ISSN: 0975-3583,0976-2833 VOL15, ISSUE 05, 2024

ORIGINAL RESEARCH

Sonographic assessment of carotid artery atherosclerosis in stroke individuals- A prospective study

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Received: 18 March, 2024 Accepted: 23 April, 2024

Abstract

Aims and Objectives: Cerebral ischemic stroke is life-threatening and debilitating neurological disease, it is the third leading cause of death in the world. Studies have shown that there is a close relationship between carotid artery stenosis and ischemic cerebral vascular disease(2). This study is done to assess the carotid arteries with the help of color Doppler sonography and to correlate cerebrovascular accidents.

Materials and Methods: The prospective study was carried out on 50 patients using purposive sampling technique. Risk factors such as hypertension, diabetes mellitus, smoking, and family history were documented.The data gathered from color Doppler examination consisted of peak systolic velocity of common carotid artery (CCA) and internal carotid artery (ICA), velocity ratios between CCA and ICA and plaque characteristics as seen on real-time image.

Statistical Analysis Used: The collected data were analyzed and presented in the form of tables and diagrams wherever necessary.As this study deals with the only frequency distribution of various factors, so no tests of significance were applied.

Results: The highest incidence of stroke was found in the male population in the age group of 51-60 years.Various risk factors included hypertension, diabetes mellitus, smoking, and family history. Of 50 patients, 12 patients showed significant stenosis (>60%).Atherosclerotic plaques were seen in 38patients (76%).

Conclusion: Color Doppler examination is an economic, safe, reproducible, and less time-consuming method of demonstrating the cause of cerebrovascular insufficiency in extracranial carotid artery system and will guide in instituting treatment modalities.

Key words: Atherosclerotic plaque, color Doppler sonography, common carotid artery, internal carotid artery, peak systolic velocity.

Introduction

Stroke is clinical manifestation of an abrupt deficit in neurologic activity or cerebral function due to vascular cause. Transient ischemic attack (TIA) is the deficit in neurologic activity to a definite area for less than 24 hours and reversible ischemic neurologic deficit (RIND) is abrupt neurological activity for more than 24 hours until one week. Stroke has evidently grown as a major health concern worldwide due to resultant high rate of morbidity and mortality(3). Atherosclerotic disease of carotid arteries external to cranial cavity is identified as the most common source of emboli leading to stroke. Thus, carotid pathology is

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significantly associated to stroke and due to the associated high fatality rate, early diagnosis and effective as well as quick management and treatment of stroke is essential. Aging, gender, hypertension, smoking, ischemic heart disease and hyperlipidemia either alone or in combination sever as major causative factors that significantly contributes to carotid atherosclerotic plaque and carotid artery stenosis.Carotid atherosclerotic plaques can be identified by an increase in the combined thickness of the intima and media layers, and subsequently by echogenic material that encroaches on the arterial lumen(4). Intima media thickness is considered as a surrogate marker for atherosclerotic disease and is observed that intimomedial thickness greater than 0.8 mm is abnormal and may represent the earliest changes of atherosclerotic disease.

Published literature reports that atherosclerosis is a response to injury that is mediated by the endothelial cells that line the arteries(6). Literature additionally reports that denuded or ulcerated carotid plaque surfaces are common sources of cerebral emboli that cause a stroke/ other neurologic events. Therefore, ultrasound assessment of plaque surface features is of considerable diagnostic interest. Conventional diagnostic approaches like arteriography, contrasts enhanced dynamic computed tomography and magnetic resonance arteriography lacks the efficacy to accurately and quickly diagnose carotid atherosclerosis as they have the ability only to measure vessel luminal size but cannot characterize vessel wall and associated plaques. Carotid Doppler ultrasonography (CDU) is considered to be an effective and powerful tool for assessing atherosclerosis of the carotid artery. Color Doppler ultrasonography with minor modifications is an economical, non-invasive, readily available and reliable tool with relatively better sensitivity and specificity for assessing carotid atherosclerosis with smallest plaque size.Color Doppler imaging is mainly based on quantifying the degree of stenosis caused by atherosclerosis in a patient with stroke, additionally, intima-media thickness (IMT) of the common carotid artery (CCA) and plaque morphology may also help in assessing the carotid artery atherosclerosis.

