Journal of Cardiovascular Disease Research

ISSN:0975 -3583,0976-2833 VOL12,ISSUE 04, 2021

Evaluation of effect of hypertension on choroidal thickness using optical coherence tomography

[1] Dr. Farhat Abrar, [2] Dr. Munavvar Ansari

[1] Associate Professor, Department of Ophthalmology, Subharti Medical College, Meerut, Uttar Pradesh, India

[2]Assistant Professor, Department of Ophthalmology, Teerthanker Mahaveer Medical College & Research Centre, Moradabad, Uttar Pradesh, India

Corresponding Author: Dr. Munavvar Ansari (ansarimunavvar@gmail.com)

Abstract:

Purpose: To evaluate effect of Hypertension on choroidal thickness using spectral-domain optical coherence tomography (SD-OCT).

Methods: 72 eyes with hypertensive retinopathy from 36 patients in the age group of 40-65 years with hypertension (systolic blood pressure [SBP] ≥140 mm Hg or diastolic blood pressure [DBP] ≥90 mm Hg) and 72 eyes of 36 age matched controls were included in hypertensive and control groups, respectively. SD-OCT was performed on the patients in both the groups and sub-foveal choroidal thickness was measured. SD-OCT morphologic findings were evaluated and were compared between hypertensive subjects and the controls. Associations between clinical findings, OCT image features, and Keith-Wagener-Barker (KWB) hypertensive retinopathy grades were examined.

Results: Mean age was 52.9 ± 1.9 years in hypertensive subjects and 53.5 ± 2.8 years in the control group ($p = 0.742$). All choroidal thickness measurements (mean choroidal thickness, sub-foveal choroidal thickness, all nasal and all temporal choroidal thicknesses) were significantly lower in hypertensive subjects ($p<0.003$ for sub-foveal, $p = 0.002$ for Nasal; and $p = 0.01$ for temporal). The correlations between choroidal thickness measurements and blood pressure (SBP, DBP, MAP) were insignificant ($p>0.05$). There was statistically significant correlation between SBP and retinopathy grading ($r = 0.214$ $p = 0.034$) but statistically insignificant correlation between DBP ($r = 0.215$, $P = 0.129$) and MAP ($r = 0.234$, $P = 0.081$).

Conclusions: The results of this study demonstrated that there is detrimental effect on choroidal thickness in patients with systemic arterial hypertension as compared to age matched healthy subjects.

Keywords: Choroid, choroidal thickness, enhanced depth imaging OCT, spectral‐domain OCT, systemic hypertension, blood pressure.

Introduction

About 25% of the world's adult population is affected by systemic arterial hypertension and is estimated to increase to 29% by 2025 [1]. Approximately 90% of hypertensive cases are classified as essential hypertension, where the precise cause is unknown, and it has widespread effects on the eyes [2]. An overall prevalence of 26.7-33% was reported in a meta-analysis of hypertension in India [3].

Systemic hypertension remains a major health problem worldwide with silent and multisystem complications. The consequences of hypertension on ocular structures include hypertensive retinopathy, choroidopathy, optic neuropathy, retinal vascular occlusions, age‐related macular degeneration, glaucoma, etc. [4] Hypertension is associated with vascular abnormalities in the brain, heart, kidneys, and eyes. Hypertension may cause retinal hemorrhages, cotton wool spots, intraretinal lipid accumulation, and vessel closure in the retinal capillaries and choriocapillaris. Based on these fundoscopic features, Keith *et al.* developed a classification system for hypertensive retinopathy to categorize these signs into four groups of severity [5].

Providing vascular supply to the outer retinal layers, providing nourishment and oxygen, clearing waste products, and helping in temperature regulation of the outer coats of the eyeball are the main functions of the choroid. The choroidal blood flow is maintained by autoregulatory mechanism [6]. The choroidal arteries have a shorter course with fewer branches, and they supply the choriocapillaris at right angles. These unique features predispose the choroidal vasculature to systemic hypertension [7]. As the blood supply of the retina is partly through the choroid, there could be a possibility of the choroid being affected earlier in systemic hypertension. Thus, studying the choroidal circulation and thickness can benefit in detecting early ocular changes in systemic hypertension.

Spectral-domain optical coherence tomography (SD-OCT) provides visualization and measurement of the microstructure of the retinal layers and choroidal structure non-invasively. Spectral-domain optical coherence tomography (OCT) has revolutionized our ability to visualize structural abnormalities in the retina and choroid. Newer deeper penetration OCT technologies like Enhanced depth Imaging (EDI) enabled Spectral Domain OCT (SD‐OCT) or swept‐source OCT (SS‐OCT) have enabled better delineation of sclerochoroidal interface with precise measurement of choroidal thickness.

