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Original Article

Normal Doppler Ultrasonography Indices of Bilateral Common and Internal Carotid Arteries". A Cross Sectional Study

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ABSTRACT

Carotid Arterial Intima Media Thickness (CA-IMT) is taken as an important indicator of atherosclerosis with increasing age and long term exposure to particulate air pollution associated diseases like hypertension, diabetes, obesity, cigarette smoking, alcohol usage, drugs, deranged lipid profile and high cholesterol, high salt and fatty diet **Objective:** To evaluate the Doppler ultrasonography indices of common and internal carotid arteries on both sides in normal individuals. **Methods**: A prospective comparative cross sectional study was conducted at Imperial Diagnostic and Research Centre, Imperial College of Business Studies, Lahore, Pakistan for a period of four months after the approval of synopsis. Convenient sampling technique was used and all patients visiting us during study interval of and fulfilling the inclusion criteria were included. A total of 50 participants age range from15 to 68 years, were included. Aloka Prosound α 5 SV, equipped with linear array probe with frequency of 6-9MHz, was used. All the participants, who were normal volunteers, were subjected to B-mode imaging and color-coded Doppler ultrasonography of their common carotid arteries and internal carotid artery in supine position. Baseline investigation was taken for blood pressure (BP) during resting phase. Participant's age, weight and height were also assessed and recorded on questionnaire forms. MedCalc was then used to apply relevant tests for statistical analysis. Repeated Measures ANOVA was performed to see the difference between the values taken during supine and standing position on each side. **Results:** The IMT showed significant positive correlation with the age in both right and left CCA and ICAs. EDV values of right CCA showed significant positive correlation and RI and PI showed significant negative correlation with age. PSV and SD values of left CCA and PSV of right ICA showed significant negative correlation with age. Left ICA diameter and PSV showed the significant positive correlation with age. **Conclusion:** The study provides the information about normal Doppler indices which might be useful in the evaluation of cases of carotid artery diseases. These figures can be used to gain a better understanding of the aetiology of ischemic strokes in the brain.

INTRODUCTION

Intima media thickness (IMT) of carotid artery is caused by fat deposition in the artery can lead to blockage of supply to the brain and lead to stroke. Stroke will lead to deprivation of brain cells from oxygen, as a consequence the brain cells die causing permanent disability [1,2]. Ultrasound imaging or carotid duplex is a safe, painless and widely used method to produce the pictures inside body by using ultrasound waves [3]. Conventional ultrasound uses a high frequency transducer for ultrasound scanning. Doppler ultrasound on the other hand evaluates the blood flow velocity and direction across a vessel. Carotid duplex uses a combination of conventional ultrasound and Doppler ultrasound for the assessment of carotid arteries blood flow, speed and direction of blood flow in the arteries and measuring the diameter of blood vessel and degree of obstruction if present [4]. Thickness of carotid artery is measured by using ultrasound pictures of intima and media thickness of a carotid artery the two most inner layers of carotid artery. And any abnormality in the thickness of the inner most layers of carotid arteries identify the

