Retinal Arterial Tortuosity In Young Indians: A Cross Sectional Study

T Hasan, S Sharma, K Satyam, J Shilpi

Citation

T Hasan, S Sharma, K Satyam, J Shilpi. *Retinal Arterial Tortuosity In Young Indians: A Cross Sectional Study*. The Internet Journal of Health. 2013 Volume 14 Number 1.

Abstract

Background/aims:
To assess the retinal arterial tortuosity and the association between tortuosity and certain health indices in healthy young to middle aged Indians.
Methods:
This cross-sectional study included 80 fundus (right and left eyes) of 40 healthy adults aged 18 to 45 years, (18 M, 22 F; mean age 35.1yrs) who were characterized by determination of retinal arterial tortuosity using a three-level grading scale (straight, wavy, tortuous),after screening for arterial blood pressure and diabetes.
Results:
Higher grades of tortuosity were common among the study subjects, 20 (25 %) had straight retinal arteries, 24 (30 %) had wavy arteries and 36(45%) had tortuous arteries when reported as the average of right and left eyes because the correspondence between right and left eyes was high. Increasing values of mean arterial blood pressure were associated with decreasing levels of retinal arterial tortuosity even in pre-hypertensive individuals while age, sex and gender did not significantly contribute towards dimorphism.
Conclusion:
Considerable variations in retinal vasculature in terms of tortuosity can be observed among young healthy subjects. Determinants of disparities in retinal arterial layout are mainly associated with blood pressure levels while age, gender and right vs left laterality do not appear to much affect the wavy patterns of vessels in this study population. Assessment of retinal vascular tortuosity can provide a means of monitoring systemic health to recognize what determines how retinal vessels are laid out early in life, before systemic risk factors and clinical disease have developed.

INTRODUCTION

Considerable variations in retinal vasculature in terms of waviness or tortuosity can be observed in young healthy subjects. Even though there is little evidence to support the prognostic value of a single fundoscopic examination ,incidental observations of remarkable degrees of straightness or tortuosity of retinal blood vessels may be considered as potential signs of morbidity. (Cheung et al.,2011) Decreased retinal arterial tortuosity has frequently been associated with hypertension. (Hayreh et al.,1989) Recent studies have demonstrated that less tortuous retinal arteries are linked with increased risk of death from ischaemic heart disease, independent of systolic blood pressure.(Witt et al.,2006) Few studies have been performed on the normal variation in retinal vessel tortuosity and its association with fitness and well being. The relative contribution of demographic and health indices on retinal vessel tortuosity, and the association between retinal vascular morphology and development of systemic risk factors in healthy adults can serve as a means of monitoring health before clinical disease outcomes

METHODS

Participants
The cross-sectional study comprised of 80 Fundus (Right and Left eye) of 40 adults of north Indian origin (18 M, 22 F ; aged 18 to 45 years; mean age 35.1years) who reported at ophthalmology dept of BHU ,Varanasi, UP, India during the period of June to August, 2012. Systemic exclusion criteria were known diabetes, hypertension or cardiovascular disease. Ophthalmic exclusion criteria included cataract and lens opacities near the optical axis of the eye and other manifest eye diseases. To avoid confounding of undiagnosed diabetes or residual hypertension, all participants underwent screening through an oral glucose tolerance test and Blood

Pressure (BP) evaluation using digital monitors. Hypertension was defined as systolic BP >/=140 mmHg or diastolic BP >/=90 mmHg and /or current use of antihypertensive medicine. Individuals with systolic BP 120

RESULTS

All eyes included had a visual acuity of at least 0.9.
Retinal arterial tortuosity grading demonstrated that 10(25%) subjects had predominantly straight arteries (grade1), 12(30%) had wavy arteries (grade 2), and 18 (45%) had tortuous arteries (grade 3). (Table 1)

Table 1

Retinal arteriolar tortuosity distribution pattern in a study group comprising of normotensives and pre-hypertensives.(N=80; Mean age 35.1 years): Vascular wavy pattern is inversely related with blood pressure values and all subjects with straight arteries are invariably pre-hypertensive.

