Changes in the Retrobulbar Arterial Circulation after Decrease of Elevated Intraocular Pressure in Patients with Primary Open Angle Glaucoma

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INTRODUCTION

Primary open angle glaucoma (POAG) is a common optic neuropathy that appears to have a multifactorial origin. A central debate has focused on the potential disordered perfusion of the optic nerve head [1].

Elevated intraocular pressure (IOP) has been defined as the most important risk factor in the pathogenesis of glaucomatous optic neuropathy. Over the past several decades evidence has grown that vascular factors also contribute to the pathogenesis of glaucoma [2-5]. Numerous techniques have been developed in an attempt to quantify ocular blood flow in the different ocular vascular beds [3, 4].

The observation of the retrobulbar circulation after IOP elevation in POAG patients has been proposed as a pathogenic factor in glaucoma [1].

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SUMMARY

Introduction

An altered perfusion of the optic nerve head has been proposed as a pathogenic factor in glaucoma.

Objective

To evaluate changes of haemodynamic parameters in the retrobulbar arterial circulation after a decrease of elevated intraocular pressure (IOP) in patients with primary open angle glaucoma (POAG).

Methods

Twenty-six patients were examined, 14 men and 12 women, 21 up to 50 years old and 5 below, all with previously diagnosed and treated POAG, and all examined at the Eye Clinic, Clinical Centre of Serbia. IOP was measured both with a Goldmann aplanation tonometer and dynamic contour tonometer. Central corneal thickness was measured with ultrasound pachymeter. Imaging of the retrobulbar arterial circulation by colour Doppler was performed at the Neurology Clinic, Clinical Centre of Serbia. It involved measuring of haemodynamic parameters of the ophthalmic artery, central retinal artery, and posterior ciliary arteries. Peak systolic velocity (PSV) and end-diastolic velocity (EDV) were measured, and resistive index (RI) and pulsatility index (PI) were calculated.

Results

Haemodynamic arterial parameters PSV and EDV in the ophthalmic and central retinal artery after decrease of IOP were lower, while RI and PI were higher. In the posterior ciliary arteries PSV, EDV and PI were lower, and RI was higher.

Conclusion

Changes of the retrobulbar arterial circulation after elevated IOP in POAG patients are important for approach and treatment, while the role of vascular factors in the supplement of the optic disc neuroretinal rim could be a key for progression backlash of glaucoma and the radix of neuroprotection.

Keywords: elevated intraocular pressure; retrobulbar arterial circulation; primary open angle glaucoma
dent. To relate the systolic and diastolic velocities to each other, a ratio, the resistive index (Pourcelot’s index), is used [10]. This ratio is angle-independent and is regarded as a good method to quantify the vascular resistance of the circulation, particularly in the cephalic region. The velocity and resistive index have been studied in the ophthalmic artery, the central retinal artery, and the short posterior ciliary arteries of patients with glaucoma. These measurements have been shown to be reproducible [11] and investigators have followed up by comparing disease populations and normal subjects to ascertain the basic findings of CDI within these groups.

**OBJECTIVE**

The aim of this study was to evaluate changes in the retrobulbar arterial vessels circulation before and after decrease of the elevated IOP in patients with POAG.

**METHODS**

The research followed the tenets of the Declaration of Helsinki, and informed consent was obtained after explanation of the nature and possible consequences of the study.

All patients were examined at the Institute of Eye Diseases and at the Institute of Neurology, Clinical Centre of Serbia, Belgrade, between December 2009 and March 2010. All patients were obtained from the General Ambulatory Ophthalmology Unit.

We examined 26 patients, 14 men and 12 women, 21 up to 50 years old and 5 below, all with diagnosed and treated POAG. All patients had elevated IOP (>25 mm Hg) in one (18 patients) or both eyes (8 patients). IOP was measured both with a Goldmann Aplanation tonometer (GAT) and Dynamic Contour tonometer (DCT) developed by Swiss Microtechnology AG (Port, Switzerland). Central corneal thickness was measured by ultrasonic pachymetry. Imaging of the retrobulbar arterial circulation using CDI was performed at the Neurology Clinic of the Clinical Centre of Serbia. After a decrease (compensation, IOP<20 mm Hg) of the elevated IOP by medication (21 patients) or surgery (5 patients) we repeated Goldmann and Dynamic contour tonometry and CDI of the retrobulbar arterial vessels.

Haemodynamic parameters were measured in the ophthalmic artery (OA), central retina artery (CRA), and posterior ciliary arteries (PCA). PSV and EDV were measured, and resistive index (RI) and pulsatility index (PI) were calculated using ultrasound machine Aloka Alpha 10; 7.5–10 MHz, linear probe.

**RESULTS**

IOP measurements, before and after compensation, had normal data distribution. In the ophthalmic artery (Table 1) and in the central retinal artery (Table 2), PSV and EDV decreased after IOP compensation, but RI and PI increased. In the posterior ciliary arteries, PSV, EDV and PI decreased and only RI increased (Table 3). Statistical significance appeared only in RI after the IOP decrease (Table 4).

