Optical coherence tomography angiography and the visual field in hypertensive and normotensive glaucoma

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Background. Hypertensive glaucoma (HTG) causes damage to the retinal ganglion cells and eventually to the entire visual pathway due to high intraocular pressure (IOP). However, increased IOP will also affect the vessel density (VD) of the posterior pole of the eye and the related retinal ganglion nerve fibres (RNFL). In normotensive glaucoma (NTG), the retinal ganglion cells are relatively intact. The pathology is at the level of ganglion fibres. The unanswered question is what has altered ganglion cell fibres at the level of the retina and optic nerve head in NTG?
Aim. The aim of this study was to determine whether there is a correlation between the retinal nerve fibre layer (RNFL) and vessel density (VD) at the same altitudinal half of the retina and the sum of sensitivities of the contralateral half of the visual field of the same eye in hypertensive and normotensive glaucoma (NTG).
Methods. Our group included 20 patients with HTG and 20 patients with NTG. The Pearson's correlation coefficient r was used for evaluation of the relationship of the peripapillary RNFL and VD, visual field (using the fast threshold glaucoma program) as the sum of sensitivities in apostilbs (asb) to the extent of 0-22 degrees. The results of sensitivity were compared with the RNFL and VD of the contralateral altitudinal half of the retina in the same eye.
Results. In the HTG group there was a moderate relationship between RNFL and VD (both hemifields), but no relationship between RNFL and VF. VD SH and VF IH showed weak correlation and VD IH and VF SH showed no correlation. In patients with NTG, we found a strong correlation between RNFL and VD (both hemifields), between VD SH and VF IH a moderate correlation, between VD IH and VF SH also a moderate correlation and a weak correlation between RNFL and VF.
Conclusion. By comparing the RNFL and VD at the same altitudinal halves of the retina, we found a moderate correlation in HTG and a strong correlation in NTG. We found no or a weak correlation between VD and VF in HTG. In NTG the relationship between VD and VF showed a strong correlation. These findings reveal the differences in the diagnostic groups.

Key words: retinal nerve fibre layer, optical coherence tomography angiography, vessel density, visual field, hypertensive glaucoma, normotensive glaucoma

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INTRODUCTION

Hypertensive glaucoma (HTG) causes damage to the retinal ganglion cells and consequently to the entire visual pathway due to high intraocular pressure (IOP) (ref.[1]). However, increased IOP will also affect the vessel density (VD) of the posterior pole of the eye and the related retinal ganglion nerve fibres (RNFL) (ref.[2-4]). In normotensive glaucoma (NTG) the retinal ganglion cells are relatively intact. The pathology is in the level of ganglion fibres[5]. The unanswered question is what has altered ganglion cell fibres at the level of the retina and optic nerve head in NTG? OCTA is a new imaging modality that has begun to expand our knowledge of the role of ocular blood flow in glaucoma[7].

Peripapillary perfusion parameters are better than macular perfusion parameters for glaucoma diagnosis, supporting the idea that glaucomatous superficial retinal vascular changes are more pronounced in the peripapillary region[8].

Therefore, in this investigation we focused on evaluation of peripapillary VD. Our previous work showed a greater correlation of the VD of small vessels (VDs) than of all vessels (VDa) (ref.[9]). The results of previous work also gave us some clues, where we examined the progression of changes in the visual fields in HTG (treated by prostaglandins and beta-blockers) and NTG for five years with or without various types of topical treatment (prostaglandins and beta-blockers). We found that in eyes where prostaglandins were used that affected the posterior pole vessels of the eye or the eye was untreated, there was a statistically significant progression of changes in visual fields, especially in NTG.

This means that the vessels of the anterior part of the optic nerve may play an important role in the pathogenesis of NTG. Therefore, the aim of this work was to

determine whether in the HTG and NTG group there is a correlation between RNFL, vessel density in the peripapillary region (VD) in the same altitudinal half of the retina to the sum of sensitivities of the bilateral half of the visual field of the same eye.

PATIENTS AND METHODS

Our group included 20 patients with HTG, 13 females of mean age 64.7 years (54-73 years) and 7 males mean age 60.8 years (53-73 years) and 20 patients with NTG: 17 females of mean age 56.1 years (43-79 years) and 3 males of mean age 60 years (51-66 years). Inclusion criteria: visual acuity 1.0 with possible correction of less than ± 3 dioptres, approximately the same changes in visual field in all patients, whereas initial HTG and NTG were concerned without any other ocular and neurological disease. Complex ophthalmology examinations including electrophysiological examination were performed in all patients to confirm glaucoma. The RNFL and peripapillary VD were measured peripapillary, using Avanti RTVue XR from Optovue. Visual field was examined using the fast threshold glaucoma program in the Medmont M-700 machine (Medmont International Pty Ltd Australia). The sum of sensitivities in apostilbs (asb) was evaluated in the extent of 0-22 degrees both in the upper and lower half of the visual field. The results of sensitivity were compared with the RNFL and VD of the contralateral altitudinal half of the retina in the same eye. Each group (HTG and NTG) was evaluated separately. The Pearson's correlation coefficient r was used for evaluation of the relationship of the selected parameters.

