Resistive Index of Retrobulbar Ocular Vessels Increases in Glaucoma

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Purpose

Glaucoma is recognized as a leading cause of irreversible blindness in the developed world (1). Primary open-angle glaucoma is usually a bilateral illness although is not a symmetrical one. It is characterized by its onset in adulthood, elevated intraocular pressure (IOP), normal open angle, glaucomatous optic nerve damage and visual field defects. Nevertheless, it has been reported (2) that 16% of primary open-angle glaucoma patients presents IOP less than 22 mm Hg and that they are known as a primary open-angle glaucoma without an increased intraocular pressure.

Several studies in primary open-angle glaucoma without an increased intraocular pressure patients have shown that reduced retrobulbar blood flow velocities and resistivity index are increased in these patients. Nevertheless, retrobulbar vessels color Doppler imaging does not predict primary open-angle glaucoma (3). For a color Doppler imaging US correct study is necessary to know eye and orbit anatomy, in addition a good management of the US parameters is also needed (4).
Methods and Materials

A total of 7 patients with primary open-angle glaucoma, 3 patients with primary open-angle glaucoma and hypertension and 14 control subjects were included in this prospective study. Patients were asked about age, sex and clinical history. All patients signed a written informed consent form in accordance with the tenets of the Declaration of Helsinki. All controls had intraocular pressure below 20 mm Hg, optic disc considered non-glaucomatous in both eyes and normal visual fields. Measurements of only one eye of each patient were included in the analyses.

Important clinical history was arterial hypertension (is prevalent and is linked with blood flow) and diabetes (is prevalent and is linked with arterial hypertension). Patients between 18 and 90 years old were included. Patients with a history of systemic vasculopathies were excluded. Furthermore, patients with a history of trauma or ocular inflammations were excluded too.

Blood flow velocity was measured by means of Sonoline Antares (Siemens) using 10-5 MHz transducer. The transducer was applied gently to the closed eyelid using a coupling gel. The test was performed with undilated pupils. During the examination subjects were in the supine position with the head elevated at a 30º angle. The central retinal artery and short posterior ciliary artery were examined and mean values were calculated for Peak-systolic velocity (Pv), End-diastolic velocity (Ev) and resistive index (RI). All velocity measurements are in centimeters per second. The resistive index was calculated using the Pourcelot’s formula (Peak systolic velocity - End diastolic velocity/ Peak systolic velocity).

Statistical analysis was performed with SPSS 18 (PASW18). Variations in the scores of hemodynamic parameters between different groups (central retinal artery and short posterior ciliary artery) were examined with one way analysis of variance (ANOVA). When the null hypotheses was rejected Least Significant Difference (LSD) post hoc procedure was used.
Images for this section:

**Fig. 0:** Color Doppler imaging, blood velocity spectrum and quantitative parameters of short posterior ciliary arteries.

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Results

The results of the color Doppler imaging at the central retinal artery in patients with glaucoma, glaucoma and hypertension and control subjects are shown in table 1. The hemodynamic measurements taken at the central retinal artery revealed a Pv of 15.2 ± 5.2 cm/s in the normal subjects, 11.2 ± 3.6 cm/s, in the glaucomatous patients and 8.5 ± 2.6 cm/s in the glaucomatous and hypertension patients. The Ev was 4.0 ± 2.1 cm/s, 2.5 ± 1.2 cm/s and 2.4 ± 1.0 cm/s respectively (P 0.05). Finally RI in the control group was 0.74 ± 0.07 cm/s, 0.79+- 0.08 cm/s in the glaucomatous patients and 0.71 ± 0.11 cm/s in the glaucomatous and hypertension patients, these differences were not significant.

The mean Pv was found to be significantly lower (P 0.05) in glaucomatous and glaucomatous plus hypertension than in normal subjects while no significant differences in Pv were noted among glaucomatous and glaucomatous plus hypertension. The mean Ev was found to be significantly lower (P 0.05) in glaucomatous and glaucomatous plus hypertension than in normal subjects while no significant differences in Ev were noted among glaucomatous and glaucomatous plus hypertension. The RI did not differ significantly among the three groups.

The results of the color Doppler imaging at the short posterior ciliary arteries in patients with glaucoma, glaucoma and hypertension and control subjects are shown in table 2. The hemodynamic measurements taken at the short posterior ciliary arteries revealed a Pv of 15.9 ± 5.4 cm/s in the normal subjects, 13.2 ± 5.2 cm/s in the glaucomatous and 10.9 ± 3.2 cm/s in the glaucomatous and hypertension patients, these differences were no significant. The Ev was 5.6 ± 2.8 cm/s, 3.1 ± 2.6 cm/s and 3.8 ± 0.9 cm/s, respectively (P 0.05). Finally RI in the control group was 0.66 ± 0.09 cm/s, 0.76 ± 0.16 cm/s in the glaucomatous patients and 0.62 cm/s ± 0.05 cm/s in the glaucomatous and hypertension patients (P 0.05). The Pv did not differ among the three groups.