ISSN:0975 -3583,0976-2833 VOL12,ISSUE 04, 2021

There are studies describing the correlation of choroidal thickness with various parameters like age, gender, refractive status, axial length and racial variation [8, 9]. Owing to the limited studies describing the correlation of hypertension with choroidal thickness and effect on visual acuity, this study was planned to compare the choroidal thickness in hypertensive subjects with age‐ matched healthy individuals by EDI enabled SD‐OCT and to study the association of grades of hypertensive retinopathy with best corrected visual acuity.

Methods

This prospective comparative study was conducted at the ophthalmology departments of two tertiary care institutes in North India for a duration of 1 year from Jan 2019 to Dec 2019. The study group comprised 72 eyes of 36 adult individuals who were diagnosed with essential hypertension from the internal medicine department. The control group comprised 72 eyes of 36 healthy age-matched subjects selected from other patients visiting ophthalmology outpatient department.

Patients and control subjects with clear ocular media and no ocular or other systemic diseases were included. Hypertension was defined as systolic blood pressure (SBP) >140 mm Hg and/or diastolic blood pressure (DBP) >90 mm Hg according to the 2013 European Society of Hypertension/European Society of Cardiology Guidelines for the management of arterial hypertension [10]. The mean arterial pressure (MAP, mm Hg) was calculated as follows: MAP = (SBP + 2DBP)/3. The blood pressure measurements were performed on the right upper arm by auscultation after subjects had been seated for at least 15 minutes. Mercury sphygmomanometers were used and the appropriate adult cuff size was applied. Ophthalmic examinations were performed after the blood pressure measurement.

The exclusion criteria included diabetic retinopathy, macular edema, any type of previous retinal treatment (macular laser photocoagulation, vitrectomy, intravitreal steroids and/or antiangiogenic drugs), history of any intraocular surgery, refractive error at the higher axis >3 D, glaucoma, ocular hypertension, uveitis, other retinal diseases, neurodegenerative disease (e.g., Alzheimer, Parkinson, dementia), and media opacities. Each subject underwent full ophthalmic examination including refractive error, best spectacle-corrected visual acuity, anterior segment findings, intraocular pressure (Goldmann applanation tonometry) and 90-D lens fundoscopy.

All individuals in the study and control group were subjected to Spectral Domain Optical Coherence Tomography (SD‐ OCT; CirrusTM, Carl Zeiss Meditec, Dublin, CA) after adequate pupillary dilation. All images were taken ensuring adequate signal strength (at least 7) in each of the scanned images. To measure the choroidal thickness, Macular 5 Line Raster scan protocol with enhanced depth imaging (EDI) mode was followed at three locations in each eye (subfoveal, 500µm nasal to fovea and 500µm temporal to fovea) and thickness was measured using the in‐ built calliper function. Both the eyes of each individual were subjected to scan sequentially. The choroidal thickness was measured as the perpendicular distance between the hyper-reflective outer border of the retinal pigment epithelial-Bruch's membrane layer (RPE‐ BM) and the sclerochoroidal interface.

Data entry was done in a Microsoft Excel Spread Sheet (Microsoft Corporation, USA) and analyzed using Statistical Package for the Social Sciences (SPSS), version 23. Values were expressed as mean ± standard deviation (SD). Independent t‐ test, Chi‐ square test and Mann-Whitney U test were applied to the appropriate values after checking the normality of the data. A value of $P < 0.05$ was considered as statistically significant.

Results

Demographic and Clinical Data

Table 1 shows demographic and clinical features of the groups. Differences in age, sex, spherical equivalents, and IOP between the groups were not significant. The SBP, DBP and MAP were significantly higher in the hypertension group. None of the patients had hypertensive retinopathy higher than grade 3 according to the Keith-Wagener-Barker classification. Mean disease duration after diagnosis was 5.8 ± 1.7 years (min-max 3-12 years) in the hypertension group.

