



Role of Colour Doppler Ultrasonography Imaging in the Evaluation of Carotid Artery Disease.

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Abstract

Background: Carotid artery atherosclerosis is an important contributor to ischemic stroke and transient ischemic attack. Colour Doppler ultrasonography provides non-invasive assessment of plaque morphology and hemodynamic stenosis. **Purpose:** To evaluate the role of colour Doppler ultrasonography in the assessment of carotid artery disease and its association with cerebrovascular symptoms. **Materials and Methods:** This cross-sectional observational study included 80 patients referred for carotid Doppler evaluation. B-mode, colour Doppler and spectral Doppler parameters were assessed bilaterally. Data included intima-media thickness, plaque characteristics, peak systolic velocity, end-diastolic velocity, ICA/CCA ratio and stenosis grading. **Results:** Increased intima-media thickness was observed in 49 patients (61.3%) and carotid plaque in 52 patients (65.0%). Significant internal carotid artery stenosis of 50% or more was detected in 18 patients (22.5%). Heterogeneous and irregular plaques were more frequent among patients with cerebrovascular symptoms. **Conclusion:** Colour Doppler ultrasonography is a useful first-line modality for evaluating carotid artery disease, providing both morphological and hemodynamic information relevant to cerebrovascular risk stratification.

Keywords: Carotid artery disease, Atherosclerosis, Colour Doppler ultrasonography, Duplex ultrasonography, Carotid artery stenosis.



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INTRODUCTION

Carotid artery atherosclerosis is an important cause of ischemic stroke and transient ischemic attack, especially in patients with hypertension, diabetes mellitus, dyslipidemia and smoking. Early identification of carotid artery disease is clinically relevant because intima-media thickening, plaque formation and stenosis reflect progressive atherosclerotic burden and may guide preventive management.¹ Duplex ultrasonography combines B-mode imaging, colour Doppler and spectral Doppler assessment, and is widely used as a first-line, non-invasive imaging technique for extracranial carotid artery evaluation.² B-mode ultrasonography helps assess intima-media thickness, plaque location, plaque echogenicity and surface morphology, while Doppler evaluation provides hemodynamic parameters such as peak systolic velocity, end-diastolic velocity and internal carotid artery/common carotid artery velocity ratio.³

Standardized Doppler velocity criteria are useful for grading internal carotid artery stenosis and deciding the need for further angiographic evaluation or intervention.⁴ In addition to percentage stenosis, plaque morphology is increasingly recognized as an important marker of cerebrovascular risk. Echolucent, heterogeneous and irregular plaques may be associated with higher embolic potential and ischemic events.⁵ Therefore, a combined assessment of plaque morphology and Doppler flow parameters can provide a comprehensive evaluation of carotid artery disease. The present study was conducted to evaluate the role of colour Doppler ultrasonography in assessing carotid artery disease and to study its association with cerebrovascular symptoms.

MATERIALS AND METHODS

This hospital-based cross-sectional observational study was conducted in the Department of Radiodiagnosis, Prakash Institute of Medical Sciences & Research, Islampur, Maharashtra, over a period of 12 months. Institutional ethics committee approval was obtained before commencement of the study, and written informed consent was obtained from all

participants. A total of 80 patients aged 30 years and above referred for carotid Doppler evaluation were included. Patients were referred with cerebrovascular symptoms such as stroke, transient ischemic attack, dizziness, syncope or focal neurological deficit, or with vascular risk factors including hypertension, diabetes mellitus, smoking and dyslipidemia. Patients with previous carotid surgery or stenting, traumatic neck injury, inadequate acoustic window or unwillingness to participate were excluded. All examinations were performed using a high-frequency linear transducer. Bilateral common carotid arteries, carotid bulbs, internal carotid arteries, external carotid arteries and vertebral arteries were examined. B-mode evaluation included measurement of intima-media thickness, presence or absence of plaque, plaque site, echogenicity and surface characteristics. Plaques were classified as homogeneous or heterogeneous and as smooth or irregular based on sonographic appearance.

Colour Doppler was used to identify luminal narrowing, flow disturbance and aliasing. Spectral Doppler waveforms were obtained with angle correction kept at 60 degrees or less. Peak systolic velocity, end-diastolic velocity and ICA/CCA peak systolic velocity ratio were recorded. Internal carotid artery stenosis was graded using accepted Doppler velocity criteria based on plaque visualization, ICA peak systolic velocity and ICA/CCA ratio.⁴ Data were entered in Microsoft Excel and analysed using SPSS software. Continuous variables were expressed as mean and standard deviation, while categorical variables were expressed as frequency and percentage. Association between plaque characteristics and cerebrovascular symptoms was assessed using the chi-square test. A p-value less than 0.05 was considered statistically significant.

RESULTS

A total of 80 patients were included in the study. The mean age was 61.4 ± 10.8 years. The majority of patients were older than 60 years. Males constituted 65.0% of the study population. Hypertension was the most common risk factor, followed by diabetes mellitus, smoking and dyslipidemia. A history of stroke or transient ischemic attack was present in 43.8% of patients.

Table 1. Demographic and clinical profile of study participants

Variable	Number of patients	Percentage
Total patients	80	100
Age 30-45 years	8	10.0
Age 46-60 years	29	36.3
Age >60 years	43	53.7
Male	52	65.0
Female	28	35.0
Hypertension	54	67.5
Diabetes mellitus	38	47.5
Smoking	31	38.8
Dyslipidemia	27	33.8
History of stroke/TIA	35	43.8

On carotid Doppler assessment, increased intima-media thickness was observed in 49 patients (61.3%), and carotid plaque was identified in 52 patients (65.0%). Unilateral plaque was seen in 30 patients, while bilateral plaque was observed in 22 patients. Heterogeneous plaques were more common than homogeneous plaques. Significant internal carotid artery stenosis of 50% or more was present in 18 patients (22.5%).

