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Review Article

Sonographic Assessment of Carotid Artery Stenosis in Atherosclerotic Patients by Color Doppler Ultrasound: Literature Review

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ABSTRACT

Mostly patients with neck pain, cold sweats, chest pain, high blood pressure and heart palpitations are assessed by sonography. Because major blood vessels supplying the brain and face through carotid arteries. Mostly, intima media thickness is one of the markers of atherosclerotic patient that is widely used. The aim of study is to find out stenosis with carotid arteries with the help of color Doppler scan. The data was included in literature review from several search engines. In this literature review, olny 20 articles were used for extraction of data related to topic statement. The current study looked sonographic assessment of carotid artery in atherosclerotic patients. It is concluded that Color Doppler ultrasound is a non-invasive and easier modality of choice for evaluating the patient with atherosclerosis, it helps in diagnosis of flow as well as prediction of carotid artery stenosis.

INTRODUCTION

The principal blood vessels supplying the brain and face are the carotid arteries. In contrast to the left common carotid artery (LCCA), which emerges from the arch of the aorta in the thorax, the right common carotid artery (RCCA) begins in the neck from the brachiocephalic artery. Additionally, the internal carotid artery (ICA), which serves the brain, and the external carotid artery (ECA), which supplies the neck and face, divide the right and left common carotid arteries into two different blood vessels at the level of carotid bulb in neck [1]. The intima-medial thickness (IMT) is one of the markers of atherosclerosis that is widely used. A two-dimensional (2D) grayscale image is used to measure the IMT. Two echogenic interfaces are seen along the arterial wall in the best gray-scale image of the carotid artery with longitudinal scan, which passes by the center of artery. The interface between the blood and intima is represented by the upper echogenic line in the far wall, while the middle layer and outer layer are represented by the lower

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echogenic line. No interface is created by the tunica intima and tunica media layers. The thickness of the inner and middle layer is indicated by the distance between the top and lower echogenic lines. The carotid artery should ideally be parallel to the probing surface in order to lessen the diagonal measurement's tendency to overestimate the intima media thickness. The intima media thickness is generally determined on the distal common carotid artery at the far wall because it is less variable than the internal carotid artery owing to the beam angling with vessel depth [2]. Gray-scale imaging should be used to determine the size, location, and features of plaque in internal and common carotid arteries (CCA and ICA). The transducer should be angled caudally in the supraclavicular region and cephalically at the level of the mandible in order to obtain the most accurate images of the vasculature. To identify locations with aberrant blood flow that demand Doppler spectrum analysis, color Doppler imaging should be used [3]. Color Doppler sonography enables the real-time imaging of vascular lesions and accompanying flow irregularities, directs the cursor location on suspected sites of stenosis, and helps distinguish between critical stenosis and occlusion [4]. Real-time B-mode and color-flow images of these vessels are combined with the analysis of Doppler velocity spectra to identify and quantify stenotic lesions. There are several ways to calculate the degree of stenosis based on various velocity criteria, but they all exhibit significant variation [5]. For risk assessment, carotid artery sonography is performed; on a gray scale ultrasonography, CIMT in the common carotid artery is assessed. The plaques are classified as echogenic, calcified, or hypoechoic, or they may be connected to intraplaque hemorrhage, and surface ulceration[6]. Furthermore, tiny, nonstenotic(50%)plaque identification and echo morphology description are made achievable by the use of high-resolution B-mode real-time sonography. The general applicability of traditional duplex analysis is constrained because it has trouble identifying local changes in flow patterns near tiny plaques and distinguishing them from complicated blood-flow variants in the normal carotid bifurcation[7].

METHODS

Data from several search engines were retrieved for this literature view. Data for this literature study was collected from PubMed, science direct, NCBI, Medline, Medscape and Google scholar. Intima-media thickness, Carotid arteries and atherosclerosis were utilized as search terms for publication. Only those papers which shows that individuals with atherosclerosis with intima-media-thickness were included after conducting unbiased database searches. Research was evaluated for both its quality and its usefulness. Data extraction from the whole journal articles was done.

RESULTS

Only 20 articles were used for extraction of data related to sonographic assessment of carotid artery stenosis in atherosclerotic patients. The current study looked at the assessment of carotid artery stenosis.

