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ORIGINAL ARTICLE

The Effects of Spinal Anaesthesia and Tourniquet Use on Optic Nerve Sheath Diameter in Total Knee Replacement Cases

Total Diz Protezi Vaklarında Spinal Anestezi ve Turnike Kullanımının Optik Sinir Çapı Üzerine Etkisi

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ABSTRACT

Background: Optic nerve sheath diameter measurement is a non-invasive method that provides rapid results in intracranial pressure assessment. Our aim in this study is to investigate how tourniquet use affect optic nerve sheath diameter values in total knee arthroplasty operations under spinal anaesthesia.
Methods:30 cases were included in the study. After spinal anaesthesia, the tourniquet cuff was inflated. Right and left optic nerve sheath diameter measurements were performed 5 times with ocular ultrasound before spinal anaesthesia, after spinal anaesthesia, at 10th minutes after tourniquet inflation, 30th minutes after tourniquet inflation, and after tourniquet was deflated. The measurements were recorded in centimetres. During the first 24 hours postoperatively, the patients were followed up for the headache and/or visual impairment.
Results: A significant difference was found between optic nerve sheath diameter values before and after spinal anaesthesia (p<0.001, p<0.001). When comparing the optical diameter, tourniquet and tourniquet deflation values obtained on the right and left sides over time, we found a linear increase.
Conclusion: The use of a tourniquet in spinal anaesthesia and orthopaedic surgery increases intracranial pressure. Optical measurement of nerve sheath diameter is a non-invasive and successful method that can be used safely for diagnosis and follow-up of elevated intracranial pressure. We believe that anaesthesiologists should pay more attention to the measurement of optic nerve sheath diameter in clinical practice.

Keywords: Optic nerve sheath diameter, intracranial pressure, spinal anaesthesia, tourniquet, total knee prosthesis

ÖZ

Giriş ve Amaç: Optik sinir kılıf çapı ölçümü, intrakranial basınç değerlendirmesini sağlayan ve hızlı sonuç veren non-invazif bir yöntemdir. Bu çalışmadaki amacımız, total diz artroplastisi ameliyatlarında , spinal anestezinin ve turnike kullanımının optik sinir kılıf çapı değerlerini nasıl etkilediğini araştırmaktır.
Material ve Method: Çalışmaya 30 olgu dahil edildi, olguların demografik verileri kaydedildi. Spinal anestezi yapıldıktan sonra turnike manşonu şişirildi. Sağ ve sol optik sinir kılıf çapları; spinal anestezi öncesi, spinal anestezi sonrası , turnike şişirilmesi sonrası 10. dakikada, turnike şişirilmesi sonrası 30. dakika ve turnike indirildikten sonra olmak üzere 5 kez okuler usg ile optik sinir kılıf çapı ölçümü yapıldı. Ölçümler santimetre olarak kaydedildi.Postoperatif ilk 24 saatlik dönemde olguların başağrısı ve / veya görme bozukluğu olup olmadığı takip edildi.
Bulgular: Vücut kitle indeksi, ameliyat süresi, turnike süresi, turnike basıncı ile spinal öncesi optik sinir kılıf çap değerleri arasında istatistiksel olarak anlamlı bir ilişki bulunmamıştır (p>0.050). Spinal anestezi öncesi ve sonrası optik sinir kılıf çapı değerleri arasında anlamlı fark tespit edilmiştir (p<0.001, p<0.001). Zamana göre sağ-sol tarafta elde edilen optik çap, turnike ve turnike indirme değerlerinin karşılaştırılması yapıldığında lineer bir artış olduğunu tespit ettik. Postoperatif ilk 24 saatlik dönemde , başağrısı ve /veya görme bozukluğu olan olguya rastlanmamıştır.
Sonuç: Spinal anestezi ve ortopedik cerrahide kullanılan turnike kullanımı intrakranial basıncı artırmaktadır. Artmış intrakranial basınçta optik sinir kılıf çapını artırmaktadır. İntrakranial basınç artışının tanı ve takibinde, optik sınır kılıf çapı ölçümü güvenle kullanılabilecek non-invaziv ve başarılı bir yöntemdir. Anesteziyologların optik sinir kılıf çapı ölçümüne, klinik pratikte daha fazla yer vermesi gerektiği inancındayız.