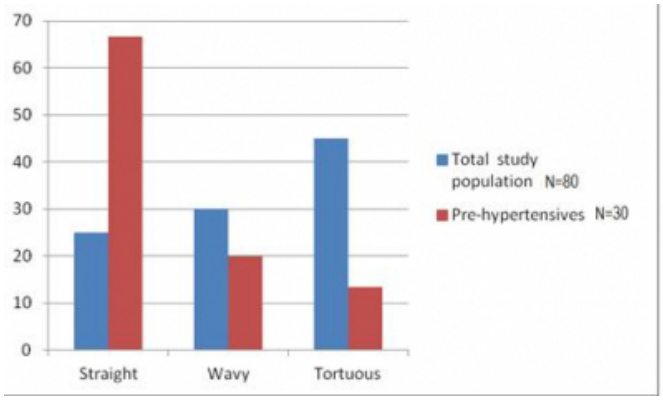
Morphology of retinal arteries in terms of tortuosity #	Total study population(N=80) n(%)	Pre-hypertensives (N=30) ** n(%)
Straight	20 (25 %)	20 (66.66%) *
Wavy	24 (30 %)	6 (20%)
Tortuous	36 (45%)	4 (13.33%)

 # Reported as the average of right and left eyes because the correspondence between right and left eyes was high (Fearson correlation=0.85).
*** N represents total number of fundus in the study group and n represents the number of fundus in each Graded sub group*
**p < 0.05; highly significant*

None of the participants had arterial hypertension or clinical diabetes but 15 participants met the criterion for pre-hypertension.
Pre-hypertensives showed a strong inclination for straight vessels.(Table 1, Figure 2)

Figure 2

Retinal arteriolar tortuosity distribution pattern (Straight:Wavy:Tortuous) in a study group comprising of normotensives (25:30:45%) and pre-hypertensives (66.66: 20: 13.33%)



Gender did not appear to affect wavy patterns of vessels in the study population except for Inferior nasal arteries of right eyes where differences were prominent; Females had more straight vessels as compared to Males.(Table 2 a,b)

Table 2a

Gender dimorphism in retinal arteriolar tortuosity of young healthy Indian adults (left eyes) ; N=40; 18 M and 22F; Mean age 35.1 years.

Retinal artery	Sex	Number of subjects	Mean	Standard deviation	95% confidence interval for mean		P value*
Superior Temporal vessel - Tortuosity (Left Eye)	Female	22	2.09	1.06	1.62	2.56	
	Male	18	2.44	1.15	1.87	3.02	
	Total	40	2.25	1.10	1.90	2.60	0.287
Superior Nasal vessel - Tortuosity (Left Eye)	Female	22	1.68	0.78	1.34	2.03	
	Male	18	2.44	1.50	1.70	3.19	
	Total	40	2.03	1.21	1.64	2.41	0.134
Inferior Temporal vessel - Tortuosity (Left Eye)	Female	22	1.86	1.28	1.29	2.43	
	Male	18	2.17	1.04	1.65	2.69	
	Total	40	2.00	1.18	1.62	2.38	0.168
Inferior Nasal vessel - Tortuosity (Left Eye)	Female	22	1.77	1.23	1.23	2.32	
	Male	18	1.94	1.30	1.30	2.59	
	Total	40	1.85	1.25	1.45	2.25	0.622

*Gender wise Mann Whitney test

Table 2b

Gender dimorphism in retinal arteriolar tortuosity of young healthy Indian adults (right eyes) ; N=40; 18 M and 22F; Mean age 35.1 years.