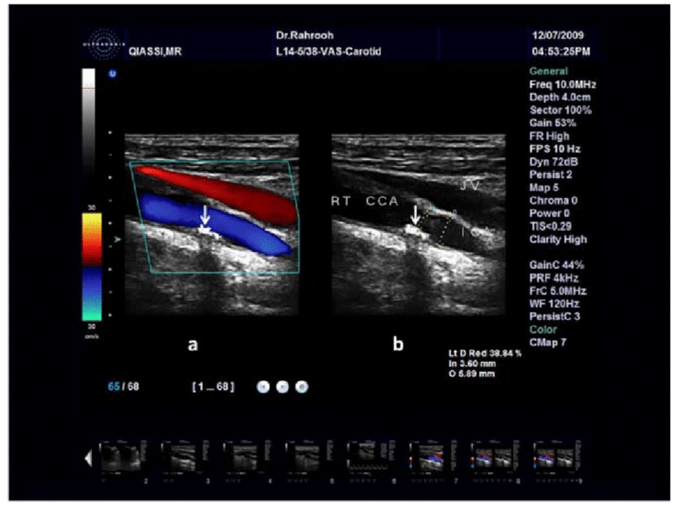

Figure 1: Unilateral calcified plaque with narrowing of right common carotid and internal carotid artery[8].

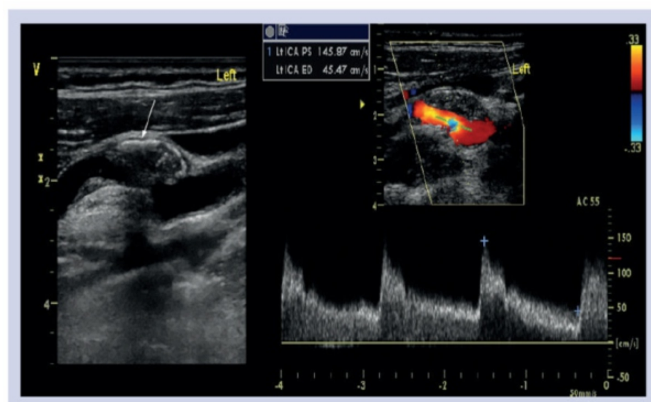

Figure 2: Doppler ultrasound of left carotid artery in a patient with asymptomatic stenosis with suggestive of plaque hemorrhage [9].

DISCUSSION

Color Doppler US in combination with a grayscale image has shown to be a noninvasive technique to evaluate carotid artery atherosclerosis by measuring the intima-media thickness of the carotid wall. According to US recommendations, the susceptibility of atherosclerotic plaque is highlighted utilizing echogenicity. However, there are a number of drawbacks to using color Doppler US to assess plaque. A large calcification within the plaque first creates an auditory shadow that impedes further analysis of interior segments. Second, with greatly vessel bifurcation above at the level of mandible, it demonstrates the internal carotid artery. Third, in a complicated plaque