Anahtar Kelimeler: Optik sinir çapı, Turnike, Total diz protezi, intra kraniyal basınç, intracranial pressure

Introduction

Primary total knee arthroplasty is a widely used surgical method in advanced knee degenerative osteoarthritis and inflammatory arthritis treatments (1). Tourniquet is often used by orthopaedists in knee arthroplasty surgery. The purpose of tourniquets includes reducing bleeding during surgery, creating a clean operating field, and increasing the effectiveness of cementation. Whether a tourniquet reduces bleeding volume is controversial (2). Although the use of tourniquets is common, it has been observed to have negative effects. It is known to cause many complications secondary to ischemia and reperfusion injury. Free oxygen radicals are the main cause of ischemia-reperfusion injury after tourniquet placement in total knee arthroplasty. Free oxygen radicals that enter the systemic circulation after tourniquet deflation is known to cause cerebral vasodilation. Cerebral vasodilation causes an increase in intracranial pressure (3).

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The optic nerve sheath is an extension of the dura mater towards the optic nerve and is surrounded by a subarachnoid space containing cerebrospinal fluid (CSF)(4). For this reason, the sheath is expected to stretch as the CSF (cerebrospinal fluid) increases (5). Studies have shown that changes in CSF pressure reflect on the optic nerve due to the interaction between the subarachnoid cavity and the intracranial cavity (6).

Our study aimed to investigate how spinal anaesthesia and tourniquet use affect optic nerve sheath diameter during total knee arthroplasty surgery.

Materials and Methods

Ethical approval for our study was obtained from the Clinical Research Ethics Committee of Ordu University at the meeting of 05.10.2017 with decision number CREC 2017/116. Our study was planned as a prospective randomized single-blind clinical observation study. Between January 1, 2018, and December 31, 2018, 30 patients aged 18-65 years in ASA I-II risk class to undergo unilateral total knee arthroplasty in the surgery room of Ordu University Training and Research Hospital, were included in the study. Informed consent forms were signed by the patients who agreed to participate in the study. Those who did not agree to participate in the study, those who did not want to undergo spinal anaesthesia, cases under the age of 18 and over 65, those with coagulopathy, those with infection in the area to be injected, those with severe spinal deformity, and morbidly obese cases (BMI). ≥ 40 kg/m2) and cases with intracranial mass were excluded from the study. In the cases included in the study, no premedication was administered before they reached the operating table. On admission to the operating table, standard monitoring was used. Vascular access was opened on the back of the right hand with a 22 G i.v cannula. Intraoperative intravenous (i.v) infusion of 4 ml/kg/h saline (0.9% NaCl) was administered. The spinal anaesthesia was administered to 15 mg hyperbaric bupivacaine through Quincke-tipped 25 Gauge spinal needles.

After making sure that sufficient motor and sensory block, tourniquet cuffs were applied to the patients. The pneumatic tourniquet was inflated to 150-250 mmHg above the systolic blood pressure. The time the tourniquet was inflated was recorded on the perioperative anaesthesia follow-up sheet. Measures were taken to ensure that the tourniquet time did not exceed 120 minutes. The surgical area was closed with a drape (sterile membrane) to cover all the exposed skin. The same brand of total knee prosthesis was applied to all patients.

Demographic data such as ASA risk score, age, weight, height, and body mass index (BMI) were recorded in all cases. Operation time, tourniquet duration and applied tourniquet pressure were recorded for each case separately. Considering the moment before and immediately after spinal anaesthesia as minute 0, systolic blood pressure, diastolic blood pressure, mean arterial pressure, and heart rate measurements were recorded 13 times every 5 minutes.