Retinal artery	Sex	Number of subjects	Mean	Standard deviation	95% confidence interval for mean		P value*
Superior Temporal vessel - Tortuosity (Right Eye)	Female	22	1.68	0.65	1.40	1.97	
	Male	18	1.83	0.71	1.48	2.18	
	Total	40	1.75	0.67	1.54	1.96	0.500
Superior Nasal vessel - Tortuosity (Right Eye)	Female	22	1.82	0.85	1.44	2.20	
	Male	18	1.83	0.92	1.37	2.29	
	Total	40	1.83	0.87	1.55	2.10	1.000
Inferior Temporal vessel - Tortuosity (Right Eye)	Female	22	1.82	0.66	1.52	2.11	
	Male	18	2.00	0.69	1.66	2.34	
	Total	40	1.90	0.67	1.69	2.11	0.397
Inferior Nasal vessel - Tortuosity (Right Eye)	Female	22	2.27	0.98	1.84	2.71	
	Male	18	1.61	0.61	1.31	1.91	
	Total	40	1.98	0.89	1.69	2.26	**0.027****

*Gender wise Mann Whitney test ** p value significant

The arteriolar wavy pattern or tortuosity was similar on both eye sides in the study subjects except for Superior Temporal arteries where statistically significant differences were observed between right and left eyes. Left side was predominantly wavy while right side was mainly straight.(Table 3)

Table 3

Right versus left sided dimorphism in retinal arteriolar tortuosity of young healthy Indian adults (N=40; 18 M and 22F; Mean age 35.1 years)

Retinal artery	Side	Number of fundus	Mean	Standard deviation	95% confidence interval for mean		P value*
Superior Temporal vessel - Tortuosity	Left side	40	2.25	1.10	1.90	2.60	**.032****
	Right side	40	1.75	0.67	1.54	1.96	
	Total	80	2.00	0.94	1.79	2.21	
Superior Nasal vessel - Tortuosity	Left side	40	2.03	1.21	1.64	2.41	.564
	Right side	40	1.83	0.87	1.55	2.10	
	Total	80	1.93	1.05	1.69	2.16	
Inferior Temporal vessel - Tortuosity	Left side	40	2.00	1.18	1.62	2.38	.739
	Right side	40	1.90	0.67	1.69	2.11	
	Total	80	1.95	0.95	1.74	2.16	
Inferior Nasal vessel - Tortuosity	Left side	40	1.85	1.25	1.45	2.25	.563
	Right side	40	1.98	0.89	1.69	2.26	
	Total	80	1.91	1.08	1.67	2.15	

*Wilcoxon sign rank test sidewise

** p value significant

Age was not a determinant of retinal arterial wavy layout in our study population.(Table 4)

Table 4

Correlation of tortuosity with age in retinal arteries of young healthy Indian adults (N=40, 18 M and 22F; mean age 35.1 years)

Spearman coefficient correlation with age	Superior Temporal vessel - Tortuosity (Right Eye)	Superior Nasal vessel - Tortuosity (Right Eye)	Inferior Temporal vessel - Tortuosity (Right Eye)	Inferior Nasal vessel - Tortuosity (Right Eye)	Superior Temporal vessel - Tortuosity (Left Eye)	Superior Nasal vessel - Tortuosity (Left Eye)	Inferior Temporal vessel - Tortuosity (Left Eye)	Inferior Nasal vessel - Tortuosity (Left Eye)
Correlation coefficient (r value)	.150	-.024	.161	.040	-.074	-.022	.247	-.032
P value*	.363	.885	.328	.809	.655	.896	.130	.845

*Not significant for all, showing that age is not associated with changes in retinal arterial wavy patterns among young healthy adults.

*Not significant for all, showing that age is not associated with changes in retinal arterial wavy patterns among young healthy adults.