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cardiovascular disease [5]. Predictive value of carotid artery test is increased when carotid artery media thickness is measured at multiple extra cranial sites.
Normal IMT in healthy young people is < 0.8mm and value at or above 1mm is an indicator of atherosclerosis or any cardiovascular disease in any age group. Adults less than 30 years of age have a thickness of 0.73mm and <0.7mm respectively [6]. Focal areas of vessel stenosis have little effect on total flow in a vessel until a critical narrowing is reached. Generally about 70% reduction in area or a 50% reduction in diameter beyond this value blood flow rapidly decreases as the pressure drop across the narrowing increases [7]. Embryologic vascular system develops at 19th day before the appearance of somites. Primitive mesenchyme and mesoderm forms vascular channels within embryonic disc that coalesce into blood vessel. First three arches formed at 28th day of pregnancy and these arches involute at the formation of 5th, 6th and 7th arches. This pattern of formation and regression is considered as normal anatomical pattern of variations in great vessels [8]. The carotid vessel turns superiorly to emerge from carotid canal at the foramen lecerum. The carotid artery then runs medially, anteriorly and laterally to the sella turcica into the cavernous sinus. And it then enters into the subarachnoid space by turning upward and medial to the anterior clinoid process and pierces the dura into arachnoid [9]. Right common carotid artery takes its origin from brachiocephalic trunk at the base of neck. Left common carotid artery is the 2nd branch of aortic arch which takes its origin from highest part of aortic arch. Left common carotid artery is located posterior laterally to the brachiocephalic trunk in the superior media sternum and ascends antero-laterally to trachea to enter into the neck posterior to the left sternoclavicular joint [10]. The common carotid arteries and internal carotid artery peak systolic ratio lies within range of 0.3 to 1.0 in normal individuals. These velocities increase with increasing age. Volume flow measurement obtained from B-mode and Doppler ultrasound which requires knowledge of velocity profile within the vessel and it limits the accuracy of method. Normal variations are found in the origin of carotid artery 1st variant which is found is named as bovine arch in which origin of brachiocephalic trunk and left common carotid artery have the same origin. Ratio of bovine arch is 7-27%in patients. In 2.5% of patients another variant found in which right common carotid artery arising directly from the aortic arch and right sub-clavian artery arise distally from the arch and right common carotid artery is considered to be the 1st branch of the arch .third variant found have the same origin of left common carotid artery and sub-clavian artery which can lead to the formation of bilateral symmetrical brachiocephalic trunk [11]. Internal carotid artery remains in the carotid sheath and retains the same relationship with internal jugular vein and vagus nerve at the point which is located above the bifurcation of carotid artery into external and internal carotid arteries. Point of bifurcation of carotid arteries is superior border of the thyroid cartilage. Fusiform dilatation is seen at the point of carotid bifurcation due to presence of carotid bulb and carotid sinus which is encompassing the distal common carotid and proximal internal carotid and is present in almost 40% of cases [12]. Blood flow in the region of carotid artery bifurcation area reflects complex vessel anatomy in this segment. Blood flow adjacent to the opposite wall of the carotid sinus is characterized by recirculation documented by ultrasonography in young individuals. Beginning at early or peak systole and persisting for about 20% of the cardiac cycle flow reversal occupied about one third of the carotid sinus. Blood flow in the portion of bulb is stagnant in diastole [13]. Research work in recent ere in elastic models of cadaver bifurcations using Newtonian pattern of flow and physiologic pulsatile flow stagnant region in the posterior bulb seems to act as a buffer in systole high shear region and deflecting streamlines anteriorly into a high flow. Ultrasonography of carotid artery is a most popular tool for the evaluation of carotid artery diseases like atherosclerosis in the carotid artery to check the blood flow to brain in case of CVA and also in case of plaque characterization. Plaque ulceration could be a cause of future embolic event. Plaque morphology such as surface of plaque, echogenicity of plaque, presence of ulceration and stenosis is important for prediction of cardiovascular events.

METHODS

It was a prospective cross sectional study. The study was conducted at Imperial Diagnostic and Research Centre, Imperial College of Business Studies, Lahore, Pakistan. The research took place over the course of four months. Convenient sampling was done and all subjects fulfilling the inclusion criteria who volunteered and gave consent for the participation in the study were included. Healthy subjects without any history of stroke or transient ischemic attack, space occupying lesion in the brain, known atheromatous disease and uncontrolled hypertension were included in the study. A total of 50 patients were included in the study. The subject was made to lie comfortably in a supine or semi-supine position, with his or her neck somewhat hyperextended and rotated away from the side being checked. The architecture of the carotid artery, including intima media thickness and diameter, was documented using a high frequency linear transducer with a frequency of 7.5 MHz. By angulating the transducers caudally in the supraclavicular region and cephalically at the level of the