Optic nerve sheath thickness measurements of the cases were performed in the operating room using a ultrasonography device. Right and left optic nerve sheath diameters; 5 measurements were made before spinal anaesthesia, after spinal anaesthesia, at the 10th minute after tourniquet inflation, 30th minute after tourniquet inflation, and after the tourniquet was deflated. The measurements were recorded in millimetres. In the first 24 hours postoperatively, it was recorded whether the cases had a headache and/or visual impairment.

Statistical Analysis

The data were analysed using IBM SPSS v23. The Pearson correlation coefficient is used, and results are presented as R and p values. The Friedman test was used for data not showing normal distribution as Repeated Measures Variance Analysis. Analysis results were presented as mean ± standard deviation and median (minimum-maximum) for quantitative data, and as frequency and percentage for categorical data. The level of significance was considered as p <0.050. For statistical significance p <0.05 is accepted.

Results

In this study, there were 26 female participants (86.7%) and 4 male participants (13.3%), 2 of them had ASA I and the others had ASA II.

Table 1. Descriptive statistics of quantitative data

	n	Mean ± S. Deviation	Median (Minimum - Maximum)
Age	30	66.50 ± 8.40	66.5 (52 - 82)
Height	30	160.27 ± 9.15	159 (150 - 185)
Weight	30	80.70 ± 13.36	78 (55 - 110)
BMI	30	31.76 ± 6.56	31.43 (19.03 - 46.67)
Operation Duration (min)	30	53.40 ± 12.51	52 (36 - 80)
Tourniquet Duration (min)	30	52.33 ± 12.99	50 (35 - 80)
Tourniquet Pressure (mmHg)	30	330.67 ± 21.64	335 (300 - 360)

The average was 66.5 years old, 160.27 cm tall, 80.07 kg, 31.76 BMI, 53.4 minutes of surgery, 52.33 minutes of tourniquet time, and 330.67 mmHg of tourniquet pressure (Table 1).

Table 2 shows the correlation between BMI, operation time, tourniquet time, tourniquet pressure, and measured optic nerve sheath diameter over time.

Table 2. The correlation between BMI, operation time, tourniquet pressure, and measured optic nerve sheath diameter

		BMI		Operation Duration min		Tourniquet Duration min		Tourniquet Pressure	
		r	p	r	p	r	p	r	p
Right	Pre-Spinal Optic Diameter	0.295	0.113	0.159	0.402	0.152	0.421	-0.139	0.465
	Post-Spinal Optic Diameter	0.269	0.150	0.211	0.263	0.221	0.241	-0.035	0.854
	After Tourniquet 10 min	0.150	0.428	0.286	0.125	0.309	0.097	-0.013	0.947
	After Tourniquet 30 min	0.201	0.287	0.264	0.159	0.269	0.151	0.132	0.487
	After Tourniquet Deflation min	0.206	0.276	0.088	0.645	0.098	0.608	0.155	0.414
Left	Pre-Spinal Optic Diameter	0.266	0.156	-0.009	0.964	0.010	0.958	-0.150	0.428
	Post-Spinal Optic Diameter	0.294	0.115	0.182	0.336	0.214	0.257	-0.068	0.723
	After Tourniquet 10 min	0.186	0.324	0.263	0.161	0.306	0.100	-0.018	0.924
	After Tourniquet 30 min	0.192	0.310	0.285	0.127	0.295	0.114	0.002	0.992
	After Tourniquet Deflation 5 min	0.206	0.274	0.068	0.720	0.080	0.675	0.119	0.531

r: Pearson correlation coefficient

BMI, operation time, tourniquet time, tourniquet pressure, and assessed optic nerve sheath diameter did not significantly correlate with one another statistically. ($p>0.050$).

Table 3. A comparison of the values for the optic nerve sheath diameter on the right and left sides

		Mean ± Standard Deviation	Test Statistics	p
Right Optical Diameter	Pre-Spinal	5.3 ± 0.003^{a}	50,201	<0.001*
	Post-Spinal	5.5 ± 0.004^{b}		
	After Tourniquet 10 min	5.7 ± 0.004^{c}		
	After Tourniquet 30 min	5.8 ± 0.004^{d}		
	After Tourniquet Deflation 5 min	6 ± 0.004^{e}		
Left Optical Diameter	Pre-Spinal	5.3 ± 0.003^{a}	102,359	<0.001**
	Post-Spinal	5.5 ± 0.003^{b}		
	After Tourniquet 10 min	5.6 ± 0.004^{c}		
	After Tourniquet 30 min	5.8 ± 0.004^{d}		
	After Tourniquet Deflation 5 min	5.9 ± 0.005^{e}		

*Repeated analysis of variance; **Friedman test; a-e There is no difference between values with the same letter.