The distinction between a total vessel occlusion and 99% diameter reduction is crucial since the former is a contra-indication to surgery.Internal carotid artery occlusion on the ultrasonography can be inferred on the basis of the lack of pulsation or expansion of vessel walls but this is unreliable. The diagnosis of occlusion based on the detection of a thrombus-filled lumen, the absence of wall motion characteristics and the lack of Doppler flow signal has a high reported accuracy.Color Doppler improves the ability of ultrasonography to distinguish between occlusion and severe stenosis by allowing a narrow channel to be identified. The ICA PSV and the presence of plaque at grey-scale or color Doppler imaging are primary parameters for the grading of ICA stenosis. If the degree of stenosis is indeterminate according to the primary parameters, then additional parameters including the ICA/CCA PSV ratio and the ICA end-diastolic velocity will be taken into consideration. If the CCA is stenotic, the PSV of the non-stenotic segment of the CCA (point A) proximal to the stenotic segment (point B) may also be measured to calculate the ICA/CCA point A PSV ratio and the CCA point B/CCA point A PSV ratio. Sonographic features of a severe ICA or CCA stenosis may include the following: PSV greater than 230 cm/sec, a significant amount of visible plaque (≥50% lumen diameter reduction on a gray-scale image), color aliasing despite a high color velocity scale setting (≥100 cm/sec), spectral broadening, post-stenotic turbulence at color Doppler and PW Doppler imaging, color bruit artifact in the surrounding tissue of the stenotic artery, end-diastolic velocity of greater than 100cm/sec, ICA/CCA PSV ratio of 4.0 or greater, and finally a high-pitched sound at PW Doppler imaging.The higher the degree of stenosis, the more likely it was associated with heterogeneous plaques. Heterogeneous plaques were also associated with an incidence of cerebrovascular symptoms (TIA/stroke) that was higher than that inhomogeneous plaque for all grades of stenosis. Heterogeneity of the plaques was reported to be more positively correlated with symptoms

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 05, 2024

than with any degree of stenosis, regardless of the plaque structure. Thus, Duplex color Doppler ultrasound imaging study of carotid arteries in stroke patients can aid in planning management strategies and deciding whether medical or surgical treatment is required for stroke patients.

Materials and methods

This descriptive study was carried out on 50 patients who had symptoms and signs of a stroke or TIAs at PBM hospital bikaner for a period of 1 year. Patients were selected using purposive sampling technique without any age, sex, ethnic, or socioeconomic discrimination. A detailed history and thorough physical examination were carried out on a questionnaire. Risk factors such as hypertension, diabetes mellitus,smoking,and ischemic heart disease were documented. The patients underwent computed tomography (CT) scan study prior to the color Doppler sonography of carotid arteries and findings were documented. Cases with history,clinical and CT scan findings consistent with cerebral ischemic stroke were included in this study. Patients having symptoms suggestive of vertebrobasilar insufficiency, head injuries, and those having primary and metastatic brain tumors were excluded from the study.

Data collection techniques and tools

The data gathered from the CT scan examination consisted of: Side of the infarct – Right, left;Vascular territory – Middle cerebral artery, anterior cerebral artery, posterior cerebral artery; Cortical or subcortical infarct – Time interval between the onset of clinical signs/symptoms of ischemic stroke and CT scan performed. The data gathered from the color Doppler examination consisted of:Peak systolic velocity (PSV) of common carotid artery (CCA) and ICA; ICA/CCA velocity ratios; Plaque characteristics;The presence of spectral broadening; and Detection and grading of carotid artery stenosis.

Equipment Color Doppler sonography was done using sonoscape P20 machine with a linear array transducer of 7 MHz. Prior CT scan was performed using GE 128 slice CT machine. Criteria used for measuring percentage of stenosis in our study (a) ICA/CCA PSV ratios, and (b) Residual lumen diameter at most stenotic portion was compared to lumen diameter in the ICA bulb as used in Asymptomatic Carotid Atherosclerosis Study. The diameter of the residual lumen and the external diameter of the artery at the same level were measured and the degree of stenosis was calculated using the relationship: Percent stenosis = (D − d) 100/D,where D is vessel wall-to-wall diameter and d, is patent vessel diameter.

Results

Among the 50 patients, 34 patients (68%) were males and 16 (32%) were females. Of the 50 patients studied, the maximum patients were seen in the age group of 50–59 years that is 18 (36%) patients. Next age group was of 70–79 years with 5 (10%) patients. In age group 40-49 years there were 10 (20%) patients and >80, there was only one patient (2%).20 (40%) patients had right-sided stroke and 18 (36%) patients had left-sided stroke. Bilateral involvement was seen in 2 (4%) patients and 10 (20%) patients hadTIA. 10 patients with significant stenosis (>60% stenosis) were seen. Smoking and hypertension were the most prevalent risk factors for cerebral ischemic stroke. CT brain findings showed normal findings in 13 cases, whereas lacunar infarcts (13 cases) were the most common pathological involvement. Of the 10 patients with significant stenosis,none of the patients showed bilateral involvement. seven (70%) patients had right-sided involvement and 3 (30%) patients had left-sided involvement. Six patients have 60–79% occlusion, 2 patients have 80–89% occlusion whereas 2 patients have complete occlusion . Of the total 38 patients with occlusion, 28 have occlusion <60%.