DISCUSSION

The results of the present study demonstrated that wide variations in retinal arterial tortuosity may mostly be explained by the effect of demographic factors and health indices. Our findings established that BP status, age, gender and even side of the eye may affect tortuoisity patterns, even though BP levels exerted the highest degree of correlation with tortuosity while age, sex and right vs left laterality had minimalistic association. Population based studies establish that retinal venules are significantly more tortuous than retinal arterioles and less arteriolar tortuosity is independently associated with older age, higher blood pressure and higher body mass index. (Cheung ,2011) Our findings disagree with earlier studies in context of having found no effect of age on retinal arterial tortuosity. Perhaps age does matter, as quoted by others; but only after a certain period of time and maturity. Our study subjects were quite young (mean age 35.1 years) and physically healthy. Advancing age does take its toll on retinal vasculature; but more frequently in old aged or diseased individuals, particularly diabetics and hypertensives. Another research on retinal vascular morphology had findings similar to ours and recorded no change in tortuosity with respect to age in subjects 'without' hypertension. (Wang et al.,2006) In this study, pre-hypertensives, who had BP levels bordering around the upper limit of the clinically 'normal' range had strong inclination for straight arteries; or in other words, one can assume that BP levels are inversely related to tortuosity and less tortuosity might be an indicator of future cardiovascular events. Cheung et al(2011) found that retinal arteriolar tortuosity alterations were associated with higher levels of BP and BodyMassIndex and that venular tortuosity was associated with lower HDL levels. The role of arterial hypertension in modulating retinal arterial caliber, dilation and tortuosity is particularly interesting. Experiments on canines show that in response to increased transmural pressure, carotid artery dilates and elongates. (Van,1977) Qualitatively, one would naturally expect such effects from a flaccid elastic tube and observation of such passive behaviour in retinal arteries may indicate exhausted auto regulatory capacity in hypertensives, leading to arterial straightening. The exact mechanisms underlying the development and later modulation of the retinal vascular network are largely unknown. Retinal arterial tortuosity demonstrates strong heritability without adjustment for covariates among first order blood relations; especially twins.(Taarnh

CONCLUSION

The retina is a unique site where 'in vivo' microvasculature can be directly visualized and monitored repeatedly. Advances in retinal imaging techniques have facilitated the development of computer-assisted methods to measure and quantify subtle variations and abnormalities in the retinal microvasculature. These assessments can be applied to large populations in the community and clinic settings. Retinal

arteriolar tortuosity is variable; it may change with age, gender, right to left laterality and ethnicity. Fluctuations in BP levels strongly affect vascular morphology even in normotensives, with a predominantly straightening effect. Fundus photography may be used in the evaluation of a persons

References

Cheung CY, Zheng Y, Hsu W, Lee ML, Lau QP, Mitchell P, Wang JJ, Klein R, Wong TY.Retinal vascular tortuosity, blood pressure, and cardiovascular risk factors. Ophthalmology. 2011 May;118(5):812-8.

Christensen K, Vaupel JW, Holm NV, Yashin AI. Mortality among twins after age 6: fetal origins hypothesis versus twin method. BMJ 1995 February 18;310(6977):432-6.

Dirani M, Chamberlain M, Shekar SN, Islam AF, Garoufalis P, Chen CY, Guymer RH,Baird PN. Heritability of refractive error and ocular biometrics: the Genes in Myopia(GEM) twin study. Invest Ophthalmol Vis Sci 2006 November; 47(11): 4756-61. (95)

Hammond CJ, Snieder H, Gilbert CE, Spector TD. Genes and environment in refractive error: the twin eye study. Invest Ophthalmol Vis Sci 2001 May;42(6):1232-6.

Hayreh SS, Servais GE, Virdi PS. Retinal arterial changes in malignant arterial hypertension.Ophthalmologica 1989;198:178-96.

Hsu W, Lee ML, Lau PQ, Mitchell P, Wang JJ.Correlation and reproducibility of retinal vascular geometric measurements for stereoscopic retinal images of the same eyes.Ophthalmic Epidemiol. 2012 Oct;19(5):322-7.