Table 1: Demographic and clinical features of hypertensives and control subjects

	Hypertension, mean ± SD (min-max)	Control, mean ± SD (min-max)	p
Age (years)	52.9±1.9 (40-65)	53.5±2.8 (40-65)	0.742
Male/Female n/(%)	21/15 (58.3/41.7)	25/11 (69.4/30.6)	0.874
SBP (mm Hg)	160.4±10.6 (140-190)	112.3±9.6 (90-130)	<0.001
DBP (mm Hg)	98.8±7.5 (90-120)	82.5±8.2 (65-85)	<0.001
MAP (mm Hg)	118.6±8.2 (106-145)	98.4±7.8 (80-116)	<0.001
IOP (mm Hg)	15.6±2.4 (10-21)	15.2±2.0 (10-21)	0.624
Spherical equivalent, D	-0.21±0.69 (-2.75 to +2.50)	-0.15±0.50 (-1.75 to +1.50)	0.478

No statistically significant difference was found between the mean age, gender distribution, spherical equivalent and mean IOP between the two groups. All the blood pressure (BP) parameters (SBP, DBP, MAP) were significantly higher in hypertensive group as compared to control group ($P < 0.001$).

ISSN:0975 -3583,0976-2833 VOL12,ISSUE 04, 2021

Choroidal Thickness

The mean choroidal thickness (mean of nasal, sub-foveal and temporal regions) in control group was 300.87±49.41µm, which was significantly higher (P = 0.001) than mean choroidal thickness in the hypertensive group (259.22±51.94µm). Similarly, the independent subfoveal, nasal and temporal choroidal thickness was also found to be statistically higher in control group as compared to hypertensive group (P = 0.003, 0.002, 0.01 respectively) for all locations. The choroidal thickness values of both the groups at different locations were shown in Table 2, Fig. 1.

Table 2: Choroidal thickness measurements between controls and hypertensives

Choroidal Thickness (µm)	Control (n = 72)	Hypertensive (n = 72)	p
Subfoveal	305.53 ± 50.67	261.45 ± 55.45	0.003
Nasal	297.61 ± 48.31	257.65 ± 51.14	0.002
Temporal	299.47 ± 49.25	258.57 ± 49.25	0.01
Mean	300.87 ± 49.41	259.22 ± 51.94	0.001

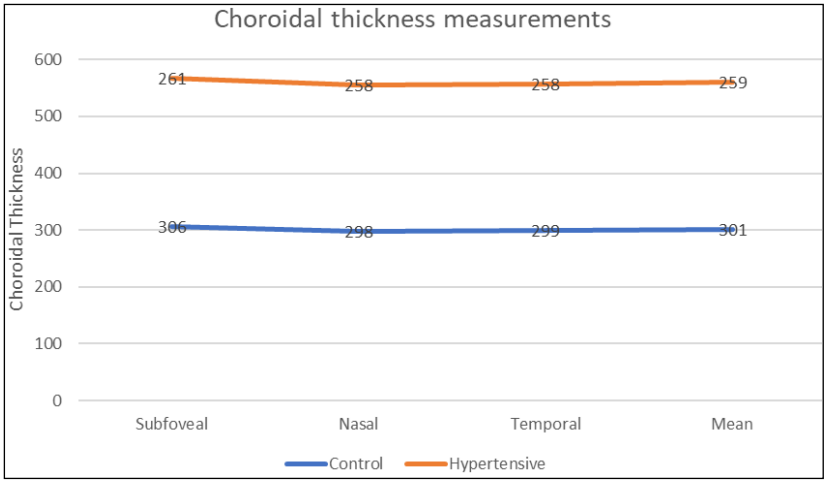

Fig 1: Choroidal thickness measurements between controls and hypertensives

The correlations between blood pressure (SBP, DBP and MAP) and choroidal thickness in all locations were not significant (Table 3).

Table 3: Correlation analysis results between choroidal thickness and blood pressure

Choroidal Thickness	r p	SBP	DBP	MAP
Subfoveal	r p	-0.152 0.174	0.051 0.721	-0.073 0.417
Nasal	r p	-0.161 0.159	0.041 0.719	-0.085 0.451
Temporal	r p	-0.161 0.147	0.025 0.815	-0.088 0.348
Mean	r p	-0.112 0.342	0.073 0.513	-0.043 0.706
Fundoscopic grading, KWB	r p	0.214 0.034	0.215 0.129	0.234 0.081

Discussion

Choroid supplies oxygen and nutrients to the retinal layers between retina pigment epithelium and up to the inner nuclear layer. It also plays a role in waste removal and temperature regulation of the eye [11]. Therefore, healthy choroidal vasculature is essential for the normal functioning of the retina. Choroid also has one of the highest blood flow rates in the body [12]. There have been various studies describing choroidal thickness in different posterior segment ocular disorders. The thickness of choroid is found to be increased in polypoidal choroidal vasculopathy, central serous chorioretinopathy and Vogt- Koyanagi-Harada syndrome [13-16]. Whereas, studies performed on disorders like macular hole, high myopia, chorio-retinal atrophies have reported a thinner choroid [17-19].