Table 2. Carotid Doppler findings among study participants

Doppler finding	Number of patients	Percentage
Increased intima-media thickness	49	61.3
Carotid plaque present	52	65.0
Unilateral plaque	30	37.5
Bilateral plaque	22	27.5
Homogeneous plaque	24	30.0
Heterogeneous plaque	28	35.0
Smooth plaque surface	31	38.8
Irregular plaque surface	21	26.3
<50% ICA stenosis	34	42.5
50-69% ICA stenosis	12	15.0
≥70% ICA stenosis	6	7.5
Vertebral artery flow abnormality	5	6.3

Among patients with cerebrovascular symptoms, carotid plaques were more frequently observed compared with asymptomatic high-risk patients. Heterogeneous and irregular plaques showed a statistically significant association with history of stroke or transient ischemic attack. Patients with 50% or more stenosis demonstrated higher mean internal carotid artery peak systolic velocity and ICA/CCA ratio compared with patients with less than 50% stenosis.

DISCUSSION

In the present study, colour Doppler ultrasonography was found to be a useful non-invasive modality for evaluation of carotid artery disease. Carotid plaque was detected in 65.0% of patients, and increased intima-media thickness was observed in 61.3% of patients. These findings support the role of carotid ultrasonography in identifying early and established atherosclerotic changes in patients with cerebrovascular symptoms and vascular risk factors.³ Hypertension was the most common risk factor in the present study, followed by diabetes mellitus and smoking. Similar associations between carotid atherosclerosis and conventional vascular risk factors have been reported in previous studies.⁶ Increased intima-media thickness is considered an imaging marker of subclinical atherosclerosis and has been associated with increased cardiovascular and cerebrovascular risk.² The present study showed that heterogeneous and irregular plaques were more commonly associated with cerebrovascular symptoms. This is clinically important because plaque morphology may influence embolic risk independent of the percentage of luminal stenosis. Previous literature has emphasized that plaque echogenicity, surface irregularity and ulceration are relevant markers of plaque vulnerability.⁷ Thus, B-mode plaque characterization adds important information beyond stenosis grading alone.

Doppler parameters such as internal carotid artery peak systolic velocity, end-diastolic velocity and ICA/CCA velocity ratio are important for grading carotid artery stenosis.⁴ In this study, patients with 50% or more stenosis showed increased velocity parameters, supporting the value of spectral Doppler in functional assessment of stenosis severity. Standardized Doppler criteria help uniform reporting and guide the need for further evaluation with CT angiography, MR angiography or digital subtraction angiography.⁸ The major advantage of carotid Doppler is that it is safe, repeatable, inexpensive and widely available. It can be used for initial screening, risk stratification and follow-up. However, it is operator-dependent and may be limited in heavily calcified plaques, high carotid bifurcation, short neck and poor acoustic windows. Despite these limitations, it remains an excellent first-line investigation for extracranial carotid artery disease.⁴ The present study has a few limitations. It was a single-centre study with a moderate sample size. CT angiography or digital subtraction angiography correlation was not available for all cases. Follow-up outcome data were also not assessed. Larger prospective studies with angiographic correlation and clinical follow-up are recommended to further validate the diagnostic and prognostic value of carotid Doppler parameters.

CONCLUSION

Colour Doppler ultrasonography is a reliable, non-invasive and cost-effective imaging modality for evaluation of carotid artery disease. It provides useful information regarding intima-media thickness, plaque morphology, degree of stenosis and hemodynamic changes. Heterogeneous and irregular plaques, as well as significant stenosis, showed association with cerebrovascular symptoms. Carotid Doppler should be considered an important first-line investigation in patients with stroke, transient ischemic attack and vascular risk factors.

REFERENCES

1. Fernandes M, Keerthiraj B, Mahale AR, Kumar A, Dudekula A. Evaluation of carotid arteries in stroke patients using color Doppler sonography: a prospective study conducted in a tertiary care hospital in South India. *Int J Appl Basic Med Res.* 2016;6(1):38-44.
2. Ravikanth R. Relevance of carotid intima-media thickness and plaque morphology in acute ischemic stroke. *J Med Ultrasound.* 2020;28(2):91-96.
3. Nezu T, Hosomi N. Usefulness of carotid ultrasonography for risk stratification of cerebral and cardiovascular disease. *J Atheroscler Thromb.* 2020;27(10):1023-1035.
4. Grant EG, Benson CB, Moneta GL, Alexandrov AV, Baker JD, Bluth EI, et al. Carotid artery stenosis: gray-scale and Doppler US diagnosis-Society of Radiologists in Ultrasound Consensus Conference. *Radiology.* 2003;229(2):340-346.
5. Johri AM, Nambi V, Naqvi TZ, Feinstein SB, Kim ESH, Park MM, et al. Recommendations for the assessment of carotid arterial plaque by ultrasound for the characterization of atherosclerosis and evaluation of cardiovascular risk. *J Am Soc Echocardiogr.* 2020;33(8):917-933.
6. Johnsen SH, Mathiesen EB. Carotid plaque compared with intima-media thickness as a predictor of coronary and cerebrovascular disease. *Curr Cardiol Rep.* 2009;11(1):21-27.
7. AbuRahma AF, Srivastava M, Stone PA, Mousa AY, Jain A, Dean LS, et al. Critical appraisal of the carotid duplex consensus criteria in the diagnosis of carotid artery stenosis. *J Vasc Surg.* 2011;53(1):53-59.
8. Del Brutto VJ, Gornik HL, Rundek T. Why are we still debating criteria for carotid artery stenosis? *Ann Transl Med.* 2020;8(19):1270.