Koh V, Cheung CY, Zheng Y, Wong TY, Wong W, Aung T.Relationship of retinal vascular tortuosity with the neuroretinal rim: the singapore malay eye study.Invest Ophthalmol Vis Sci. 2010 Jul;51(7):3736-41. doi: 10.1167/iovs.09-5008. Epub 2010 Mar 5

Lyhne N, Sjolie AK, Kyvik KO, Green A. The importance of genes and environment for ocular refraction and its determiners: a population based study among 20-45 year old twins. Br J Ophthalmol 2001 December;85(12):1470-6.

Owen CG, Rudnicka AR, Nightingale CM, Mullen R, Barman SA, Sattar N, Cook DG, Whincup PH.Retinal arteriolar tortuosity and cardiovascular risk factors in a multi-ethnic population study of 10-year-old children; the Child Heart and Health Study in England (CHASE).Arterioscler Thromb Vasc Biol. 2011 Aug;31(8):1933-8.

Sasongko MB, Wong TY, Nguyen TT, Cheung CY, Shaw JE, Wang JJ.Retinal vascular tortuosity in persons with diabetes and diabetic retinopathy .Diabetologia. 2011 Sep;54(9):2409-16. doi: 10.1007/s00125-011-2200-y. Epub 2011 May 29.

Sasongko MB, Wong TY, Donaghue KC, Cheung N, Jenkins AJ, Benitez-Aguirre P, Wang JJ.Retinal arteriolar tortuosity is associated with retinopathy and early kidney dysfunction in type 1 diabetes.Am J Ophthalmol. 2012 Jan;153(1):176-83

Sodi A, Guarducci M, Vauthier L, Ioannidis AS, Pitz S, Abbruzzese G, Sofi F, Mecocci A, Miele A, Menchini U.Computer assisted evaluation of retinal vessels tortuosity in Fabry disease. Acta Ophthalmol. 2012 Nov 20. doi: 10.1111/j.1755-3768.2012.02576.x. [Epub ahead of print]

Taarnhøj NC, Munch IC, Sander B, Kessel L, Hougaard JL, Kyvik K, Sørensen TI, Larsen M. Straight versus tortuous retinal arteries in relation to blood pressure and genetics.Br J Ophthalmol. 2008 Aug;92(8):1055-60.

Teikari JM, Kaprio J, Koskenvuo MK, Vannas A. Heritability estimate for refractive errors--a population-based sample of adult twins. Genet Epidemiol 1988;5(3):171-81.

Van LP. Length-force and volume-pressure relationships of arteries. Biorheology 1977;14:181-201.

Wang S, Xu L, Jonas JB, Wang YS, Wang Y, Yang H, Li J.Retinal vascular abnormalities in adult Chinese in rural and urban Beijing: the Beijing Eye Study. Ophthalmology. 2006 Oct;113(10):1752-7. Epub 2006 Jul 31.

Witt N, Wong TY, Hughes AD et al. Abnormalities of retinal microvascular structure and risk of mortality from ischemic heart disease and stroke. Hypertension 2006;47:975-81.

Wolffsohn JS, Napper GA, Ho SM et al. Improving the description of the retinal vasculature and patient history taking for monitoring systemic hypertension. Ophthalmic Physiol Opt. 2001;21:441-9.

Wong TY, Knudtson MD, Klein R, Klein BE, Meuer SM, Hubbard LD.Computer-assisted measurement of retinal vessel diameters in the Beaver Dam Eye Study: methodology, correlation between eyes, and effect of refractive errors.Ophthalmology. 2004 Jun;111(6):1183-90.

Author Information

Tabinda Hasan, Dr, Lecturer
Dept Of Anatomy, Faculty Of Medicine, Jazan University
Jazan, Saudi Arabia
drtabindahasan@gmail.com

Sanjay Sharma, Dr, Assistant Professor
Department Of Ophthalmology, Subharti Medical College
Meerut, Up, India

Khare Satyam, Dr, Professor And Head
Anatomy Department, Subharti Medical College
Meerut, Up, India

Jain Shilpi, Dr, Professor
Anatomy Department, Subharti Medical College
Meerut, Up, India