In our study, we evaluated the choroidal thickness in normotensive as well as hypertensive individuals in the absence of any other ocular disorders and also looked for any correlation of choroidal thickness with blood pressure. In our study, both the controls and hypertensives were comparable with regard to age, refractive status and intra ocular pressure, thus ruling out any possible impact of these parameters on the measurement of choroidal thickness.

ISSN:0975 -3583,0976-2833 VOL12,ISSUE 04, 2021

Chhabalani *et al*. conducted a study on the choroidal thickness profile in 211 eyes of healthy Indian subjects and revealed that choroidal thickness varies according to the location. They also found thinner choroid in the nasal region and a thicker choroid in the sub‐ foveal region [20]. Jo *et al*. studied choroidal thickness changes after acute diabetic control in type 2 diabetic patients. The authors reported significantly increased choroidal thickness 2 weeks after eucaloric diet, glucose control and blood pressure control. They also found statistically significant correlations between the changes in choroidal thickness and the changes in SBP, DBP, MAP, BMI, and AL and mean ocular perfusion pressure. The findings in that study cannot be compared with our findings because of the potentially confounding effect of diabetes and acute diabetic control [21].

In contrast to our findings, Gök *et al*. reported similar subfoveal choroidal thickness between patients with essential hypertension and healthy controls [22]. In a study by Sansom *et al*., a modest negative correlation was found between subfoveal choroidal thickness and SBP in normal individuals. However, this study did not include any hypertensive individual [23]. In a study conducted on 68 eyes of 34 individuals in the age group of 40-60 years including hypertensive group and control group by Waghamare SR *et al*., they found decreased choroidal thickness in systemic hypertensive subjects as compared to age‐ matched healthy individuals. The choroidal thickness in hypertensive subjects also had a significant but weak negative correlation with SBP and duration of hypertension [24].

In our study, there was significantly decreased choroidal thickness in the hypertensive group as compared to the control group. This finding of our study was in agreement with a study by Akay *et al*., who in their prospective, case‐ control study involving 80 hypertensive patients and 80 control individuals also found decreased choroidal thickness in systemic arterial hypertension. However, this study was done in a relatively younger age group (20‐ 29 years) as compared to our study and included patients with clinically visible changes of hypertensive retinopathy also (upto grade two hypertensive retinopathy according to Keith‐ Wagner classification) [25]. A retrospective study done by Masis *et al*. involving 112 hypertensive patients and 15 healthy individuals also revealed significant choroidal thinning in hypertensive subjects [26]. Geraci *et al*. studied choroidal thickness and renal hemodynamic changes based on renal resistive index in subjects with essential hypertension. They explained that the pathophysiological mechanism of arterial stiffening leads to increased hemodynamic pressure on the choroidal circulation causing vascular damage and reduced choroidal thickness. Also, endothelial dysfunction increases the passage of strong vasoconstrictors which further increases the vasoconstriction eventually leading to ischemia which may also contribute to thinning of the choroidal layer further [27].

Conclusion

In conclusion, we found choroidal thickness is decreased in sub-foveal, nasal and temporal quadrants significantly in hypertensive subjects as compared to normal individuals. The choroidal thickness in the hypertensive subjects did not have a significant correlation with SBP. There was statistically significant correlation between SBP and retinopathy grading ($r = 0.214$ $p = 0.034$). Thus, by using SD-OCT for the measurement of choroidal thickness we can assess the effect of systemic hypertension on the eye before other clinically detectable fundus changes of hypertension become appreciable.

