

Evaluation of Retrobulber Blood Flow of Primary Angle Glaucoma and Normal-tension Glaucoma with Color Doppler Ultrasonography Parameters

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ABSTRACT

Objective: Primary open angle glaucoma (POAG) is an important cause of blindness. Evaluation of retrobulbar hemodynamic may be helpful in determining the progression of POAG and normal tension glaucoma (NTG). In this study, we examined flow rates and resistivity indices of retrobulbar arteries by color Doppler ultrasonography (CDUS) in patients with POAG and NTG.

Material and Methods: Thirty POAG cases and 10 NTG cases were introduced into the study. In addition, 15 normal subjects were included as a control group. The measurements were performed for ophthalmic (OA), central retinal (CRA) and posterior ciliary arteries (PCA) in all groups.

Results: In both study groups, end diastolic velocity (EDV) values were significantly decreased and resistivity indices (RI) were significantly increased in CRA and PCA than to be in the control group. Their peak systolic velocities (PSV) were also decreased when compared with the control group, however, the differences were not statistically significant. There were no statistically significant differences in retrobulbar blood flow between the two glaucoma groups.

Conclusion: This study showed that changes of retrobulbar blood flow in POAG and NTG diseases may play a crucial role in glaucomatous optic nerve damage and color CDUS is an appropriate noninvasive imaging method in clinical follow-up of such patients.

Keywords: Color Doppler ultrasonography, normal tensional glaucoma, primary open angle glaucoma

ÖZ

Primer açık açılı glokom ve normal basınçlı glokomda renkli doppler ultrasonografi parametreleri ile retrobulber kan akımının değerlendirilmesi

Amaç: Primer açık açılı glokom körlüğün önemli nedenlerinden biridir. Retrobulber hemodinaminin değerlendirilmesi primer açık açılı glokom ve normal tansiyonlu glokomda progresyonu tesbit açısından faydalı olabilir. Bu çalışmada primer açık açılı glokom ve normal tansiyonlu glokom hastalarında renkli Doppler ultrasonografi ile retrobulber arterlerin akım hızlarını ve rezistivite endekslerini inceledik.

Gereç ve Yöntem: Çalışmaya 30 primer açık açılı glokom, 10 normal tansiyonlu glokom olgusu dahil edildi. Kontrol grubu 15 normal bireyden oluşmaktaydı. Ölçümler oftalmik, santral siliar ve posterior siliar arterlerden yapıldı.

Bulgular: Kontrol grubu ile kıyaslandığında her iki glokom grubunda santral retinal arter ve posterior siliar arter diastol sonu hız değerlerinde anlamlı azalma ve rezistivite endeksi değerlerinde anlamlı artış tespit edildi. Tepe sistolik hız değerlerinde ise istatistiksel olarak anlamlı olmasa da kontrol grubuna oranla azalma tespit edildi. Heriki glokom grubu arasında yapılan karşılaştırmada retrobulber kan akım değerlerinde istatistiksel olarak anlamlı fark elde edilmedi.

Sonuç: Çalışmamız primer açık açılı ve normal tansiyonlu glokom hastalıklarında ortaya çıkan retrobulber kan akım değişikliklerinin glokomatöz optik sinir hasarında önemli rol oynayabileceğini ve renkli Doppler ultrasonografinin bu tür hastaların klinik takibinde uygun bir non invaziv görüntüleme yöntemi olduğunu gösterdi.

Anahtar kelimeler: normal tansiyonlu glokom, primer açık açılı glokom, renkli Doppler ultrasonografi

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Introduction

Primary open angle glaucoma (POAG) is an important reason to cause blindness (1). Capillaries that cause optic nerve ischemia in the glaucomatous intraocular pressure result in an increase in optical nerve damage through microinfarction and loss of potential visual field. POAG and normal tension glaucoma (NTG) are a group of diseases of unknown etiology with multifactorial causes. Inheritance and some environmental factors may be involved in etiopathogenesis and they can result in visual loss if untreated (2).

