

# CHANGES OF OCULAR HAEMODINAMIC PARAMETERS ASSESSED BY COLOUR DOPPLER IMAGING IN GLAUCOMA PROGRESSION PATIENTS

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**Keywords:** colour Doppler imaging, open angle glaucoma, ocular blood flow, visual field progression

**Abstract:** Purpose: to find the existence of alterations in retrobulbar hemodynamics in patients with progressive glaucoma comparing with the patients with stable disease. Methods: 35 patients with open angle glaucoma (POAG) were included in the study. Eye checks were carried out for 24 months at an interval of four months which consisted in determining Tio, FO examination and computerized perimetry to determine disease progression. Also, color Doppler ultrasound was performed and systolic velocities were measured and enddiastolic ophthalmic artery (OA), central retinal artery (ACR) and posterior ciliary arteries (PCA). Resistivity index was calculated automatically by the device. Results: Among the 35 patients, 9 experienced disease progression through the evolution of perimeter deficits. Compared with patients with stable disease, patients with disease progression in the measurements showed a significant increase in Doppler resistance index (RI) in the ophthalmic artery - averaged 0.80 ( $p = 0.028$ ) and a low speed in the ophthalmic artery enddiastolic - average 2.32 cm / sec ( $p = 0.03$ ). Conclusion: In patients with primary open-angle glaucoma and progression of the disease, retrobulbar hemodynamic parameters measurements show a significant increase in vascular resistance and a decrease in ophthalmic artery enddiastolic velocity in ophthalmic artery.

**Cuvinte cheie:** ecografie doppler color, glaucom primar cu unghi deschis, fluxul sanguin ocular, progresia deficitelor de câmp vizual

**Rezumat:** Scop: de a găsi existența unei alterări în hemodinamica retrobulbară la pacienții cu glaucom progresiv față de pacienții cu boala stabilă. Material și metodă: 35 de pacienți cu glaucom primitiv cu unghi deschis (GPUD) au fost incluși în studiu. S-au efectuat controale oftalmologice timp de 24 de luni la un interval de 4 luni care au constat în determinarea Tio, examenul FO, și perimetrie computerizată în vederea determinării progresiei bolii. De asemenea, s-a efectuat ecografie doppler color și s-au măsurat vitezile sistolice și enddiastolice în artera oftalmică (AO), artera centrală a retinei (ACR) și arterele ciliare posterioare (ACP). Indicele de rezistivitate a fost calculat automat de aparat. Rezultate: Din cei 35 de pacienți, 9 au înregistrat progresie a bolii prin evoluția deficitelor perimetrice. Comparativ cu pacienții cu boala stabilă, pacienții cu progresie a bolii au prezentat în cadrul măsurătorilor doppler o creștere semnificativă a indicelui de rezistivitate (IR) în artera oftalmică – valoare medie 0,80 ( $p=0,028$ ) și o viteză enddiastolică scăzută în artera oftalmică – valoare medie 2,32 cm/sec ( $p=0,03$ ). Concluzii: La pacienții cu glaucom primar cu unghi deschis și progresie a bolii, măsurătorile parametrilor hemodinamici retrobulbari arată o creștere semnificativă a rezistențelor vasculare în artera oftalmică și o scădere a vitezei enddiastolice în artera oftalmică.

## INTRODUCTION

Vascular factors play an important role in glaucomatous optic neuropathy. There is growing body of evidence from clinical studies that retrobulbar circulation abnormalities are involved both in ethiopathogeny and visual field deficits in glaucoma patients.(1-3)

New technologies for ocular blood flow evaluation have been introduced to clinical practice but colour Doppler imaging has its strategic place and is particularly useful because of its low invasiveness and the reliability of its results.(4,5)

In primary open angle glaucoma several abnormalities of blood flow in the ophthalmic artery(OA), short posterior ciliary arteries(SPCAs) and central retinal artery(CRA) were reported(6-12)

Previous studies showed reduced perfusion of the optic nerve, retina and reduced blood velocities in retrobulbar vessels in normal tension glaucoma versus healthy controls.(13)The blood flow velocities of retrobulbar vessels have been correlated to functional defects in glaucoma and are

associated with interocular differences in asymmetric visual field defects(14-16).