While changes in right and left side optic nerve sheath diameter measurements over time were statistically significant, there was no statistical difference between right and left side optic nerve sheath diameter measurements taken at the same time (Table 3). Figure 1 depicts the linear increase in optic nerve sheath diameter.

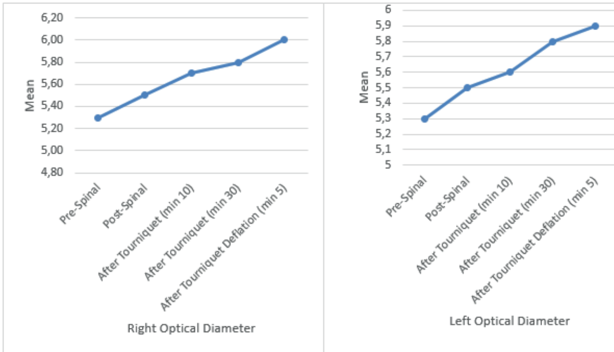

Figure 1. Optic nerve sheath diameter values obtained on the right and left side according to time.

There were no cases of headache or visual impairment in the first 24 hours after surgery.

Discussion

Non-invasive methods are more important than invasive methods for detecting intracranial pressure. Ocular ultrasound stands out among non-invasive methods because it is a practical bedside measurement. In our study, we measured the diameter of the optic nerve sheath using ultrasound and found that it increased after spinal anaesthesia, tourniquet inflation, and tourniquet deflation.

In the study of Dubost et al. (10), pregnant patients with preeclampsia and without preeclampsia were taken into a caesarean section with spinal anaesthesia. Optic nerve sheath diameter values were found to be above 5.8 mm in approximately 20% of patients with preeclampsia in the postoperative period. Moreover, they monitored preeclamptic patients for 7 days postoperatively and found that optic nerve sheath diameter was significantly higher compared to normal pregnant women. At the same time, this study evaluated the incidence of headache, one of the neurological symptoms of preeclampsia, and the headache was observed in about 31% of patients. In our study, the headache was followed up as neurological symptoms, but we did not have any patients with headaches in the postoperative period. In our study, spinal anaesthesia was applied, and the tourniquet was used. The optic nerve sheath diameters exceeded 5.8 mm after the tourniquet was deflated. The high incidence of headache in the cases of Dubost et al. may be related to preeclampsia causing headaches secondary to hypertension.

Besir et al. (11) measured the optic nerve sheath diameters of patients who developed post-spinal headache after spinal anaesthesia (n=20) and patients who did not develop headache (n=20) under the guidance of USG. Optic nerve diameters were significantly higher in the group with a headache. The authors also stated that there was a correlation between headache severity and optic nerve diameter length. Our study results are consistent with the study results of Besir et al. We did not find any complaints of headache in our clinical observations, however, we found that our optic nerve diameters increased after spinal anaesthesia and the use of a tourniquet.

Wang et al. (12) reported that there was a relationship between optic nerve sheath diameter and body mass index in healthy individuals in a study that included 230 people. However, in a larger-scale study by Kim DH et al. (13), no significant relationship was found between optic nerve sheath diameter and body mass index. In our study, no significant relationship was found between body mass index and optic nerve sheath diameter.