The progression of injury of optic nerve head in NTG and POAG patients has brought about the perfusion properties of the optic nerve head. To evaluate retrobulbar blood flow, various methods have been developed. by color Doppler ultrasonography (CDUC) is a noninvasive, easily applicable, reproducible and comparable method (3).

In this study, we evaluated retrobulbar vasculature with CDUC parameters in POAG and NTG patients and investigated the pathological changes. We tried to reveal the role of CDU on pathophysiology and diagnosis of these diseases and in the clinical follow-up of these patients.

Materials and Methods

This study was prospectively performed in the Department of Radiology of Vakif Gureba Hospital. An ethical approval was taken from the local ethics committee.

Forty glaucoma patients, admitted to the radiology clinic within 6 months, were evaluated.

The diagnosis of POAG was made according to the following criteria in the Department of Ophthalmology of our hospital:

1. Glaucomatous optic nerve head appearance;
2. In the repeated visual field tests, the local visual field losses areas were normal and no complaints regarding the visual field were present;
3. Intraocular pressure higher than 21 mm Hg in repeated periodic measurements.

In all of the NTG patients, visual field deficits and glaucomatous optic disc findings were present, and the intraocular pressure was below 21 mmHg.

The patients whose carotid arteries were narrowed over than 70% in carotid CDUS examination were excluded from the study to exclude possible changes in retrobulbar blood flow.

The rate of presence of hypertension was not significantly different in the glaucoma groups.

All patients in the POAG and NTG groups were evaluated by CDUS 20 days after the drugs were discontinued in order to prevent any possible change in retrobulbar blood flow for the drugs used to treat topical beta-blocker therapy.

Total 55 cases were included in the study, 15 of them were in the normal control group, 30 were in the POAG group and 10 were in the NTG group. The age and gender distribution of the groups were given in Table 1.

To investigate the retroorbital blood flow, Toshiba SSH 140-A Color Doppler device was used in the Department of Radiology of our hospital. All studies were performed using a 7.5 mH linear transducer. Right and left eyes were examined separately.

Color Doppler examination was performed in supine position. The eyes were closed. The probe was placed on top of the eyelid with gel applied to prevent artifacts from moving and applying pressure to the eye. Work began in the transverse plane for optimum visualization of the orbital vessels. The probe was then angled to fit the longest axis of the vessel that could be examined for spectral analysis.

In the analysis of each vessel, the spectral evaluation (the three consecutive waveforms of the same shape, the strongest signal obtained) was chosen as the correct spectral sample.

To examine the ophthalmic artery, the "sampling interval" (the selected segment of the vessel lumen width over the transmitted sound beam for spectral analysis) was applied immediately to the nasal side of the optic nerve in where it crossing the ophthalmic artery. The sample volume (4-6 mm)

Table 1: Age and gender distribution of patients of normal control, primary open angle glaucoma and normotensive glaucoma groups.

	Normal	POAG	NTG
Number	15	30	10
Gender (F/M)	9/6	20/10	6/4
Age	55±6	58±8	54±6

POAG: Primary open-angle glaucoma NTG: Normal tensional glaucoma

was placed in the ophthalmic artery lumen that's visualized 25-30 mm posterior to the eye globe. And the spectral analysis was performed when the Doppler angle was about 30-60 degrees (4) (Figure1).

Nasal and temporal short PCAs were visualized on the nasal and temporal sides of the optic nerve shadow. In this study, we chosed to obtain spectral analysis of only temporal

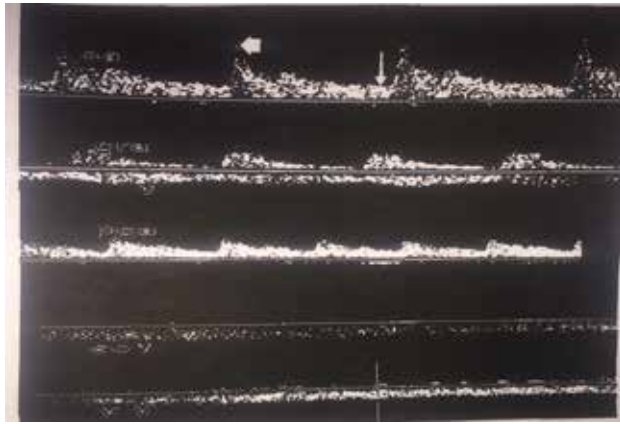


Figure 1: Spectral waveforms of orbital vascular structures
 OA: ophthalmic artery, CRA: central retinal artery,
 PCA: posterior ciliary artery, SOV: superior ophthalmic artery,
 VV: Veins of vortex

short PCA according to the theory by Hayreh et al. (5,6). For the measurements of this artery, the sampling interval was 1 mm and the Doppler angle was 20-30 mm.

