

Color Doppler Ultrasound Evaluation of Optic Nerve Head Arteries in Young Black Africans with Primary Open-angle Glaucoma (POAG)

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Abstract

Background: Primary open-angle glaucoma (POAG) is a common cause of blindness. It is particularly common and severe in the black population, occurring in younger subjects.

Aim: The aim of this study was to investigate color Doppler ultrasound (CDU) characteristics of the arteries of the optic nerve head (ONH) in young black patient with POAG.

Method: a prospective descriptive and analytical study of the measures of the blood flow parameters of the arteries of the ONH by CDU, in a consecutive series of 30 black-Africans glaucomatous patients of both sexes, aged 18 to 45 years diagnosed positive for POAG.

Results: A female predominance with a sex ratio of 0.76 was noted. Intra ocular pressure (IOP) was normal in 60% in the right eye, 66.7% in the left eye, or 63.3% in both eyes. The Arterial peak systolic velocity (PSV) was normal in 53.3%, low (46.7%) for the ophthalmic artery (OA). No cases of increased PSV were recorded. The PSV was accelerated in 98.3% in the central retinal artery (CRA), and normal (33.3%) or accelerated (65%) in the paraoptic short ciliary artery (PCA). The correlation analysis between variations in PSV and IOP does not show a statistically significant relationship ($p > 0.05$) for the three arteries of the ONH. The resistive index (RI) were elevated in 11.7%, 70% and 45%, respectively in the OA, CRA and PCA. No case of decreased resistance was found for the three arteries. The correlation between RI and IOP also did not show a statistically significant correlation ($p > 0.05$).

Conclusion: CDU of the arteries of ONH in black origin young glaucomatous patients presents peculiarities. PSVs are low or normal in OA, with RI most often normal, while PSV are high or normal in CRA and PCA and RI high in the majority of cases.

Keywords: Color Doppler ultrasound; primary open-angle glaucoma; black-African.

Introduction

Primary open-angle glaucoma (POAG) is a chronic progressive anterior optic neuropathy characterized by visual field test alterations and pathological excavation of the optic nerve head (ONH) [1].

Glaucoma is the second leading cause of blindness in the United States of America [2]. In Africa, it is the second leading cause of blindness after cataract in rural areas [3]. According to the World Health Organization, more than 100 million people are suspected of glaucoma, more than 20 million suffer from it and more than 5 million are blind because of this condition [4].

The PAOG is called primitive, because there is no identifiable cause, even there are known risk factors, including African ethnicity or the black color of the skin and age. Indeed, it is the leading cause of blindness in American black [2]. Regarding the age, if in the white population PAOG is more common in the elderly, with an average age of 65.6 years in the study of Bresson-Dumont H. et al. [5] and 63.7 years in that of Martinez A. et al. [6]. In black African's, it predominates in a younger population, around 45 years [7, 8].

The pathophysiology of POAG is not clearly established. Hypo perfusion of the optic nerve, linked to microcirculatory abnormalities is considered to be one of the physiopathological factors. This hemodynamic factor has been cited by several studies as a risk factor and prognosis for POAG [9-14]. Most of the studies available focus on groups of glaucomatous subjects of high average age and Caucasian

origin [5, 6]. The objective of this study was to study the color Doppler ultrasound (CDU) characteristics of arterial vascularization in the ONH in young black patients with PAOG.

Method

A prospective, descriptive and analytical study was designed to analyze velocity parameters measured by CDU in the arteries of the ONH in glaucomatous patients. The study included in 30 patients aged from 18 to 45 years who were diagnosed positive with PAOG by an ophthalmologist based on ophthalmological arguments. The CDU was performed by the same operator to avoid inter-observer variations, by using the same ultrasound device (MINDRAY CD-60) equipped with a linear probe with Doppler-Color, to avoid the bias related to the machine. The parameters studied included epidemiological data (age and sex, family history of glaucoma), ophthalmic examination data (visual field, intraocular pressure (IOP), tachymetry), the upper

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extremity blood pressure measurement and the velocity parameters of arterial peak systolic velocity (PSV), end-diastolic velocity (EDV), and resistive index (RI) calculated using the $RI = (PSV - EDV) / PSV$ formula. CDU parameters were recorded bilaterally on the following arteries: the central retinal artery (CRA), ophthalmic artery (OA) and the paraoptic short ciliary artery (PCA). These arteries were identified on CDU using a 10 MHz frequency probe. Mode B was used to highlight the anatomical landmarks of the eye, namely the lens, the vitreous, the posterior edge of the eyeball and the shadow of the optic nerve. After locating the optic nerve, switching on the color Doppler enabled the arteries to be identified and the pulsed Doppler spectrum to be recorded there Figure 1.