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with atherosclerotic patient, ultrasound waves may be substantially reflected at the calcified boundary, which results in an underestimating of the plaque's susceptibility. Finally, a plaque that is evenly formed of fibrous plaque may have poor echogenicity within the arterial wall [10]. According to Mathiesen *et al.*, smoking, high blood pressure, hyperlipidemia, male sex, and advanced age all contribute to a higher incidence of carotid stenosis [11]. In terms of prevalence, the majority of the plaques is hyperechogenic, followed by calcified plaque, moderately echogenic plaques, and low echogenic plaques. The majority of those with severe stenosis have a peak systolic velocity ratio of ICA/CCA > 1.5 [12]. Carotid duplex ultrasound has a 90% to 95% sensitivity and specificity range for measuring carotid diameter reduction, and it may be more sensitive to find small amounts of atherosclerotic plaque Early detection, clinical staging, surgical planning, and postoperative therapeutic surveillance can all be referred to as carotid imaging objectives [13]. In rating ultrasonography plaques subjectively, Geroulakos *et al.*, discovered good repeatability and a strong association with histology. Thus, the plaque's sonographic characterization plays a predictive significance. Currently, it is thought that anechoic or hypoechoic plaques, which are linked to an elevated risk of stroke, are caused by intraplaque hemorrhage or lipid deposits. Calcified plaques are typically stable and present in asymptomatic patients. A nidus for emboli that can result in transient ischemic stroke or cerebrovascular accidents can be irregular or ulcerated plaques [14]. It's possible that increased IMT, a sign of subclinical atherosclerotic disease, is a result of prior exposure to conventional risk factors. Even while IMT is present in the majority of patients with arterial hypertension, their degree of thickness is comparable to that of those without arterial hypertension. There is no correlation between other risk variables and IMT [15]. Atherosclerotic stenosis of the ICA, particularly in the proximal section, is the cause of about 10%–15% of all strokes and transient episodes with ischemic origin. Differentiating between a total ICA occlusion and a preclusive stenosis, which is defined as a stenosis of at least 90%, is crucial in the first workup of ICA stenosis. Surgery may be used to treat preclusive symptomatic stenosis [16]. The clinical acquisition of even more pertinent information about the relationship between biological age and early atherosclerotic changes, as well as the relationship between arterial hypertension, hyperlipidemia, diabetes, and other risk factors for ICV and the progression of atherosclerotic changes in the intima of carotid arteries, is made possible by ultrasound [17]. Imaging studies have also highlighted the possibility that stroke risk may depend on the plaque's morphological characteristics, such as ulcers or fissures that can rupture the plaque itself, in addition to the degree of stenosis. In order to reduce the frequency and severity of acute cerebrovascular illness, a proper diagnostic and preventative approach that focuses on risk stratification and treatment planning must therefore take into account all of these factors [18]. Furthermore, if collateral flow events associated with an ICA occlusion are mistaken for residual ICA flow, needless diagnostic procedures with a high risk of harm may be carried out [19]. Color Doppler with low PRF enables quick detection of the low flow conditions in the arteries distal to the occluded CCA. We can make judgments about the major cause of the obstruction and, in certain situations, the severity of obstruction based on the sonographic characteristics of the discrete thrombus. Bilateral CCA blockage is generally uncommon, mostly observed in atherosclerotic patients and Takayasu's arteritis [20]. The carotid arteries have a significantly bigger diameter and experience distinct hemodynamic conditions, according to commonly held belief, hence the situation is different there. Additionally, carotid arteries often generate symptoms by embolization without local vascular closure, whereas coronary arteries typically do so due to plaque rupture leading to thrombotic luminal occlusion. However, regardless of the level of stenosis, there is mounting evidence that active, unstable plaques in the carotid arteries are more susceptible to embolization [21]. The IMT of the distal CCA below the carotid bifurcation in cases of CCA stenosis is frequently determined noninvasively using ultrasound imaging in particular. The IMT readings determined by various factors using this technique are subject to both inter-observer and intra-observer variability [22].

CONCLUSIONS

Color Doppler ultrasound is a non-invasive and easier modality of choice for evaluating the patient with atherosclerosis, it helps in diagnosis of flow as well as prediction of carotid artery stenosis.

Authors Contribution

Conceptualization: MAR
Methodology: FSZ
Formal analysis: MAR, MS, LA
Writing, review and editing: HS, SHMG

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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REFERENCES