For each vessel, end-diastolic velocity (EDV), peak systolic velocity (PSV) and resistive index (RI) were calculated.

Not normally distributed data were compared with chi-square test and the normally distributed data were analyzed by Student's t tests, and the difference if the p value<0.05 considered as statistically significant.

Results

There was no statistically significant difference in terms of gender and age between the groups.

We found our study to be safe in terms of reproducibility (Table 2) because the PSV and the RI of the vessels examined in normal subjects showed a coefficient of variation of 14%. The RIs of all three vessels showed a constant coefficient of variation, and the coefficient of variation obtained from the EDV was about twice that of the PSV.

Values calculated for the same vessels are widely presented in patients with POAG and NTG. The values of the measurements were given in Table 3.

Table 2: Coefficients of variation of 3 vessels examined RI: (

Speed and RI Change %	OA	CRA	PCA
Peak systolic speed	13	14.3	13.8
End-diastolic speed	27	23	27
Resistivity Index	9.3	10.4	12.7

OA: Ophthalmic artery, CRA: Central retinal artery, PCA: Posterior ciliary artery

Table 3: Mean PSV, EDV and RI values found in NTG and POAG groups

		Speed (m/s)	OA	CRA	PCA
R I G H T	NTG n=10	PSV	0.43±0.12	0.12±0.02	0.09±0.02
		EDV	0.11±0.04	0.03±0.01	0.03±0.09
		RI	0.70±0.02	0.75±0.06	0.70±0.04
	POAG n=30	PSV	0.44±0.13	0.12±0.03	0.09±0.02
		EDV	0.12±0.03	0.02±0.01	0.02±0.08
		RI	0.72±0.04	0.76±0.06	0.71±0.07
L E F T	NTG n:10	PSV	0.44±0.14	0.12±0.03	0.09±0.02
		EDV	0.12±0.03	0.02±0.01	0.03±0.92
		RI	0.70±0.06	0.76±0.06	0.70±0.05
	POAG n:30	PSV	0.42±0.015	0.11±0.03	0.08±0.02
		EDV	0.12±0.03	0.02±0.01	0.03±0.09
		RI	0.72±0.04	0.76±0.09	0.74±0.09

PSV: Peak systolic velocity; EDV: End-diastolic velocity, RI: Resistivity index; POAG: Primary open angle glaucoma; NTG: normal tensional glaucoma

When the POAG group was compared with the normal group, the mean EDVs of the CRA and PSA were significantly lower and the mean RIs were significantly higher ($p < 0.05$). The mean PSVs of CRA and temporal short PCA were significantly lower ($p < 0.05$). There was no significant difference in the PSV, the EDV and the RI measurements of the OA in the POAG group than measurements of the normal group.

The mean PSV and EDV of the CRA in NTG group were significantly lower than the normal group. The mean EDV of the temporal short PCA was significantly lower. The RI measurements at CRA and temporal short PCA were found to be higher than normal group measurements. The mean PSV and the mean EDV of the OA in the NTG group were lower than to be in the normal group, but the difference was not statistically significant.

Statistical comparison between the POAG group and the NTG group showed no significant difference in the mean EDV and the RI of OA and CRA. In the POAG group, the EDV of the temporal short PCA was not statistically significant, although it was lower when compared with the NTG group ($p = 0.625$).

The mean EDV and RI of the OA were not statistically significant between two glaucoma groups.

In summary, the PSV and the EDV of the CRA and temporal short PCA were significantly lower in the POAG and the NTG groups compared to normal subjects. However, the RI was significantly increased in both glaucoma groups compared to the normal group. The measurements of the OA were not significantly different between all three groups.