Results

General data

The patients included in the study were composed of 43% (13) male and 57% (17) of female, with a sex ratio of 0.76. The mean age of the patients was 30.4 ± 7.6 years. The most represented age group was that of 20 to 25 years (30%) Table 1.

Clinical and ophthalmological data

IOP was normal in more than half of the cases, with 60% in the right eyes, 66.7% in the left eyes, and 63.3% in both eyes. The values of IOP, central corneal thickness or pachymetry and visual field examination results are summarized in Table 2.

The blood pressure measurement noted systolic arterial pressure, elevated in 5 patients (16.7%) among whom there were 3 cases of ocular hypertension (10%). All other cases of IOP elevation were seen in non-hypertensive patients.

The systolic and diastolic perfusion pressure was low in 33.33% of cases (n = 10) and high in 3.33% (n = 1) with a high mean perfusion pressure, measured at 146 mm Hg.

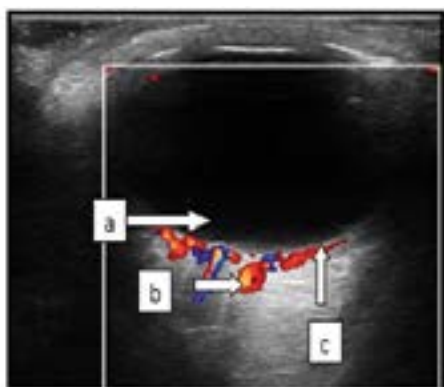


Figure 1: Identification of the ophthalmic artery by color Doppler ultrasound. a: vitreous humor, b: central retinal artery, c: posterior short ciliary artery.

Age	Number	Percentage
≤ 18	1	3.3
20-25	9	30
26-30	5	16.7
31-35	8	26.7
36-40	3	10
41-45	4	13.3
Total	30	100

Table 1: Distribution of patients by age group.

Intra ocular pressure (IOP)	Right eye n (%)	Left eye n (%)	Total n (%)
Normal	18(60)	20(66,7)	38(63,3)
abnormal (increased)	12(40)	10(33,3)	22(36,7)
Pachymetry (Central corneal thickness)			
Normal	19(63,3)	21(70)	40(66,7)
Abnormal (thin)	11(36,7)	9(30)	20(33,3)
Visual field test			
Normal	10(33,3)	8(26,7)	18(30)
Abnormal	20(66,7)	22(73,3)	42(70)

Table 2: Results of the ophthalmologic examination.

Ophthalmic artery (OA)	IOP >21 (n = 22)	IOP ≤ 21 (n = 38)	p value
	n (%)	n (%)	
High PSV (> 58.1)	0(0)	0(0)	0.347
Normal PSV (23.1- 58.1)	15(68.2)	17(44.7)	
Low PSV (< 23.1)	7(31.8)	21(55.3)	
Central Retinal Artery (CRA)			
High PSV (> 13.4)	22(100)	37(97.4)	0.887
Normal PSV (5.8- 13.4)	0(0)	1(2.6)	
Low PSV (< 5.8)	0(0)	0(0)	
Paraoptic short Ciliary Artery (PCA)			
High PSV (> 18.6)	5(22,7)	15(39.5)	0.092
Normal PSV (8.1 – 18.6)	17(77,3)	22(57.9)	
Low PSV (< 8.1)	0(0)	1(2.6)	

Table 3: Distribution of peak systolic velocity (PSV) and the IOP.

Doppler velocity data

In the Doppler study of the arteries of the ONH, the PSV was normal (53.3%) or low (46.7%) in the OA. No case of acceleration of the PSV was recorded. The PSV was accelerated in almost all cases (98.3%) in the CRA and normal (33.3%) or accelerated (65%) in the PCA (Table 3).

Correlation analysis between variations in PSV and IOP does not show a statistically significant link for the three ONH arteries studied ($p > 0.05$).

The calculation of the resistive index generally finds normal or high RIs. No case of decrease of RI was found for the three arteries of the ONH. RIs were elevated in 11.7%, 70% and 45%, respectively, in the OA, CRA and PCA (Table 4).

The correlation between RI and IOP also did not show a statistically significant correlation ($p > 0.05$).

The illustrates on Doppler ultrasound with spectral recording, measurement of velocities and calculation of the RI, of the right CRA of a 40-year-old glaucomatous patient, an acceleration of the PSV and an elevation of the RI (Figure 2).

Discussion

A female predominance with a sex ratio of 0.76 was found in our study. This predominance is not a constant. Indeed if this was also found by Quigley et al. with a frequency of 55% of POAG cases [4]. Atipo-Tsiba PW et al. found in a black population in Congo male predominance [15].

