

# Colour Doppler Study of Extracranial Carotid Arteries in Stroke

Rajesh Sharma, Priyanka Mattoo

## Abstract

The current observational study was conducted to evaluate the morphology of extracranial parts of carotid arteries by colour doppler in patients of stroke and to assess the peak systolic velocity ratio of internal carotid artery/common carotid artery and its utility in diagnosis of the carotid arterial disease. Duplex ultrasound is an inexpensive, non-invasive method that can provide functional and anatomical information about vessel stenosis and plaque morphology. It is a sensitive method for detection of atherosclerotic plaque and provides considerable information about the extent and severity of plaque as well as the resulting diminution of arterial lumen. The study of Colour Doppler of carotid arteries was carried on 35 patients presenting with stroke. The data gathered included grey scale and Doppler findings of common carotid, internal carotid and external carotid arteries. In this study, the commonest lesion found was the atherosclerotic plaque. Most common risk factor for increased intima-media thickness of carotid vessel is found in patients with history of smoking > 10 years. Atheromatous plaque was most commonly found in the left carotid and bilateral system (41.1%). Most common site for atheromatous plaque was found to be carotid bifurcation (48.5%). Significant stenosis (i.e. >40%) was found in 24(64%) of the cases. Peak systolic velocity ratio showed significant stenosis in 24 (68.5%) of patients. The role of carotid Doppler in detecting the site and morphology of atherosclerotic plaque with quantifying the amount of stenosis is very well-justified. In addition carotid Doppler can also be used to assess the prognosis in potential symptomatic and asymptomatic patients with one or the other risk factors for cerebrovascular disease.

## Key Words

Carotid artery, Carotid Doppler, Peak systolic, Velocity Ratio

## Introduction

Stroke is one of the leading cause of death worldwide. One-third of these cases are fatal and survivors usually have prolonged or irreversible disabilities (1). An estimated 80% of strokes are thromboembolic in origin, often with carotid plaque as embolic source (2). For more than a decade various sonographic techniques have been used for the assessment of carotid arteries in cerebrovascular disease (3). Atherosclerotic disease of the carotid arteries outside the cranial cavity has long been recognized as the most common source of emboli that travel to the brain causing stroke (4). High-degree internal carotid artery stenosis is the most well-known risk factor for the development of cerebrovascular events (5). Arteriography has been long regarded as the gold standard diagnostic tool for carotid artery stenosis. Arteriography is a costly and invasive technique with potentially serious complications. The results of

arteriography have not been standardized which makes comparison of results from different laboratories difficult. Duplex ultrasound is inexpensive, non-invasive method and can provide functional and anatomical information about vessel stenosis and plaque morphology (6,7). Color duplex flow ultrasonography has thus become the most widely used noninvasive method for assessing extracranial cerebrovascular occlusive disease, as it avoids the expense and risk of routine arteriography (8). The sensitivity and specificity of carotid duplex ultrasound ranges from 90% to 95% for the measurement of carotid diameter reduction, and duplex ultrasound may be more sensitive for detection of minimal atherosclerotic plaque (9,10). The goals of carotid imaging can be described as early detection, clinical staging, surgical road mapping, and postoperative therapeutic surveillance (11). In this study, we evaluated the extracranial carotid system

From the Section of Radiodagnosis, Atulaya Healthcare, Jammu J&K India

Correspondence to : Dr. Rajesh Sharma Consultant Radiologist Asst Professor Deptt of Radiodiagnosis GMC Jammu

with the help of color doppler ultrasound of patients whose CT scans showed ischemic strokes. The purpose of our study was to know the frequency of carotid artery stenosis in ischemic stroke patients, thus showing the relationship of carotid atherosclerosis with ischemic stroke.