**DISCUSSION**

Our study confirmed that retrobulbar circulation changed after IOP lowering in the POAG patients. PSV and EDV velocities were decreased in all the observed arterial retrobulbar vessels (OA, CRA and PCA) and RI and PI were increased in OA and CRA; RI increased in CRA also, but PI in CRA decreased. Our results are in an agreement with other studies.

Various studies have compared the vascular parameters in POAG and normal tension glaucoma with those of normal control subjects.

**Statistics**

Data are presented as mean value with standard deviation. Normal distribution and homoscedasticity of continuous variables were tested by means of the Kolmogorov-Smirnov test. Statistical evaluations were performed by running the SPSS/PC + software package (SPSS, Chicago, IL) on a personal computer. P values of less than 0.05 were regarded as statistically significant.

**Table 1. Relation between haemodynamic parameters in the ophthalmic artery after IOP compensation**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>r (mm Hg)</th>
<th>p</th>
<th>Δr</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSV I/II</td>
<td>0.44</td>
<td>0.04</td>
<td>0.001</td>
</tr>
<tr>
<td>EDV I/II</td>
<td>0.23</td>
<td>0.16</td>
<td>0.11</td>
</tr>
<tr>
<td>RI I/II</td>
<td>0.16</td>
<td>0.21</td>
<td>0.27</td>
</tr>
<tr>
<td>PI I/II</td>
<td>0.05</td>
<td>0.17</td>
<td>0.71</td>
</tr>
</tbody>
</table>

Excluded criteria were: 1) narrow/closed angle on gonioscopy (grades 0, 1, and 2 using the Scheie classification); 2) astigmatism >2D or corneal abnormalities (such as oedema, scars, or dystrophy, which may prevent contour matching on the DCT); 3) history of intraocular surgery/previous refractive surgery.
Early studies of retrobulbar circulation in glaucoma patients reported a significant reduction in the EDV and an increase in the RI [12, 13, 14]. Galassi et al [13] also identified a reduced PSV in the OA in glaucoma patients as compared with normal subjects. A subgroup of patients with uncontrolled IOP showed significant reduction in EDV and an elevated RI in the CRA and PCA after IOP compensation.

Punjabi’s [15] study of retrobulbar circulation in glaucoma reported a significant reduction in the EDV and increase in the RI of the vessels of this region in patients with glaucoma.

Several studies support the idea that circulatory abnormalities represent risk factors for glaucoma [16]. With the use of Doppler ultrasound of the orbit, a non-invasive examination of the retrobulbar circulation is possible. Several studies using orbital CDI have revealed altered orbital haemodynamics in patients with glaucoma [17, 18].

The RI is a factor related to blood flow resistance in the vascular system downstream to the measurement point [19]. Akarsu and Bilgili [20] found lower EDV and higher RI in the posterior ciliary artery in open-angle glaucoma than in ocular hypertension.

As already known, the main blood supply of the anterior optic nerve derives from the posterior ciliary arteries [21]. Cheng’s study had controlled factors, which are known to affect ocular blood-flow velocity, such as IOP [22], age [8], systemic blood pressure [23], and anti-glaucoma medications [24]; therefore, they hoped to eliminate the effect of these variables and to give a more useful comparison between glaucoma and ocular hypertensive patients.

**CONCLUSION**

Changes in the retrobulbar arterial circulation after elevated IOP in POAG patients are of importance for approach and treatment, but the role of vascular factors in the supplement of the optic disc neuroretinal rim, could be a key for progression backlash of glaucoma and the radix of neuroprotection. CDI of the blood flow in the retrobulbar vessels is a valuable method in the diagnosis of the vascular mechanism in glaucoma.

**NOTE**

This work was presented at the Serbian National Congress in Subotica in September 2010, as a short oral presentation.

Крачак садржај
Увод Поремећена перфузија главе очног живца је патогенетски фактор код глукоме.
Циљ рада Циљ рада био је да се установи како се мења хемодинамски параметри у ретробулбарној артеријској циркулацији код кратког, градиентног и претежно појединог интраокулярног притиска код особа са органичним глаукомом отвореног угла.
Методе рада Истраживање је обухватало 26 испитаника (14 мушкараца и 12 жена), од којих је 21 пацијент био старији од 50 година, са претходно дијагноствованим и леченим притиском на ретробулбарном отвореном углу. Сви испитаници су проглашени на Клиники за очне болести КЦС, а потом су прегледани на Клиници за очне болести КЦС. Поред мерења ИОП код пацијената са органичним глаукомом отвореног угла, се измерили индекси резистентности (RI) и пулсатилност (PI).
Резултати Хемодинамски цирични параметри PSV и EDV код кратког, градиентног и претежно појединог интраокулярног притиска код особа са органичним глаукомом отвореног угла значајне су за приступ лечењу, док улога васкулярних фактора у искривљеном притиску код главе очног живца може бити неодржива у непрекинутом прогресисању. Клинички износ резултата је у потпуности зависио од градиентног интраокулярног притиска код особа са органичним глаукомом отвореног угла.