Contrary to expected IOP is more often normal than pathological in POAG. This is a constant already found in other series [16]. Commonly, the tendency is to think that glaucoma is a disease linked

Ophthalmic artery (OA)	PIO >21 (n = 22)	PIO ≤ 21 (n = 38)	p value
	n (%)	n (%)	
gh RI (> 0.85)	4(18.2)	3(7.9)	1.371
Normal RI (0.61 – 0.85)	18(81.8)	35(92.1)	
Low RI (< 0.61)	0(0)	0(0)	
Central Retinal Artery (CRA)			0.309
High RI (> 0.78)	17(77.3)	25(65.8)	
Normal RI (0.48 – 0.78)	5(22.7)	13(34.2)	
Low RI (< 0.48)	0(0)	0(0)	
Paraoptic short Ciliary Artery (PCA)			0.562
High RI (> 0.73)	12(54.5)	15(39.5)	
Normal RI (0.47 – 0.73)	10(45.5)	23(60.5)	
Low RI (< 0.47)	0(0)	0(0)	

Table 4: Distribution of Resistive Index (RI) and the IOP.

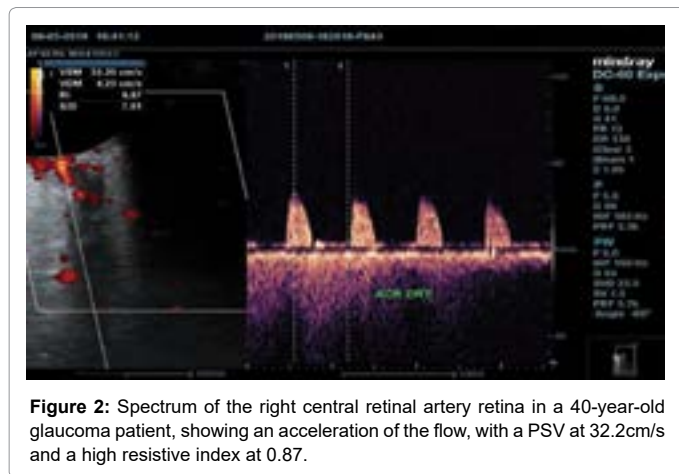


Figure 2: Spectrum of the right central retinal artery retina in a 40-year-old glaucoma patient, showing an acceleration of the flow, with a PSV at 32.2cm/s and a high resistive index at 0.87.

to the elevation of IOP. In fact, it has been established for several decades that glaucomatous neuropathies can occur at normal IOPs, located below 21 mmHg [17]. Currently, increased IOP is considered to be a risk factor for glaucoma [18]. It is also a part of monitoring glaucomatous patients, since its elevation is a factor of severity.

Regarding blood pressure, although considered by some to be a risk factor for POAG, its role remains much debated [19-23]. Several studies find a correlation between hypertension and IOP but the relationship between hypertension and glaucoma remains controversial [18]. This correlation may be true in Caucasian populations where glaucoma is observed at ages generally older than our study population [22]. Other studies have introduced the concept of ocular perfusion pressure, involving arterial pressure and IOP, and have shown it decrease in glaucomatous patients [24]. However, in our series, this hemodynamic disturbance was weak, found only in 33.33%.

The PSV in the ophthalmic arteries, were low or normal. No case of elevation above normal values was found. This is the opposite of what was noted in CRAs where only a single value was normal, all PSVs being high. The PCA is at the halfway with the majority of PSVs lying within normal limits. Despite these observations, no statistically significant link was found between PSV and IOP values for each of the three arteries analyzed.

Calculation of RI showed no case of decreased resistance within the arteries of the ONH in young patients with POAG. Differences were noted depending on the arteries. Indeed, RIs were normal in the

majority of cases (88.33%) for OA, while they were elevated in 70% in CRA and 50% in PCA.

In general, the results of CDU depend on the target group. Fatima Jimenez -Aragon et al. [25] showed a combination of decreased flow rates and increased resistive indexes in patients with progressing glaucoma compared to those who remain stable, which enabled them to suggest the use of Doppler ultrasound to help set up more aggressive clinical management in conflicting cases with a higher risk of progression.

The peculiarities observed in our series, made of young black Africans, can be considered on the one hand as a specificities of this group, a group which is known as higher at risk of POAG and in whom age recognized as a risk factor for glaucoma due to changes in vascular walls, is not to be taken into account.

The correlation study between RI and IOP reveals, as for PSV, an absence of statistically significant link between the different variables.

Conclusion

The color Doppler ultrasound of the arteries of the optic nerve head in young glaucomatous black African origin patients has special features. PSVs are low or normal in the OA, with RI most often normal, while PSV are high or normal in the CRA and PCA and RI elevated in the majority of cases.

Additional case-control CDU studies in the same population group would make it possible to consolidate the observations, and possibly to study other specific additional parameters, which could be used in the diagnosis, monitoring and prognostic evaluation of patients.

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