The mean Ev was found to be significantly lower (P 0.05) in glaucomatous than in normal subjects while no significant differences in Ev were noted among glaucomatous plus hypertension and normal subjects. The mean RI was found to be significantly higher (P 0.05) in glaucomatous than in normal subjects while no significant differences in RI were noted among glaucomatous plus hypertension and normal subjects.
**Table 1.** Color Doppler imaging at the central retinal artery in patients with glaucoma, glaucoma and hypertension and control subjects results.

<table>
<thead>
<tr>
<th></th>
<th>Patients</th>
<th>$P_v$</th>
<th>$E_v$</th>
<th>RI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>14</td>
<td>$15.2 \pm 5.2$</td>
<td>$4.0 \pm 2.1$</td>
<td>$0.74 \pm 0.07$</td>
</tr>
<tr>
<td>Glaucoma</td>
<td>14</td>
<td>$11.2 \pm 3.6$</td>
<td>$2.5 \pm 1.2$</td>
<td>$0.79 \pm 0.08$</td>
</tr>
<tr>
<td>Glaucoma + HT</td>
<td>6</td>
<td>$8.5 \pm 2.6$</td>
<td>$2.4 \pm 1.0$</td>
<td>$0.71 \pm 0.11$</td>
</tr>
<tr>
<td>$P$</td>
<td></td>
<td>$&lt;0.05$</td>
<td>$&lt;0.05$</td>
<td>N.S.</td>
</tr>
</tbody>
</table>

**Fig. 0:** Color Doppler imaging at the central retinal artery in patients with glaucoma, glaucoma and hypertension and control subjects results.

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Table 2. Color Doppler imaging at the short posterior ciliary arteries in patients with glaucoma, glaucoma and hypertension and control subjects results.

<table>
<thead>
<tr>
<th>Patients</th>
<th>Pv</th>
<th>Ev</th>
<th>RI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>14</td>
<td>15.9 ± 5.4</td>
<td>5.6 ± 2.8</td>
</tr>
<tr>
<td>Glaucoma</td>
<td>14</td>
<td>13.2 ± 5.2</td>
<td>3.1 ± 2.6</td>
</tr>
<tr>
<td>Glaucoma + HT</td>
<td>6</td>
<td>10.9 ± 3.2</td>
<td>3.8 ± 0.9</td>
</tr>
<tr>
<td>P</td>
<td>N.S.</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

Fig. 0: Color Doppler imaging at the short posterior ciliary arteries in patients with galucoma, glaucoma and hypertension and control subjects results.

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Conclusion

Glaucoma is an eye pathology whose etiology, traditionally, has been considered to consist in an elevated intraocular pressure. However, this etiology does not explain this pathology completely because the existence of patients with glaucoma but not with an elevated intraocular pressure (2).

Two main mechanisms have been considered. One suggests mechanical damage directly to the axons or small blood vessels by structural alterations at the lamina cribosa due to an increase in the intraocular pressure (2). The other one, known as the ischemic theory, suggests a primary problem in the optic nerve circulation as a result of localized organic changes in the blood vessels of the nerve (6) which is more evident in exfoliation glaucoma (7).

Color Doppler imaging examination showed that central retinal artery Pv and Ev are significantly lower in glaucomatous than in normal subjects. These results are similar to other studies (8) although in the present study significant differences in central retinal artery RI were found.

Color Doppler imaging examination showed that short posterior ciliary arteries Ev and RI have significant differences when glaucomatous and normal subjects are compared. Ev was found to be significantly lower in glaucomatous than in normal subjects and RI was found to be significantly higher in glaucomatous than in normal subjects. These results suggest that blood flow in the retinal central artery and in the posterior short ciliary arteries meets a higher resistance in glaucomatous than in normal subjects. These results are in a good agreement when compared with other studies previously reported (8).

In this study there is a controversy, glaucoma and hypertension group has significant differences in central retinal artery Pv and Ev but it doesn’t have significant differences in short posterior ciliary arteries Pv, Ev and RI among normal subjects. These results are not consistent with previously reported studies (8).

Open-angle glaucoma seems to be associated with a reduced retrobulbar blood flow velocities and an increase in the resistivity index. This result could be associated with ischemic theory.
References