At the base of this study is the ipotesis that glaucoma patients with compensated intraocular pressure and with normal systemic arterial blood pressure at wich exists a progression of visual field deficits, the risc factor is optic nerve perfusion alteration.

The value of haemodinamic assessment of retrobulbar vessels in detection of patients with high risk for glaucoma progression is still unknown.

## THE AIM OF THE STUDY

To find the existence of alterations in retrobulbar hemodynamics in patients with progressive glaucoma comparing to the patients with stable disease.

## MATERIAL AND METHOD

In our study we analyzed 35 glaucoma patients who met the inclusion criteria.

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## CLINICAL ASPECTS

All patients underwent a detailed ophthalmological examination including assessment of refractive error. Intraocular pressure was measured using Goldmann aplanation tonometry at each visit, at 4 months interval, and the same was repeated the visual field with the Humphrey Field Analyzer, using the 30-2 threshold full field program.

Color Doppler imaging of the retrobulbar vessels was performed using a 7,5 linear phased array transducer (Acuson Siemens) and we measured blood velocities -peak systolic and enddiastolic- of the Ophthalmic artery(OA), central retinal artery(CRA) and Short posterior ciliary artery(SPCAs).

The resistivity index (RI) –Pourcelot's ratio was calculated (PSV-EDV)/PSV after the determination of components from the velocimetric waves.

We establish inclusion and exclusion criteria to achieve an omogenous sample of the patients with primary open angle glaucoma(POAG) in our study.

**Inclusion criteria** are: clinical diagnosis of POAG, early/medium visual field defect,  $\geq 40$  years of age, visual acuity  $\geq 0,3$ , refractive error  $\pm 6D$ , TIO  $< 21$  mmHg with topical medication, willingness to participate at the study.

**Exclusion criteria:** any other form of glaucoma than POAG, any ocular pathology: diabetic retinopathy, macular degeneration, vascular disease of the retina; ocular surgery, laser, advanced medical disease : malignant HTA, diabetes.

Follow up visits were scheduled every 4 months during 2008-2010 .At each visit we performed biomicroscopic exam, ophthalmoscopy, tio determination by goldmann aplanation tonometry, and visual field measurement.

Progression occurred if an existing scotoma deepened or expanded or a new scotoma appeared.

### Statistical analysis

For the purposes of analysis only one randomly chosen eye was included and in glaucoma progression patients the eye with visual field progression was selected. When both eyes have had progression we randomly selected one eye.

For demographic and baseline characteristics of patients included in study we used descriptive statistics with mean and standard deviation.

An unpaired nonparametric test-Mann-Whitney was applied for comparisons between patients with progressive glaucoma and stable glaucoma.

Receiver Operating Characteristics (ROC) curves was constructed to assess the sensitivity and specificity of study variables for prediction of progression of glaucoma.

## RESULTS

Demographic characteristics of the eyes included in study are sintetized in Tabel 1.

After selection of patients with glaucoma progression, the variables were compared and we find statistical semnificative differences between resistivity index in ophthalmic artery(OA)( $p=0,02$ ) and end diastolic velocity in OA( $p=0,03$ ) in progressive glaucoma group compared with stable disease.-Table2

Data are expressed as mean  $\pm$  SD, Pio=intraocular pressure, RI=resistivity index, VED=end-diastolic velocity, VS=maxim systolic velocity, OA -ophthalmic artery, CRA-central retinal Artery, SPCAs-short posterior ciliary arteries.

We intended to analize obtained data throught prediction value of the studied parameters on the progression of the disease and we constructed ROC curves for the variables(fig1)

RI in OA(aria under the curve 0,748) and RI in SPCAs(aria under the curve 0,641) have a predictive value for glaucoma progression.