### Material and Methods

The study has been conducted at Atulaya health care, Jammu over a period of two years. The study material included patients of stroke who were advised carotid doppler studies. Clinical history and central nervous system examination was noted from the case sheet/ prescription slip of the patient. Evidence of hypertension, diabetes mellitus, hyperlipidemia, smoking (>10 years) and ischemic heart disease were collected from the patient. Patients of head injury, primary or secondary brain tumors and patients of vertebro-basilar insufficiency were not included in the study. Sonography examination of extracranial carotid arteries was done by using a high frequency 6-10 MHZ linear array transducer with subject lying in the supine position and the head slightly tilted to opposite side. Examination was done by using Siemens Acuson X 300 colour doppler machine. Before performing Doppler USG, informed consent was obtained from the patients. The examination was performed with a Doppler angle of less than or equal to 60 degree and sample volume

of 1 to 5 mm. Most common risk factor for increased intima-media thickness of carotid vessel is found in patients with history of smoking > 10 years. Out of 17 patients (48.5%) with atheromatous plaque in carotid bifurcation 3 had on right side (17.6%), 7 on left side (41.1%) and 7 on both sides (41.1%).

Among the 8 patients (22.8%) with atheromatous plaque in common carotid artery, 2 on the right side (25%) and 4 on left side (50%) & 2 on both sides (25%). In 10 patients (28.5%) with atheromatous plaque in internal carotid artery, 3 (30%) had on the right side, 4 on the left side (40%) and 3 on both sides (30%). In the case group (n=35), majority of the plaque were hyperechogenic in 12 (34.2%), calcified plaque in 9 (25.7%), moderately echogenic (heterogeneous plaque) in 8 (22.8%) and low echogenic plaque in 6 (17.1%) of cases. Among the patients (n=35), 24 patients had significant stenosis 68.5%. Among these majority were having 40-60% stenosis group i.e., 8 (22.8%) followed by 6 in each 60-80% and 100% stenosis group (17.1%) and 4 patient had 80-90 % (11.4%) and the remaining 11 patients were in <40% stenosis group (31.4%).

Among the patients (n=35) based on peak systolic velocity ratio of ICA/CCA, 24 had significant stenosis i.e., 68.5%, 8 (22.8%) patients had a ratio of > 1.5, 6 patients (17.1%) had a ratio of > 1.8 and 4 patients

**Table.1 Correlation Between Risk Factors and Intima Media Thickness**

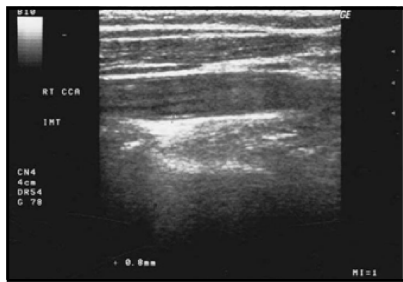
	0.9-1mm	1.0-1.5mm	1.5mm-2mm
Diabetes mellitus	3	2	1
Smoking>10 years	8	4	1
Hypertension	3	4	2
Proved ischemic heart disease	2	1	0
Hyperlipidemia	2	1	1

**Table - 2. Distribution of Atheromatous Plaque in Patients According to Site**

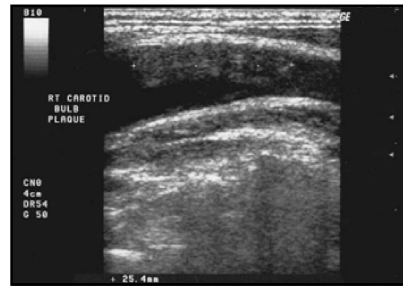
Plaque Site	Bifurcation (n=17)		CCA (n=8)		ICA (n=10)		Total (n=35)	
	No.	%	No.	%	No.	%	No.	%
Right	3	17.6	2	25	3	30	8	22.8
Left	7	41.1	4	50	4	40	15	42.8
Bilateral	7	41.1	2	25	3	30	12	34.2

**Table -3 Plaque Characterization in Patients**

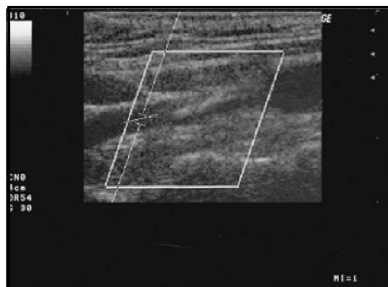
Plaque Characterization	Cases (n=35)	
	Number	Percent
Low echogenicity	6	17.1
Moderate echogenicity (heterogenous)	8	22.8
Hyperechogenicity	12	34.2
Calcified	9	25.7



**Fig 1. Right Common Carotid Artery with Intima Media Thickness of 0.8mm**



**Fig 2 . Large Moderate Echogenic Heterogeneous Plaque in Right Carotid Bulb**



**Fig. 3 Longitudinal View Showing Total Occlusion (>95%) of Stenosis in Left Internal Carotid Artery**

(11.4%) had a ratio > 3.7 and 6patients (17.1%) had total block.