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mandible, the carotid arteries were attempted to be viewed as clearly and completely as feasible. Grey-scale ultrasonography was used to obtain IMT at the near or far wall of the CCA, bulb, and ICA. The intima, which appears to be echogenic, and the media, which appears to be echo-poor, were also measured. A Doppler sample was put in the vessel's centre, with the Doppler angle kept below 60 degrees while keeping parallel to the blood flow. At the proximal section of the CCA and ICA, the flow velocity (peak systolic and end-diastolic flow velocities) was assessed using pulsed Doppler (at least 1.5 cm distal to the bulb). Same procedure on other side. Pre-designed questionnaire questionnaires and data collecting sheets were used to record the information. These were then uploaded to EXCEL, where relevant statistical tests were applied using MEDCALC. The Pearson's correlation coefficients between Doppler indices and subject ages were then determined, and a normogram of these values was created utilizing the available data.

RESULTS

Table 1 shows the demographic data. Total 50 participants are included in this study, 44 were males and 6 were females. The demographic data includes mean value of age, blood pressure (diastolic and systolic), height and weight. Table 2 includes Doppler indices for common carotid and internal carotid arteries. Table 3 shows the involved Pearson's correlation Indexes of different factors of Common carotid (R&L) & internal carotid (R&L) including diameter, Intima media thickness, End diastolic velocity, Pulsatility Index, Peak systolic velocity, Resistive Index and systolic and end diastolic ratio.

	Mean	CI	Mean	CI
Age	27	16.4–37.5	28.68	25.55–31.81
BP-(Dia)	75	66.87– 83.2	78.63	75.8– 81.4
BP-(Sys)	113	108– 118	118.2	115.4– 120.9
Height	5.2	5.03–5.36	5.64	5.5 –5.7
Weight	49	46.51– 51.5	64.9	60.8– 68.9

Table 1: Shows the demographic details of the subjects (n=50) M=Male, F=Female, BP=Blood pressure, Dia=Diastole, Sys (Systole)

Index Laterality	Internal Carotid	p-value
Dia.	Left	0.08
	Right	0.7
EDV	Left	0.004*
	Right	0.00012*
IMT	Left	0.28
	Right	0.08
PI	Left	0.2
	Right	0.36
PSV	Left	0.4
	Right	0.016*
RI	Left	0.5
	Right	0.46
SD Ratio	Left	0.04*
	Right	0.27

Table 2: Details of the Doppler indices in common carotid arteries and Internal carotid of normal subjects

Index	RCCA	LCCA	RICA	LICA
Diameter	0.7	0.75	0.71	0.05
IMT	0.05	0.0001	0.0003	0.0001
EDV	0.04	0.06	0.58	0.5
PI	0.03	0.5	0.55	0.14
PSV	0.11	0.01	0.02	0.001
RI	0.04	0.6	0.02	0.45
S/D ratio	0.34	0.001	0.9	0.9

Table 3: The Pearson's correlation Indices of Common carotid (R&L) & Internal carotid (R&L)
R CCA=Right Common carotid artery, L CCA=Left Common carotid artery, R ICA= Right Internal carotid artery, L ICA=Left Internal carotid artery, IMT= Intima media thickness, EDV= End diastolic velocity, PI= Pulsatility Index, PSV= Peak systolic velocity, RI= Resistive Index, S/D ratio= Systolic and end diastolic ratio

Index Laterality	Internal Carotid	p-value
Dia.	Left	0.63
	Right	0.76
EDV	Left	0.4
	Right	0.71
IMT	Left	0.17
	Right	0.26
PI	Left	0.25
	Right	0.06
PSV	Left	0.2
	Right	0.03*
RI	Left	0.68
	Right	0.7
SD Ratio	Left	0.005*
	Right	0.008*

Table 3:

DISCUSSION

Another study categorize the participants in three age groups: one is of adults, 2nd is of middle age, third is of old age group. This study showed a significant correlation between increased CA-IMT with age older healthy people have increased CA-IMT than middle age group and adults. CA-IMT have a significant correlation with gender distribution male in comparison female group have an increase thickness of carotid artery intima media layer [16]. The recognition of normal patterns of the Doppler indices in the arteries supplying the brain therefore remains important as only in this way we will be able to identify the changes produced as a result of abnormalities. The issue of lack of validation data that directly relate to duplex carotid