References

1. Mittal BV, Singh AK. Hypertension in the developing world: challenges and opportunities. Am J Kidney Dis 2010;55:590-8.
2. Kearney PM, Whelton M, Reynolds K, Whelton PK, He J. Worldwide prevalence of hypertension: a systematic review. J Hypertens 2004;22:11-9.
3. Anchala R, Kannuri N, Pant H, Khan H, Franco O, Di Angelantonio E *et al*. Hypertension in India. J Hypertens 2014;32:1170‐ 7.
4. Wong T, Mitchell P. Hypertensive retinopathy. N Engl. J Med 2004;351:2310‐ 7.
5. Keith NM, Wagener HP, Barker NW. Some different types of essential hypertension: their course and prognosis. Am J Med Sci 1939;197:332-343.
6. Kaufman P, Alm A, Adler F, Levin L. Adler's Physiology of the Eye (Physiology of the Eye). Elsevier Health Sciences, 2011.
7. Niknam R, Schocket L, Metelitsina T, DuPont JC, Grunwald JE. Effect of hypertension on foveolar choroidal haemodynamics. Br J Ophthalmol 2004;88:1263‐ 5.
8. Tuncer I, Karahan E, Zengin M, Atalay E, Polat N. Choroidal thickness in relation to sex, age, refractive error, and axial length in healthy Turkish subjects. Int. Ophthalmol 2014;35:403‐ 10.
9. Sanchez‐ Cano A, Orduna E, Segura F, Lopez C, Cuenca N, Abecia E *et al*. Choroidal thickness and volume in healthy young white adults and the relationships between them and axial length, ammetropy and sex. Am J Ophthalmol 2014;158:574‐ 83.e1.
10. Task Force for the management of arterial hypertension of the European Society of Hypertension; Task Force for the management of arterial hypertension of the European Society of Cardiology. ESH/ESC Guidelines for the Management of Arterial Hypertension. Blood Press 2013;22:193-278.
11. Parver LM. Temperature modulating action of choroidal blood flow. Eye 1991;5:181-5.
12. Nickla DL, Wallman J. The multifunctional choroid. Prog. Retin Eye Res 2010;29:144-68.

ISSN:0975 -3583,0976-2833 VOL12,ISSUE 04, 2021

13.Tan C, Ouyang Y, Ruiz H, Sadda S. Diurnal variation of choroidal thickness in normal, healthy subjects measured by spectral domain optical coherence tomography. Invest Opthalmol Vis Sci 2012;53:261- 6.

14.Maruko I, Iida T, Sugano Y, Ojima A, Sekiryu T. Subfoveal choroidal thickness in fellow eyes of patients with central serous chorioretinopathy. Retina 2011;31:1603- 8.

15.Fong A, Li K, Wong D. Choroidal evaluation using enhanced depth imaging spectral- domain optical coherence tomography in Vogt-Koyanagi Harada disease. Retina 2011;31:502- 9.

16.Chung S, Kang S, Lee J, Kim Y. Choroidal thickness in polypoidal choroidal vasculopathy and exudative age- related macular degeneration. Ophthalmology 2011;118:840- 5.

17.Fujiwara T, Imamura Y, Margolis R, Slakter J, Spaide R. Enhanced depth imaging optical coherence tomography of the choroid in highly myopic eyes. Am J Ophthalmol 2009;148:445- 50.

18.Spaide R. Age- related choroidal atrophy. Am J Ophthalmol 2009;147:801- 10.

19.Kubota T, Jonas J, Naumann G. Decreased choroidal thickness in eyes with secondary angle closure glaucoma. An aetiological factor for deep retinal changes in glaucoma? Br J Ophthalmol 1993;77:430- 2.

20.Chhablani J, Rao PS, Venkata A, Rao HL, Rao BS, Kumar U *et al*. Choroidal thickness profile in healthy Indian subjects. Indian J Ophthalmol 2014;62:1060- 6.

21.Jo Y, Ikuno Y, Iwamoto R, Okita K, Nishida K. Choroidal thickness changes after diabetes type 2 and blood pressure control in a hospitalized situation. Retina 2014;34:1190-8.

22.Gök M, Karabas VL, Emre E, Aksar AT, Aslan MS, Ural D. Evaluation of choroidal thickness via enhanced depth-imaging optical coherence tomography in patients with systemic hypertension. Indian J Ophthalmol 2015;63:239-43.

23.Sansom L, Suter C, McKibbin M. The association between systolic blood pressure, ocular perfusion pressure and subfoveal choroidal thickness in normal individuals. Acta Ophthalmologica 2015;94:e157- 8.

24.Waghamare SR, Mittal S, Pathania M, Samanta R, Kumawat D, Gupta N *et al*. Comparison of choroidal thickness in systemic hypertensive subjects with healthy individuals by spectral domain optical coherence tomography. Indian J Ophthalmol 2021;69:1183-8.

25.Akay F, Gundogan F, Yolcu U, Toyran S, Uzun S. Choroidal thickness in systemic arterial hypertension. Eur J Ophthalmol 2015;26:152- 7.

26.Masís M, Hernandez E, Wu L. Choroidal thickness in patients with systemic hypertension. Invest Ophthalmol Vis Sci 2011;52:5296.

27. Geraci G, Maria Zammuto M, Vadal M, Mattina A, Castellucci M, Guarrasi G *et al*. Choroidal thickness is associated with renal hemodynamics in essential hypertension. J Clin Hypertens 2020;22:245 - 53.