RESULTS

Measured values of RNFL, VD and visual field in HTG and NTG groups are shown in Tables 1 and 2. Pearson's correlation coefficients for both groups are shown in Table 3.

The Pearson's correlation coefficient (P=0.001) was used for evaluation of the relationship of the selected parameters. By comparing the RNFL and VD in HTG in the upper halves of the retina (r=0.5) and in the lower halves of the retina (r=0.51), we found a moderate correlation. By comparing the VD from the upper half of the retina and the contralateral sum of sensitivities in the visual field (r=0.2), we found a weak correlation. There was no correlation between VD from the lower half of the retina and the sum of sensitivities in the upper half of the visual fields (r=0.04). We found even less correlation between RNFL SH and VF IH (r=-0.04) and between RNFL IH and VF SH (r=-0.12).

By comparing the RNFL and VD in NTG in the upper halves of the retina (r=0.62) and in the lower halves of the retina (r=0.6), we found a strong correlation. By comparing the VD from the upper half of the retina and the contralateral sum of sensitivities in the visual field (r=0.7), we also found a strong correlation. We found a moderate relationship (r=0.52) between VD from the lower half of the retina and sum of sensitivities in the upper half of the visual fields and a weak correlation between RNFL SH and VF IH (r=0.37), RNFL IH and VF SH (r=0.32) respectively.

DISCUSSION

The effect of high IOP on retinal and choroidal vascularization was tried to prove experimentally by Patel et al. Because a significant portion of retinal thickness is comprised of vasculature, the purpose of the current study was to investigate OCT structural and vascular changes in healthy non-human primate eyes with systematic graded increases and decreases in IOP. They found that NOT does not have a direct effect on RNFL (ref.[10]).

Ma a et. all focused on changes in vessel density of the patients with narrow anterior chamber after an acute intraocular pressure elevation observed by OCT angiography. However, when the IOP rise was greater than 20 mmHg, the macular and papillary vessel density decreased significantly[3].

Mansoori et al. investigated peripapillary VD in unilateral closed angle glaucoma (PACG). They found a significant difference in RNFL (P<0.0001) and VD (P=0.001) thickness between the upper and lower hemipoles. Within the perimetrically undamaged area, RNFL was significantly lower in the superior nasal and upper nasal sectors (P=0.02) but VD showed no changes[11]. For NTG, a change in vascular density in the peripapillary region was registered[12-17].

The OAG and NTG groups evinced a lower superficial VD than did the control group, while the NTG group had a lower deep VD than the control group. The NTG group also had a larger foveal avascular zone than did the OHT group. No difference in choriocapillaris perfusion was observed among the groups[18]. The results of our research are in agreement with the above studies. By comparing RNFL and VD, we showed a medium correlation in HTG and NTG. By comparing VD from the upper half of the retina and the contralateral sum of sensitivities in the visual field, we showed a weak correlation in HTG and a strong correlation in NTG. We did not show any dependence in HTG when comparing VD from the lower half of the retina and the sum of sensitivity in the upper half of the visual fields. For NTG, this dependence was moderate. Our findings indicate that other than peripapillary vascular changes are more involved in functional changes in the visual fields of HTG, at least in the early stages of glaucoma, in contrast to NTG, where vascular changes play a crucial role in changes of visual field. We have not found a similar work as this in the literature. Even these conclusions allow us to conclude that HTG is a different diagnostic group than NTG.

Table 1. Summary of the measured values in HTG group.