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velocities should be addressed and reference standards for velocity criteria should be set up in order make the patients get benefitted from the diagnostic and therapeutic procedures such as CEA. The values of velocities such as PSV and EDV found in our study (19 cm/sec in left ICA and 24cm/sec in right ICA) were in complete agreement with the previously reported results i.e. normal ICAs PSV should be <125 cm/sec and EDV be <40cm/sec. Similarly the flow in the CCA should be greater than 45 cm/sec in normal healthy individuals [17]. As expected the values of IMT showed a significant degree of correlation with the advancement of age. These however did not differ in both the genders significantly. This finding is also in accordance with the previous studies [18-20]. This study of ours provides basic knowledge crucial to detect the abnormality found in vascular system. These data will serve as foundation or reference for the future studies. The limitation of our study however included the small sample size due to time restraints.

CONCLUSION

The study provides the information about normal Doppler indices, which might be useful in the evaluation of cases of carotid artery diseases. These values can form the basis for better knowledge about the pathogenesis of ischemic cerebral events.

REFERENCES

[1] Kaźmierski P, Pająk M, Bogusiak K. Concomitance of atherosclerotic lesions in arteries of the lower extremities and carotid arteries in patients with abdominal aorta aneurysm. Artery Research. 2016 Dec 1;16:11-7. doi.10.1016/j.artres.2016.08.003

[2] Silitongo M, Mulipilwa MD, Mwaba C, Mutemwa S. Common Trunk Origin of the Brachiocephalic and Left Common Carotid Arteries from the Aortic Arch. MOJAnat&Physiol.2017;3(2):00086.doi.10.15406/mojap.2017.03.00086

[3] Li W, Yang L, Lyu H. A Rare Case of Carotid Body Tumor Presenting with Internal Carotid Artery Blood Supply and Carotid Sinus Syndrome. Chin Med J (Engl). 2016 Feb 20;129(4):496-7. doi: 10.4103/0366-6999.176085.

[4] Hossein-Nejad H, Mohammadinejad P, Ahmadi F. Internal jugular vein/common carotid artery cross-sectional area ratio and central venous pressure. J Clin Ultrasound. 2016 Jun;44(5):312-8. doi: 10.1002/jcu.22339.

[5] Todua F, Gachechiladze D. Common Carotid Artery Intima-Media Layer Changes. InNoninvasive Radiologic Diagnosis of Extracranial Vascular Pathologies 2018 (pp. 137-142). Springer, ChamS doi.10.1007/978-3-319-91367-4_11

[6] Egilmez OK, Uzun L, Kalcioglu MT, Tekin M. Multiple variations in carotid arteries: lower common carotid bifurcation, hypoplastic and tortuous internal carotid artery. British Journal of Medicine and Medical Research.2017;21(11):14.doi.10.9734/BJMMR/2017/33449

[7] Foreman PM, Harrigan MR, Griessenauer CJ, Loukas M, Tubbs RS. Access to the carotid artery bifurcation: Cadaveric study with application to nasotracheal intubation as a technique to improve access to a high carotid artery bifurcation. Br J Neurosurg. 2015;29(6):865-7.doi:10.3109/02688697.2015.1071331.

[8] Nieddu M, Boatto G, Pirisi MA, Dessì G. Determination of four thiophenethylamine designer drugs (2C-T-4, 2C-T-8, 2C-T-13, 2C-T-17) in human urine by capillary electrophoresis/mass spectrometry. Rapid Commun Mass Spectrom. 2010 Aug 30;24(16):2357-62. doi: 10.1002/rcm.4656.

[9] Girsowicz E, Georg Y, Lefebvre F, Lejay A, Thaveau F, Roy C, Ohana M, Chakfe N. Anatomical Study of Healthy Aortic Arches. Ann Vasc Surg. 2017 Oct;44:179-189. doi: 10.1016/j.avsg.2017.03.196.