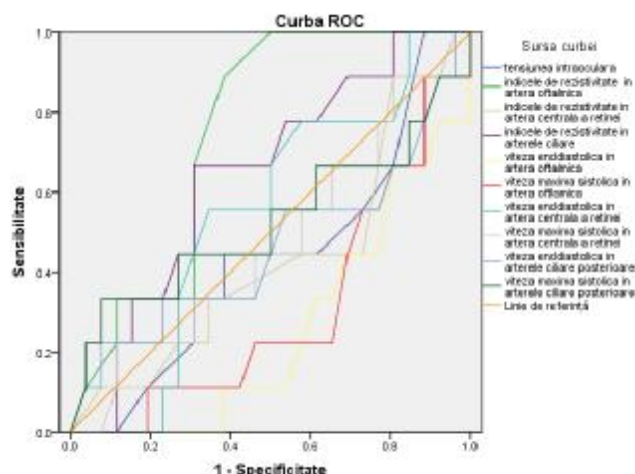
**Table no. 1. Demographic characteristics of the eyes included in the study**

		Nr. eyes = 35
		mean $\pm$ standard deviation
<b>Sex</b>		
Males		17
Females		18
<b>Age</b>		64 $\pm$ 10,48
<b>Intraocular pressure</b>		20,23 $\pm$ 4,36
<b>Rezistivity Index</b>	Ophthalmic Artery	0,77 $\pm$ 0,06
	Central retinal Artery	0,74 $\pm$ 0,09
	Short posterios ciliary artery	0,71 $\pm$ 0,07
<b>Peak systolic velocity</b>	Ophthalmic artery	17,32 $\pm$ 10,96
	Central retinal artery	12,20 $\pm$ 4,17
	Short posterior ciliary artery	12,31 $\pm$ 5,60
<b>End diastolic velocity</b>	Ophthalmic artery	3,84 $\pm$ 3,04
	Central retinal Artery	2,30 $\pm$ 1,36
	Short posterior ciliary artery	3,43 $\pm$ 1,62

**Table no. 2. Demographic characteristics from the two patients groups with progressive glaucoma/ stable glaucoma**

	progressive glaucoma (n=9)	stable glaucoma (n=26)	P
<b>Age(years)</b>	68,78 $\pm$ 8,01	62,35 $\pm$ 10,85	0,130
<b>Sex (m/f)</b>	6/3	11/15	-
<b>PIO</b>	19,66 $\pm$ 3,90	20,42 $\pm$ 4,56	.569
<b>RI OA</b>	0,81 $\pm$ 0,04	0,76 $\pm$ 0,06	.028
<b>RI CRA</b>	0,73 $\pm$ 0,09	0,74 $\pm$ 0,10	.544
<b>RI SPCAs</b>	0,74 $\pm$ 0,59	0,70 $\pm$ 0,07	.212
<b>VED OA</b>	2,32 $\pm$ 0,88	4,37 $\pm$ 3,34	.031
<b>PSV OA</b>	12,39 $\pm$ 3,45	19,03 $\pm$ 12,05	.086
<b>VED CRA</b>	2,98 $\pm$ 0,71	3,00 $\pm$ 1,14	.691
<b>PSV CRA</b>	11,89 $\pm$ 4,09	12,31 $\pm$ 4,28	.821
<b>VED SPCAs</b>	3,44 $\pm$ 2,06	3,43 $\pm$ 1,49	.734
<b>PSV SPCAs</b>	13,62 $\pm$ 7,68	11,86 $\pm$ 4,79	.821

**Figure no. 1. ROC curves**



## DISCUSSIONS

Based on the results presented, Doppler color imaging of the retrobulbar vessels parameters evidenced that glaucoma progression patients have RI in OA statistical semnificative high and end-diastolic velocity statistical semnificativ low compared with stable glaucoma patients.

## CLINICAL ASPECTS

One measure of blood supply to a tissue is the Pourcelor resistive index (1975), which can range from 0 to 1, with higher values corresponding to greater distal resistance (15).

In our study Ri in OA is an important haemodynamic parameter because it is a high reproducibility measurement comparative with Ri in SPCAs which can have a greater variability due to small and sinuous trajectory of these vessels.

Galassi et al (1992) and Nicoletta et al (1996) have published low velocities and high resistivity index in OA, CRA and SPCAs at glaucoma patients.

Our data are similar with Galassi and Drance published data: high RI and low EDV in OA at glaucoma progression patients (Galassi) and a reduced flow in OA (transcranial measurements) at progressive glaucoma patients compared with stable patients (Drance).

### CONCLUSIONS

Ocular blood flow alteration is a risk factor in glaucomatous optic neuropathy and our study evidence that OBF alteration is correlated with visual field deterioration in patients with glaucoma progression.