[1] Khan H, Shaikh F, Syed MH, Mamdani M, Saposnik G, Qadura M. Current Biomarkers for Carotid Artery Stenosis: A Comprehensive Review of the Literature. Metabolites. 2023 Aug; 13(8): 919. doi: 10.3390/metabo13080919.
[2] Lee W. General principles of carotid Doppler ultrasonography. Ultrasonography. 2014 Jan; 33(1): 11. doi: 10.14366/usg.13018.
[3] Tahmasebpour HR, Buckley AR, Cooperberg PL, Fix CH. Sonographic examination of the carotid arteries. Radiographics. 2005 Nov; 25(6): 1561-75. doi: 10.1148/rg.256045013.
[4] Gaitini D, Soudack M. Diagnosing carotid stenosis by Doppler sonography: state of the art. Journal of Ultrasound in Medicine. 2005 Aug; 24(8): 1127-36. doi: 10.7863/jum.2005.24.8.1127.
[5] Bucek RA, Reiter M, Dirisamer A, Haumer M, Fritz A, Minar E, *et al.*, Three-dimensional color Doppler sonography in carotid artery stenosis. American Journal of Neuroradiology. 2003 Aug; 24(7): 1294-9.
[6] Haq S, Mathur M, Singh J, Kaur N, Sibia RS, *et al.*, Colour Doppler evaluation of extracranial carotid artery in patients presenting with acute ischemic stroke and correlation with various risk factors. Journal of Clinical and Diagnostic Research. 2017 Mar; 11(3): 1-5. doi: 10.7860/JCDR/2017/25493.9541.
[7] Steinke W, Kloetzsch C, Hennerici M. Carotid artery disease assessed by color Doppler flow imaging: correlation with standard Doppler sonography and angiography. American Journal of Neuroradiology. 1990 Mar; 11(2): 259-66.
[8] Imanimoghaddam M, Rooh MR, Hashemi EM, Blouri AJ. Doppler sonography confirmation in patients showing calcified carotid artery atheroma in panoramic radiography and evaluation of related risk factors. Journal of Dental Research, Dental Clinics, Dental Prospects. 2012; 6(1): 6-11.
[9] Mughal MM, Khan MK, DeMarco JK, Majid A, Shamoun F, Abela GS. Symptomatic and asymptomatic carotid artery plaque. Expert Review of Cardiovascular Therapy. 2011 Oct; 9(10): 1315-30. doi: 10.1586/erc.11.120.
[10] Watanabe Y, Nagayama M, Suga T, Yoshida K, Yamagata S, Okumura A, *et al.*, Characterization of atherosclerotic plaque of carotid arteries with histopathological correlation: vascular wall MR imaging vs. color Doppler ultrasonography (US). Journal of Magnetic Resonance Imaging: An Official Journal of the International Society for Magnetic Resonance in Medicine. 2008 Aug; 28(2): 478-85. doi: 10.1002/jmri.21250.
[11] Rustempasic N and Gengo M. Assesment of carotid stenosis with CT angiography and color Doppler ultrasonography. Medical Archives. 2019 Oct; 73(5): 321-5.
[12] Sharma R and Mattoo P. Colour Doppler study of extracranial carotid arteries in stroke. JK Science. 2015 Apr; 17(2): 88-91.
[13] ul Hadi N, Khan R, Awan KH, Iqba N. Frequency of carotid artery stenosis in ischemic stroke by using carotid doppler ultrasonography in a teaching hospital. Gomal Journal of Medical Sciences. 2009 Dec; 7(2).
[14] Lam WW, Liu KH, Leung SF, Wong KS, So NM, Yuen HY, *et al.*, Sonographic characterisation of radiation-induced carotid artery stenosis. Cerebrovascular Diseases. 2002 Mar; 13(3): 168-73. doi: 10.1159/000047771.
[15] Medina G, Casaos D, Jara LJ, Vera-Lastra O, Fuentes M, Barile L, *et al.*, Increased carotid artery intima-media thickness may be associated with stroke in primary antiphospholipid syndrome. Annals of The Rheumatic Diseases. 2003 Jul; 62(7): 607-10. doi: 10.1136/ard.62.7.607.
[16] Rübenthaler J, Reiser M, Clevert DA. Diagnostic vascular ultrasonography with the help of color Doppler and contrast-enhanced ultrasonography. Ultrasonography. 2016 Oct; 35(4): 289-301. doi: 10.14366/usg.16027.
[17] Tetičkovič E, Gajšek-Marchett M, Matela J, Flis V. Three-dimensional ultrasonography for the evaluation of atherosclerotic stenoses of the carotid trunk. Collegium Antropologicum. 2001 Dec; 25(2): 511-20.
[18] Anzidei M, Napoli A, Zaccagna F, Di Paolo P, Saba L, Cavallo Marincola B, *et al.*, Diagnostic accuracy of colour Doppler ultrasonography, CT angiography and blood-pool-enhanced MR angiography in assessing carotid stenosis: a comparative study with DSA in 170 patients. La Radiologia Medica. 2012 Feb; 117(1): 54-71. doi: 10.1007/s11547-011-0651-3.
[19] Clevert DA, Sommer WH, Zengel P, Helck A, Reiser M. Imaging of carotid arterial diseases with contrast-enhanced ultrasound (CEUS). European journal of radiology. 2011 Oct; 80(1): 68-76. doi: 10.1016/j.ejrad.2010.12.103.
[20] Bajkó Z, Bălaşa R, Moţăţăianu A, Maier S, Chebuţ OC, Szatmári S. Common carotid artery occlusion: a case series. International Scholarly Research Notices. 2013;2013. doi: 10.1155/2013/198595.
[21] Brinjikji W, Huston J, Rabinstein AA, Kim GM, Lerman A, Lanzino G. Contemporary carotid imaging: from degree of stenosis to plaque vulnerability. Journal of

DOI: https://doi.org/10.54393/pjhs.v4i10.1088

Neurosurgery. 2016 Jan; 124(1): 27-42. doi: 10.3171/2015.1.JNS142452.
[22] Saba L, Sanfilippo R, Montisci R, Mallarini G. Carotid artery wall thickness: comparison between sonography and multi-detector row CT angiography. Neuroradiology. 2010 Feb; 52: 75-82. doi: 10.1007/s00234-009-0589-5.