In a meta-analysis by Schroeder et al. (14), which included 39 studies in which optic nerve sheath diameter was measured by transorbital sonography, the mean age of patients was 36.1 years, and 44.4% of patients included in the study were female. In a similar study by Kim et al. (13), the mean age was 21.4 ± 1.9 years and 90% of the participants were male. In the study by Goereset al. (15), the mean age was 29.3 years, and 54.2% of the patients were female. In our study, the mean age was 66.5±8.4 years, and 86.7% of the patients were female. The fact that the age distribution is older than the literature in our study constitutes a better sample. In addition, degenerative knee diseases are more common in women as they work as agricultural workers in the Black Sea region of our geographical region. Our discrepancy with the literature data is due to the characteristics of our geographic region.

Optic nerve sheath diameter may be affected by factors such as the experience of the anaesthesiologist performing the measurement, the quality and resolution of the device, and the cooperation of the study participants (16). In our study, optic nerve sheath diameter measurements with USG were made by an experienced anaesthesiologist. The measurements were always performed by the same person, and the measurements were performed twice for both the right and left eyes and the averages were taken.

In the study by Ji-Yeon Kim et al. (17), EtCO2 values of patients under general anaesthesia decreased from 40 mmHg to 30 mmHg by applying hyperventilation for 10 minutes, and sonographic measurement of optic nerve sheath diameter in patients was performed at both EtCO2 values. It has been observed that there is a significant difference in the diameter value between the two measurements, and it has been shown that the effect of the change in EtCO2 value on the intracranial pressure can be instantly monitored by measuring the optic nerve sheath sonographic diameter. This study reports a result that can improve our clinical practice in terms of showing that instant changes can be monitored. In our study, we detected instantaneous changes with measurements made before spinal anaesthesia, after spinal anaesthesia, at the 10th and 30th minutes after the tourniquet, and the 5th minute after the tourniquet deflation. USG-guided optic nerve sheath diameter measurement is a safe non-invasive method that can detect even instantaneous changes in intracranial pressure.

The optic nerve is the white matter bundle of the central nervous system. There is a direct connection between the subarachnoid area of the optic nerve and the chiasmatic cistern of the brain. This connection allows the free movement of CSF between both areas. When intracranial pressure increases, CSF flows into the perineural subarachnoid space and the pressure around the optic nerve increases. This results in enlargement of the dural sheath and an increase in optic nerve sheath diameter (18). This has been proven in the experimental studies. It was found that an increase of intracranial pressure by 1 mm Hg will increase the diameter of the optic nerve sheath by approximately 0.0034 mm. In an experimental study conducted on Yorkshire pigs, a linear relationship was found between optic nerve sheath diameter and increased intracranial pressure (19). In our study, we observed a linear increase in optic nerve sheath diameter after spinal anaesthesia and tourniquet use.

Studies have reported that optic nerve sheath diameter measurement can be used not only to diagnose patients with increased intracranial pressure but also to monitor the effectiveness of treatment. Ertl et al. (21) stated in their study conducted in patients with hydrocephalus that the diameter of the optic nerve sheath increased due to the increased CSF fluid and that the optic nerve diameter measured after the CSF was drained was significantly lower.

There are some limitations of our study. First, the first limiting factor of our study is the narrow population. The second limiting factor is that most of the patients included in the study were female. The third limiting factor is that since our study did not have a control group, it could not be fully evaluated whether spinal anaesthesia influenced optic nerve diameter. Our study was able to examine whether the optic nerve sheath diameter elevations observed at certain time intervals had any intracranial impact in the postoperative period using cognitive assessments. The fact that we did not make any cognitive evaluation in our study limits our study.

In conclusion, our study demonstrated that the use of tourniquets in spinal anaesthesia and orthopaedic surgery increases intracranial pressure. Increased intracranial pressure increases the diameter of the optic nerve sheath. The fact that we found no headache or visual disturbance in any of our patients indicates that the increase in intracranial pressure during spinal anaesthesia and tourniquet use is clinically tolerable. However, in high-risk patients who may be sensitive to increased intracranial pressure, the duration of tourniquet use can be shortened by measuring the perioperative optic nerve sheath diameter. The measurement of optic nerve sheath diameter is a non-invasive and successful technique that can be used safely in the diagnosis and monitoring of increased intracranial pressure. We believe that anaesthesiologists should pay more attention to the measurement of optic nerve sheath diameter in clinical practice.

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