Atherosclerotic changes in the form of atheromatous plaques were found to be the main cause

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of obstruction. Of the 38 patients having plaque in the extracranial carotid system, 22 patients had bilateral involvement, 9 patients had plaque on right side and 7 patients had plaque on the left side.The remaining 12(24%) patients out of 50 showed no evidence of plaque. In our study, ICA was found to be the commonest site affected . Plaques in the CCA were also seen on the right side in 1 patient and 1 on the left side. Bilateral involvement was seen in 1 patient.The bilateral homogenous plaque was the most commonly seen type of plaque .

Distribution of patients based on demographic details

Age (years)	N	Percentage(%)
41-50	10	20
51-60	18	36
61-70	16	32
71-80	5	10
>80	1	2
total	50	100
GENDER		
males	34	68
females	16	32
total	50	100

Distribution of plaque based on incidence of carotid artery stenosis

% stenosis	N	Percentage(%)
<60%	28	73.6%
60-79%	6	15.78%
80-89%	2	5.2%
Complete occlusion	2	5.2%
	38	100%

Site distribution of plaque

Site distribution of plaque	N	Percentage
Carotid bulb	10	26.3%
CCA	3	7.8%
CCA bifurcation	2	5.2%
ICA	9	23.6%
ICA & CCA	14	36.8%
total	38	100%

Distribution of cases based on PSV

PSV Ratio of ICA/CCA	N	Percentage
<1.5	23	60.5%
>1.5	3	7.8%
>1.8	7	18.4%
>3.7	3	7.8%
Total occlusion	2	5.2%
	38	100%

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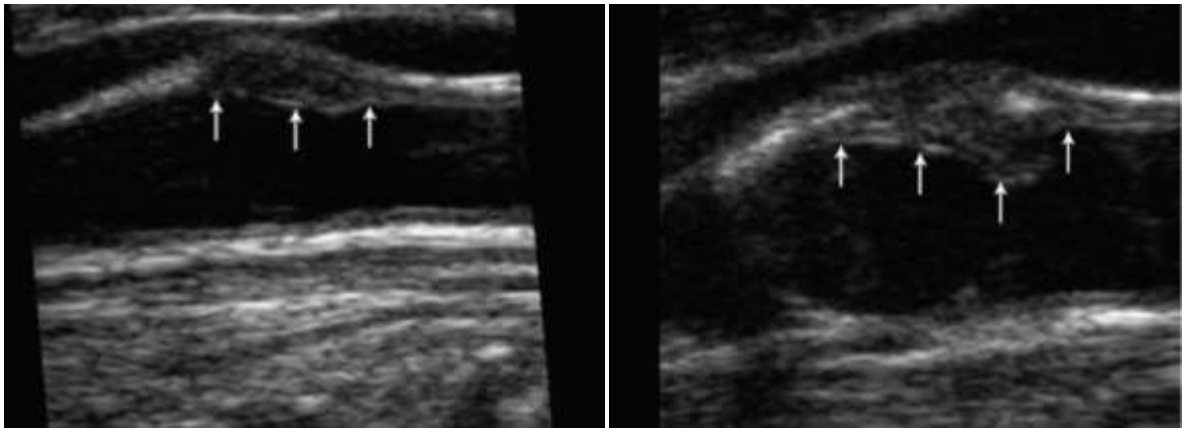
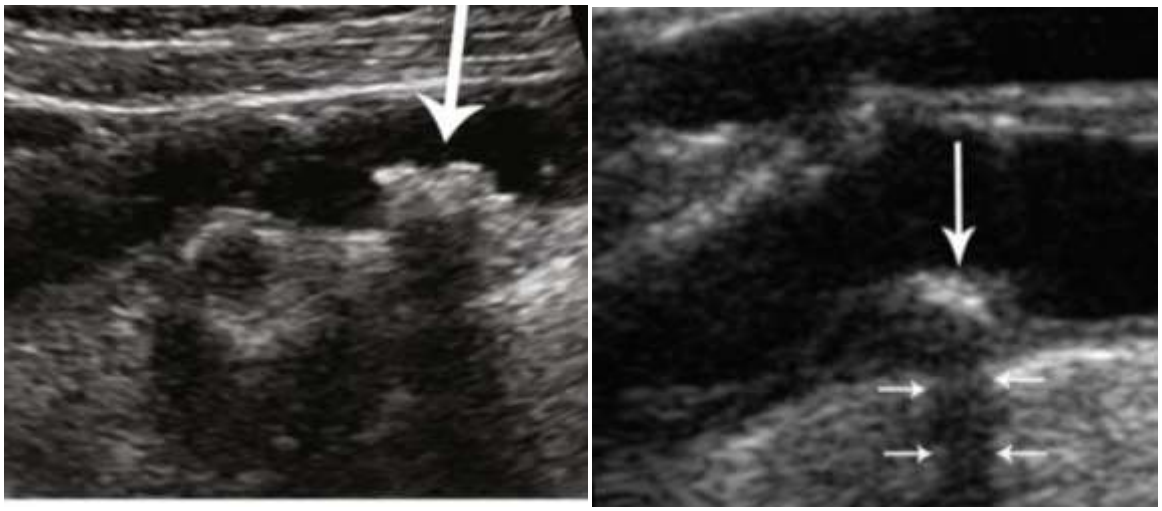


