain mean arterial pressure within normal range. Fluid overload was avoided, and PEEP was set at 5 mmHg for all patients. EtCO2 values of the patients were maintained within normal range (30-45 mmHg). Eliminating the factors that might lead to increased ICP, we investigated the impact of prone position alone on ONSD and, consequently, on increased ICP. We established that prone position did not lead to increased ICP in operations with a duration of up to 4 hours, independent of sex and age.

Patients in prone position have inadequate pulmonary expansion, which results in increased intrathoracic pressure and consequently increased ICP. However, we did not observe high peak airway pressure in the patients during surgery. Therefore, no patients were excluded.

While day-surgery used to be limited to 90-minute operations, it has now risen to 3-4 hours [12]. Therefore, we considered cases that took longer than 240 minutes as long-duration surgery in our study and carried out statistical analyses accordingly. Although the change in ONSD was established to be more pronounced in the left eye compared with the right one in longer operations, and the p value was rather closer to 0.05, the difference between the right and the left eye was not statistically significant. In fact, significant contemporary changes observed in both eyes were interpreted in favour of rICP in the literature [10]. Therefore, the increase observed in the left eye was not considered to be a significant result.

We recorded the longest surgery duration to be 5.5 hours in our study. In this patient, we observed an increase in ONSD of 5.7 mm in the left eye and 6.1 mm in the right eye, indicating rICP. Although the mean numerical increase in patients undergoing longer surgery was not established to be statistically significant, we postulate that even longer durations in prone position would have a more significant impact since the patient with the longest surgery duration had an ONSD of >5 mm in both eyes, and it was interpreted in favour of raised ICP.

As patients were in prone position during the operation, the biggest limitation of our study was the fact that measurements could only be carried out at the beginning and later when they were in supine position at the conclusion of the operation. Therefore, the second-measurement point of the patients could not be standardized. Furthermore, while raised ICP is measured non-invasively by means of ONSD measurement, no consensus exists for the present moment regarding a reference value for a significant increase [7, 9].

No significant correlation was established between operation duration and ONSD increase in our study. However, fewer number of cases with longer operation duration is one of the limitations of this study.

In conclusion, the ultrasound measurement of ONSD in operations carried out in prone position is a reliable method well-correlated with raised ICP. We maintain that prone position does not lead to raised ICP in short and medium duration operations. However, care must be taken for longer operations.

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