High resistivity index in ophthalmic artery may be a prognostic factor for progression of the disease in open angle glaucoma.

### REFERENCES

1. Fechtner RD, Weinreb RN. Mechanisms of optic nerve damage in primary open angle glaucoma. *Surv Ophthalmol.* 1994; 39:23-42. FULL TEXT | WEB OF SCIENCE | PUBMED
2. Drance SM. The vascular factors in glaucoma. In: Bucci MG, ed. *Glaucoma: Decision Making in Therapy.* New York, NY: Springer-Verlag; 1996:31-35.
3. Flammer J. To what extent are vascular factors involved in the pathogenesis of glaucoma? In: Kaiser HJ, Flammer J, Hendrickson PH, eds. *Ocular Blood Flow: New Insights Into the Pathogenesis of Ocular Diseases.* Basel, Switzerland: Karger; 1996:12-39.
4. Harris A. et al., *Atlas of ocular Blood Flow* Second edition, 2009, p66-71
5. Weinreb R., Harris A., *OCULAR Blood flow in glaucoma*, Consensus series-6, p21-23
6. Yamazaki Y, Miyamoto S, Hayamizu F. Color Doppler velocimetry of the ophthalmic artery in glaucomatous and normal subjects. *Jpn J Ophthalmol.* 1994; 38:317-321.
7. Galassi F, Nuzzaci G, Sodi A, Casi P, Vielmo A. Color Doppler imaging evaluation of optic nerve blood supply in normal and glaucomatous subjects. *Int Ophthalmol.* 1992;16:273-276. FULL TEXT | WEB OF SCIENCE | PUBMED
8. Galassi F, Nuzzaci G, Sodi A, Casi P, Cappelli S, Vielmo A. Possible correlations of ocular blood flow parameters with intraocular pressure and visual field alterations in glaucoma. *Ophthalmologica.* 1994;208:304-308. WEB OF SCIENCE | PUBMED
9. Rankin SJ, Walman BE, Buckley AR, Drance SM. Color Doppler imaging and spectral analysis of the optic nerve vasculature in glaucoma. *Am J Ophthalmol.* 1995;119:685-693. WEB OF SCIENCE | PUBMED
10. Nicoletta MT, Walman BE, Buckley AR, Drance SM. Color Doppler imaging and spectral analysis of the optic nerve vasculature in glaucoma: a comparative study of their retrobulbar blood flow velocity. *J Glaucoma.* 1996;5:308-310. WEB OF SCIENCE | PUBMED
11. Galassi F, Sodi A, Rossi MG, Ucci F. Results of color Doppler imaging in various types of glaucoma. In: Pillunat LE, Harris A, Anderson DR, Greve EL, eds. *Current Concepts on Ocular Blood Flow in Glaucoma.* The Hague, the Netherlands: Kugler Publications; 1999:119-127.
12. Galassi F, Sodi A, Ucci F, Harris A, Chung HS. Ocular haemodynamics in glaucoma associated with high myopia. *Int Ophthalmol.* 1998;22:299-305. FULL TEXT | PUBMED
13. Harris A, Sergott RC, Spaeth GL, Katz JL, Shoemaker JA, Martin BJ. Color Doppler analysis of ocular blood velocity in normal-tension glaucoma. *Am J Ophthalmol.* 1994;118:642-649. WEB OF SCIENCE | PUBMED
14. Rankin SJ, Drance SM, Buckley AR, Walman BE. Visual field correlations with color doppler studies in open angle glaucoma. *J Glaucoma* 1996; 5: 15-21.
15. Liu CJ, Chiou H-J, Chiang S-C, Chou JC, Chou Y-H, Liu J-H. Variations in ocular hemodynamics in patients with early and late glaucoma. *Acta Ophthalmol Scand* 1999; 77: 658-662.
16. Plange N, Kaup M, Arend O, Remky A. Asymmetric visual field loss and retrobulbar hemodynamics in primary openangle glaucoma. *Graefes Arch Clin Exp Ophthalmol* 2006; 244: 978-983.
17. Martinez et al Predictive value of colour doppler imaging in a prospective study of visual field progression in primary open-angle glaucoma. *Acta Ophthalmologica Scandinavica,* 2005;83:716-722.