A.homogeneous plaque with mostly echolucent elements, B.heterogeneous plaque with mixture of elements.



A. solitary echeogenic plaque causing 50-69% stenosis. B. cacified plaque with distal acoustic shadowing

Discussion

About 30–60% of strokes are caused by atherosclerotic disease involving the extracranial carotid arteries usually within 2 cm of the carotid bifurcation. Sonography is unique among vascular imaging procedures in that it can assess plaque composition. Sonographically detected plaque characteristics may have prognostic value and may be useful for selection of medical and surgical therapy.This study was done to evaluate the extracranial carotid arterial system in the patients who presented with cerebral ischemic stroke and correlated CVA with extracranial carotid artery status. In an earlier study, it was found that the incidence of stroke increases after 60 years of age.The highest number of stroke patients in our study were found in the age group of 51-60 years which was 36% (18/50), followed by the age group between 61 and 70 years which was 32% (16/50). Iemolo et al. in his study showed that only 2.5% of stroke victims were females. In this study, 68% of the patients (34/50) were males and only 32% of the patients were females (16/50).

Lawes et al. studied 188,000 patients with hypertension out of which 6800 had stroke events. In our study,of the 50 patients, 19 (38%) patients were hypertensive out of which 4 (21%) had significant stenosis. There is a positive relationship between smoking and risk of stroke. It was estimated in an earlier study that 22% of stroke was attributable to smoking. Our study found 20 (40%) with a history of smoking. Of them, 6 (30%) had significant stenosis. Diabetes mellitus is another risk factor for atherosclerosis.A study conducted by Lindsberg

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and Roine observed that two-third of all ischemic stroke types on admission had diabetes mellitus.In this study,8 (16%) patients had diabetes mellitus of which 3 (37%) had significant stenosis. Schulz et al. studied the family history of stroke and found that 23% of stroke patients had a positive family history.[15] In this study, family history of stroke was present in 7 (14%) patients of which 3 (42%) had significant stenosis.Cardiac diseases were ruled out in our patient since they interfere in the velocity profiles of the carotid system. A diminished cardiac output will reduce both systolic and diastolic velocities.

Risk factors of stroke

Risk factor	No. of patients	Patients with significant stenosis (>60%)
hypertension	19	4
diabetes	8	3
smoking	20	6
Family history	7	3

In the literature of ultrasound, different authors say that one of the 3 major Doppler parameters that is, PSV, EDV, or PSV ratio is the most accurate predictor of clinically significant ICA stenosis. Because a ratio compensates for the patient to patient physiological variability and also compensate for instrument variability, PSV ratio has been considered best for assessing stenosis. North American Symptomatic Carotid Endarterectomy Trial and European Carotid Endarterectomy Trial clearly demonstrated that the long-term benefits of endarterectomy were significantly greater than medical treatment in patients with 60% or 70% ICA stenosis, whether symptomatic, or asymptomatic. Second, the endarterectomy trials established 60–70% diameter reduction as clinically significant levels of ICA stenosis. In light of the above findings, the role of carotid Doppler in detecting the site and morphology of atherosclerotic plaque and quantifying the degree of stenosis is very well justified.

Conclusion

The carotid artery stenosis is considered as a well-known risk factor for the development of ischemic stroke. Carotid ultrasonography offers a noninvasive assessment of the extracranial neck portions of the carotid and vertebral arteries for diagnosis of atherosclerotic disease. Doppler sonography provides a rapid, noninvasive, relatively inexpensive and accurate means of diagnosing carotid stenosis, to determine the degree of cervical carotid stenosis and plaque morphology in most patients initially. Embolic occlusion of intracranial arteries is the primary cause of stroke, as opposed to the immediate hemodynamic effects of carotid stenosis or occlusion, so detection of ulcerated, denuded plaques becomes crucial. Sonography can successfully identify large ulcers. Standardized technical parameters, scanning methods, Doppler analysis, and interpretation enhance the accuracy and reproducibility of the results.

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