[10] Awad IA, Abbas HY. Ultrasound evaluation of carotid artery intima-media thickness in patients with risk factors for cardiovascular disease. Int. J. Diagn. Imaging. 2017;4:16. doi.10.5430/ijdi.v4n2p16

[11] Chen SY, Hsu HY. Analysis of Doppler blood flow waveform of cerebral arteries and common abnormal findings. J Med Ultrasound. 2014 Mar 1;22:3-6.22:3-6.doi.10.1016/j.jmu.2013.12.004

[12] Kamenskiy AV, Dzenis YA, Mactaggart JN, Desyatova AS, Pipinos II. In vivo three-dimensional blood velocity profile shapes in the human common, internal, and external carotid arteries. J Vasc Surg. 2011 Oct;54(4):1011-20. doi: 10.1016/j.jvs.2011.03.254.

[13] Cheng Q, Huang CB, Wang JY, Jiang B, Zhang LB, Zeng M, Chen YB, Zhang HF, Chen FH. Application of 3-Dimensional Computerized Tomography Angiography for Defining Cavernous Sinus Aneurysms and Intradural Aneurysms Involving the Internal Carotid Artery Around the Anterior Clinoid Process. World Neurosurg. 2017 Oct;106:785-789. doi: 10.1016/j.wneu.2017.06.172.

[14] Steinke W, Kloetzsch C, Hennerici M. Carotid artery disease assessed by color Doppler flow imaging: correlation with standard Doppler sonography and angiography. AJNR Am J Neuroradiol. 1990 Mar-Apr;11(2):259-66.

[15] Rohren EM, Kliewer MA, Carroll BA, Hertzberg BS. A spectrum of Doppler waveforms in the carotid and vertebral arteries. AJR Am J Roentgenol. 2003

DOI: https://doi.org/10.54393/pbmj.v5i6.566

Dec;181(6):1695-704. doi: 10.2214/ajr.181.6.1811695.
[16] Ishigami D, Ota T. Spontaneous Bilateral Cervical Internal Carotid Artery Dissection Treated with Simultaneous Bilateral Carotid Artery Stenting: A Case Report. NMC Case Rep J. 2019 May 25;6(3):71-74. doi: 10.2176/nmccrj.cr.2018-0257.
[17] Lee W. General principles of carotid Doppler ultrasonography. Ultrasonography. 2014 Jan;33(1):11-7. doi: 10.14366/usg.13018. Epub 2013 Dec 11. PMID: 24936490;doi.10.14366/usg.13018
[18] Casella IB, Sotelo FJ, Yamazaki Y, Presti C, Vassoler A, Melo HA. Comparison of common carotid artery intima-media thickness between Brazilian Euro-descendants and Afro-descendants with atherosclerosis risk factors. Clinics (Sao Paulo). 2009;64(7):65764.doi:10.1590/S180759322009000700009.
[19] Kiechl SJ, Staudt A, Stock K, Gande N, Bernar B, Hochmayr C, Winder B, Geiger R, Griesmacher A, Anliker M, Kiechl S, Kiechl-Kohlendorfer U, Knoflach M, Pechlaner R; Early Vascular Ageing (EVA) Study Group *. Predictors of Carotid Intima-Media Thickness Progression in Adolescents-The EVA-Tyrol Study. J Am Heart Assoc. 2021 Sep 21;10(18):e020233. doi: 10.1161/JAHA.120.020233.
[20] Bae JH, Kim WS, Lee MS, Kim KS, Park JB, Youn HJ, Park CG, Hong KS, Kim JY, Jeong JW, Park JC, Lim DS, Kim MH, Woo JT. The changes of individual carotid artery wall layer by aging and carotid intima-media thickness value for high risk. Cardiovasc Ther. 2016 Dec;34(6):397-403. doi: 10.1111/1755-5922.12209.