Discussion

In this study, generally accepted vascular parameters were investigated in the patients with POAG and NTG. In the evaluation of the CRA and the short PCA, decrease of the EDV and increase of the RI values in the POAG and the NTG groups were notable. In some studies, decrease in the PSV measurements in these vessels was observed, but decrease in the EDV values was more striking (7). In some studies, the OA assessments showed a decrease in the EDV and an increase in the RI (8). Although some early studies reported a decrease in the PSV in recent years (4), Kaiser et al. Reported, in particular, that there is not a statistically significant change in the PSV.

Therefore, it is difficult to clearly analyze the significance of the changes in the parameters investigated in this study.

The decrease in EDV and the increase in RI are indicative of the increase in current flow. Changes in the diastolic flow resistance are more important than systolic flow. Various factors such as increased intraocular pressure, vasoconstriction, or vasospasm can increase the resistance in the flow direction. Tribble et al. (9) showed that these hemodynamic changes cause chronically increased intraocular pressure and the decrease in the EDV and the increase in the RI were linked to the increase of pCO_2 . Harris et al. (2) showed the role of vasospasm in at least one subgroup of patients with glaucoma. The reason for elevation of the PSV in untreated POAG patients is unclear. The PSV is correlated with an increase in intraocular pressure (4).

In the study conducted by Nemeth et al. (10), orbital CDUS flow measurements in glaucomatous patients were based on the variation coefficient (COV). The RI COV: PSV COV was 6.4% -13.2%, and systolic acceleration time COV: diastolic-end flow pulsatility index (COV) was 10%-20%.

According to Nemeth et al. (10), the RI is the most useful parameter. It can be measured as peak systolic flow rate measurement. End diastolic flow measurement is less useful in all vessels. From this aspect, this parameter should be applied to relatively larger vessels.

In our study, a low coefficient of variation was obtained in the PSVs and RIs, and among the retrobulbar arteries, it is the CRA which is highly reproducible. The reason of this is the course of the CRA in the optic nerve. But measured blood flow rates should not be confused with blood flow volumes. The blood flow volume of a vessel is obtained from the multiplication of the flow velocity and the transverse cross-sectional area of the vessel. According to the "Poiseuille law", the flow volume is proportional to the fourth force of the diameter of the vessel (4). Despite this limitation, the vessel flow velocity is most likely an indication of the blood flow volume of that vessel.

The anatomical course of the CRA in the optic nerve makes it easy to find and to measure, therefore the accuracy of the measurements made from this vessel is high, but the same thing may not always be valid for PCA. Anatomical course of short PCA is very tortuous (11). For this reason, it is not easy to follow the direction of these vessels and to determine the Doppler angle. Therefore, the RI which is independent of the Doppler angle in short PCA should be accepted as the most reliable measurement parameter (4).

Galassi et al. (12) reported that RIs of ciliary arteries were increased in glaucoma patients. Tribble et al. (9) reported a decrease in the RI and an increase in the end-diastolic flow of CRA and PSA in glaucomatous trabeculectomy patients. Simon et al. (13) found a lower mean retrobulbar blood flow velocity and a higher RI in the POAG patients. Harris and colleagues (14) reported that selective beta blockers cause an increase in the EDV and a decrease in the RIs of CRA and PCAs in patients with NTG. According to other researches, a decrease in flow rate with increasing age was recorded (15).

This study showed that there was a significant difference between glaucoma patients and normal group, but it still is not possible that CDUS imaging may be a primary diagnostic method in the patients with glaucoma with these findings. Ocular CDUS imaging is a useful diagnostic method for explaining the pathogenesis of glaucoma. The clinical Doppler ocular imaging has begun to have a very important place in clinical aspects, as well as for its contribution to glaucoma

pathogenesis. A general tendency towards CDUS is seen in the patients with glaucoma. This method enables non-invasive and painless examination of glaucoma patients. This approach can provide us with very important information about the success rate of the medication or applied trabeculectomy and thus the prognosis of the disease.

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