**Results**

Stroke or cerebrovascular disease is a major cause of death, ranking third behind only malignancies and cardiovascular disease. Atherosclerosis of the cranial vessels, leading to cerebral infarction accounts for 85% of strokes. Duplex sonography, combining high resolution imaging and doppler Spectrum analysis has proved to be popular, non-invasive, accurate and cost effective means of detecting and assessing extracranial carotid disease.

The study was carried out on 35 patients, all of them

were symptomatic cases, had suffered stroke within one week of the Doppler examination and were suspected of cerebrovascular insufficiency. Cigarette smoking (37.1%) was the most common risk factor associated with stroke/TIA and the least was seen in ischemic heart disease (8.57%) (Table 1). Atheromatous plaque was most commonly found on left side (42.8%) followed by bilateral in 34.2% and 22.8% on right side (Table 2). Most common site for atheromatous plaque was carotid bifurcation (48%) with 41.1% on left side and bilaterally with the 17.6% observed 17.6% on right side (Table 2). In common carotid artery 50% had atheromatous plaque on left side and the other 25% on each on left side and bilaterally (Table 2). Based on plaque characteristics, 12 had hyperechogenic plaque, 9 calcific plaques, 6 low echogenic plaques and 8 moderate echogenic or heterogeneous plaques (Table 3, Fig 2).

In internal carotid artery, atheromatous plaque was, 3(30%) on the right side, 4 on the left side (40%) and 3 on both sides (30%) (Table 2) . Among the patients (n=35), maximum number of patients with significant stenosis i.e., >40% were found in 60-70 years age group i.e., 14(40.0%) followed by 70-80 years age group i.e., 12 (34.2%) (Table 4, Fig 2). 24 (68.5%) of cases had

Percentage of stenosis	Cases (n=35)	
	Number	Percent
<40%	11	31.4
40-60%	8	22.8
60-80%	6	17.1
80-90%	4	11.4
100% (total block)	6	17.1

**Table - 5 Distribution of Patients Based on Peak Systolic Velocity Ratio of ICA/CCA**

Peak systolic velocity ratio of ICA/CCA	Cases (n=35)	
	Number	Percent
<1.5	11	31.4
>1.5	8	22.8
>1.8	6	17.1
>3.7	4	11.4
Total Block	6	17.1

significant stenosis based on peak systolic velocity ratio of ICA/CCA, 8 (22.8%) patients had a ratio of > 1.5, 6 patients (17.1%) had a ratio of > 1.8 and 4 patients (11.4%) had a ratio > 3.7 and 6 patients (17.1%) had total block (Table 5 Fig 1).

### Discussion

The traditional risk factors for stroke/ TIA include diabetes mellitus, hypertension, smoking, hyperlipidemia and coronary artery diseases. Among the cases smoking was found to be the most common risk factor followed by hypertension, diabetes mellitus, hyperlipidemia, and proved ischemic heart disease. These findings correlated well with study by another study (13) where cigarette smoking was found to be strong independent risk factor for Extracranial carotid atherosclerosis. Another study reported cigarette smoking of long duration to be the strongest predictor of severe extracranial carotid atherosclerosis (14). Most studies show that most risk factors continue to be associated with increased atherosclerosis at older ages, possibly suggesting a continued value in investigation of strategies to reduce atherosclerosis by reducing risk factors at older age.

In our study the patients having intima media thickness (CCA IMT) more than 0.9mm was found in patients giving history of smoking for more than 10 years. These findings correlated well with another study which studied the role of CCC-IMT in patients of stroke and TIA (15). In our study atheromatous plaque was most commonly found on left side or both sides, followed by right side. Atheromatous plaque was most commonly present at carotid bifurcation, followed by plaque in internal carotid artery and common carotid artery (CCA). None of the patients had plaque in the external carotid artery (ECA). This finding correlated well with other study (12).