Sex-age	RNFL RE [µm]		RNFL LE [µm]		VD RE		VD LE		VF RE [asb]		VF LE [asb]		Therapy
	SH	IH	SH	IH	SH	IH	SH	IH	SH	IH	SH	IH	
F-1956	98	95	111	102	50	47	56	55	916	1041	1099	1046	xalacom
F-1948	88	97	79	81	47	44	46	47	1116	1073	1056	1061	carteolol
F-1962	98	101	110	101	59	59	56	54	1108	1104	1102	1067	xalatan
F-1950	113	109	114	104	49	49	49	52	1068	1072	1018	1003	xalatan
F-1943	89	102	102	98	52	52	56	53	963	1018	992	933	timolol
F-1959	104	102	103	103	52	50	48	47	1057	1053	1025	1015	xalatan
F-1958	116	104	108	98	54	51	50	47	1059	1058	1066	1037	vizibim
F-1965	87	76	82	85	45	42	46	41	1073	1043	1064	1030	xalatan
F-1944	98	103	101	102	48	46	46	43	1022	1020	984	986	timolol
F-1954	89	74	89	98	51	46	54	56	1032	1038	966	999	xalacom
F-1944	102	104	107	110	50	53	48	49	940	985	932	916	xalatan
F-1954	98	101	94	97	49	52	52	53	1093	1069	1060	1062	vizibim
F-1956	106	102	112	101	52	50	53	49	1052	1068	1070	1058	duotrav
F-1958	96	98	102	94	50	49	50	48	1060	1049	1069	1036	monopost
F-1947	118	113	117	112	57	52	58	54	1079	1047	970	1003	xalatan
M-1946	100	100	91	93	47	50	43	41	1064	1013	949	901	carteolol
M-1959	104	102	103	95	53	53	54	54	1048	1087	986	1040	monopost
M-1966	121	129	121	129	52	54	53	53	1037	1033	953	978	ganfort
M-1962	99	103	95	94	51	48	51	51	1057	1061	1056	1065	xalacom
M-1958	92	103	121	139	51	50	53	55	1030	988	1062	1005	monopost dualkopt

RNFL – retinal nerve fibre layer, VD – vessel density, VF – visual field, RE – right eye, LE – left eye, SH – superior hemifield, IH – inferior hemifield

Table 2. Summary of measured values in NTG group.

Sex-age	RNFL RE [µm]		RNFL LE [µm]		VD RE		VD LE		VF RE [asb]		VF LE [asb]		Therapy
	SH	IH	SH	IH	SH	IH	SH	IH	SH	IH	SH	IH	
F-1956	92	87	90	87	48	45	49	48	1104	1092	982	1035	0
F-1949	127	123	124	128	52	53	50	51	1042	991	968	900	latanoprost
F-1954	96	104	92	100	50	51	49	52	1083	1012	1043	1012	brinzolamid
F-1955	98	101	92	99	51	51	49	48	1088	1148	1029	1074	0
F-1946	75	67	77	94	27	28	31	41	683	745	294	632	brinzolamid
F-1968	95	98	93	97	48	48	53	56	1186	1204	1152	1136	0
F-1953	109	107	107	103	51	48	51	50	1042	1074	1092	1077	betoptic
F-1944	112	94	105	104	54	53	53	50	1099	1068	968	1026	0
F-1956	89	97	94	83	46	46	49	45	1060	1055	1015	1001	latanoprost
F-1946	88	88	53	81	51	53	40	50	1035	990	977	880	brimonidin
F-1953	103	122	103	110	52	53	50	52	1104	1073	1115	1106	carteolol
F-1940	93	93	106	99	41	39	47	43	955	940	942	921	timolol
F-1960	89	90	93	61	48	51	49	42	977	999	755	944	brimonidin
F-1966	96	100	104	97	51	52	52	52	1073	952	1074	1038	brimonidin
F-1948	118	114	121	124	56	57	54	54	909	1023	1030	973	latanoprost
F-1976	112	112	114	111	51	50	45	47	1098	1093	1073	1089	0
F-1960	93	90	97	104	52	52	53	53	1092	1095	1084	1105	carteolol
M-1956	76	78	91	82	41	39	48	47	1093	907	1013	1013	brimonidin
M-1968	89	86	88	93	48	48	51	52	925	960	990	881	betoptic
M-1953	80	96	102	110	48	47	50	49	1038	1063	1035	1079	betoptic

RNFL – retinal nerve fibre layer, VD – vessel density, VF – visual field, RE – right eye, LE – left eye, SH – superior hemifield, IH – inferior hemifield

Table 3. Pearson's correlation coefficients in HTG and NTG group.

DATA	VD SH	VF IH	VF IH	VD IH	VF SH	VF SH
GROUP	RNFL SH	RNFL SH	VD SH	RNFL IH	RNFL IH	VD IH
HTG	0.50	-0.04	0.26	0.51	-0.12	0.04
NTG	0.62	0.37	0.70	0.59	0.32	0.52

r = 0.00–0.19 very weak, 0.20–0.39 weak, 0.40–0.59 moderate, 0.60–0.79 strong, 0.80–1.00 very strong

CONCLUSSION

The results show a difference between the two diagnostic groups. NTG will probably be an ischemic lesion, which may not play such a role in HTG.

ABBREVIATIONS

HTG, hypertensive glaucoma; NTG, normotensive glaucoma; IOP, intraocular pressure; VD, vessel density; OCTA, optical coherence tomography angiography; POAG, primary open angle glaucoma; asb, apostilb;; SH, superior hemifield; IH, inferior hemifield; OCT, optical coherent tomography; RNFL, retinal nerve fibre layer; MRW, minimum rim width; BMO, Bruch's membrane opening; ALCS, anterior lamina cribrosa surface; PAGC, primary angle closure glaucoma; GCC, ganglion cell complex; VF, visual field.

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