Majority of the plaques were hyperechogenic, followed by calcified plaque, moderately echogenic and low echogenic plaques in order of occurrence. These findings correlated well with other study (16). Most of the patients in our study had significant stenosis, with majority of these having 40%-60% stenosis. These findings correlate well with similar study on colour doppler study (17). Among the patients with significant stenosis, maximum patients had peak systolic velocity ratio of ICA/CCA > 1.5 followed by ratio of 1.8 in other patients, whereas other similar study had shown ratios more than 1.8 or greater in such patients, which were due to advanced atherosclerotic disease in patients of this particular study group (17).

### References

- Gaitini D, Soudack M. Diagnosing carotid stenosis by Doppler sonography. *J Ultrasound Med* 2005;24:1127-36.
- Rumack CM, Wilson SR, William Charboneau J, Johnson JM. Diagnostic ultrasound. 3<sup>rd</sup> ed. Vol. 1. Uttar Pradesh, India: Elsevier; 2009. pp. 943
- Steinke W, Kloetzsch C, Hennerici M. Carotid artery disease assessed by colour Doppler flow imaging: Correlation with standard Doppler sonography and angiography. *AJR Am J Roentgenol* 1990;154:1061-68
- Norman J, Beauchamp Jr. Imaging of acute cerebral ischemia. *Radiology* 1999; 212: 307-312
- Eliasziw M, Kennedy J, Hill MD, Buchan AM, Barnett HJM. Early risk of stroke after a transient ischemic attack in patients with internal carotid artery disease. *Can Med Assoc J* 2004; 170: 1105-9.
- Strandness DE, Eikelboom BC. Carotid artery stenosis—where do we go from here? *Eur J Ultrasound* 1998; 7: 17-26
- Polak JF, O'Leary DH, Kronmal RA, et al. Sonographic evaluation of carotid artery atherosclerosis in the elderly: relationship of disease severity to stroke and transient ischemic attack. *Radiology* 1993; 188: 363-70
- Bucek RA, Reiter M, Koppensteiner I, Ahmadi R, Minar E, Lammer J. B-flow evaluation of carotid arterial stenosis: initial experience. *Radiology* 2002; 225: 295-99
- Brown PB, Zwiebel, WJ, Call GK. Degree of cervical carotid artery stenosis and hemispheric stroke: duplex ultrasound findings. *Radiology* 1989; 170: 541-43
- Polak JF. Carotid ultrasound. *Radiol Clin North Am* 2001;39:569-89
- Jadhav UM, Kadam NN. Carotid Intima-Media thickness as an independent predictor of coronary artery disease. *Indian Heart J* 2001;53:458-62
- Carroll BA. Carotid ultrasound. *Neuroimaging Clin N Am* 1996;6:875-97
- Ali A, Ali H, Mahmood T, et al. Frequency of atherosclerosis in cerebral infarctions. *Pakistan J Medical Sciences* 2008;20(1):23-27
- Grethe S Tell, George Howard, William M MC Kinney, James F. Cigarette smoking cessation and extracranial carotid Atherosclerosis. *JAMA* 1989;261(8) : 1178-1180
- Whisnant JP, Homer D, Ingall TJ, Baker HL Jr, O'Fallon WM, Wievers DO. Duration of cigarette smoking is strongest predictor of severe extracranial carotid artery atherosclerosis. *Stroke* 1990;21:707-14
- Kopp CB, Touboul PJ, Berr C. Relation of Intima Media Thickness to Atherosclerotic Plaques in carotid arteries. *Arteriosclerosis Thrombosis and vascular Biology* 1996;16:310-316
- Sethi SK, Solanki R S, Gupta H. Color and duplex Doppler imaging evaluation of extracranial carotid artery in patients presenting with transient ischaemic attack and stroke: a clinical and radiological correlation. *Indian J Radiol Imaging* 2005; 5:91-98
- Bluth EI, Stavros AT, Marich KW, Wetzner SM, Aufrechtig D, Baker JD. Carotid duplex sonography multicenter recommendation for standardized imaging and Doppler criteria. *Radiographics* 1988;8:487-506