

Original Research

Color Doppler evaluation of carotid vessels in patients with stroke

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ABSTRACT

Aim: To analyze the structure of carotid plaque morphology and quantify the percentage of carotid stenosis using high resolution color Doppler ultrasound machine in stroke patients. **Background:** Stroke or cerebrovascular disease is an important formidable health problem globally. The stroke syndrome consists of the rapid development of a focal neurological deficit that is usually localized to an area of the brain supplied by a specific artery. **Materials and Methods:** This study was carried out on all clinically suspected cerebrovascular insufficiency cases referred for color Doppler of carotid arteries to the Radiology Department of Katuri Medical College and Hospital, Guntur from 2011 to 2013. Various Doppler parameters such as characteristics of plaque, degree of stenosis, peak systolic velocity ratio, end diastolic velocity (EDV) of internal carotid artery, EDV ratios were studied. **Results:** Totally 90 cases of cerebrovascular accident studied, 58 (64%) were males and 32 (36%) were females. The majority of male patients belonged to age group of 51-60 years (37.8%) and females 61-70 years (37.5%). The risk factors included hypertension, smoking, diabetes mellitus, and ischemic heart disease. The patient's clinical symptoms included hemiparesis, hemiplegia, transient ischemic attack and altered sensorium. **Conclusion:** Color Doppler of carotid artery plays an important role in the identification of plaques and quantification of degree of stenosis and identification of "at risk" patients who may develop further stroke.

Keywords: Color Doppler, carotid vessels, common carotid artery, end diastolic velocity, internal carotid artery, peak systolic velocity, plaque, stroke

INTRODUCTION

Stroke or cerebrovascular disease is an important formidable health problem globally. The stroke syndrome consists of the rapid development of a focal neurological deficit that is usually localized to an area of the brain supplied by a specific artery.

In India, surveys show stroke prevalence of 200 per 1 lakh persons, nearly 1.5% of all urban hospital admission, 4.5% of medical and 20% of neurological cases. It has been conclusively proven that the risk for a major stroke is higher in the first 3 months after transient ischemic attack (TIA). It has been seen that 20% or more of strokes have been heralded by a TIA. Color Doppler of carotid arteries forms an important part of the evaluation of extra-cranial insufficiency.¹ Accurate diagnosis of hemodynamically significant stenosis is critical to identify patients who would benefit from surgical

intervention. The value of a safe, non-invasive and low-cost screening test is, therefore, great.

Duplex sonography, combining high-resolution imaging and Doppler spectrum analysis has provided to be popular, non-invasive, accurate and cost-effective means of detecting and assessing carotid disease. Carotid sonography has largely replaced angiography for suspected extra-cranial carotid atherosclerosis.^{2,3} If timely atherectomies of the carotid are performed, many stroke cases may be prevented or salvaged. This necessitates evaluation of extra-cranial carotid artery system. In the present study, an endeavor is made to document the cases of carotid artery plaque and an effort has been made to study the characteristics of plaque and percentage of stenosis in patients with neurological symptoms. The detailed analysis of results and comparison where is possible with the previous study was done.

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Aims and Objectives

1. To analyze the structure of carotid plaque using high-resolution color Doppler ultrasound machine in stroke patients.
2. To quantify the percentage of carotid stenosis and plaque morphology using high-resolution color Doppler ultrasound machine in patients with stroke.
3. To evaluate spectral pattern of duplex in hemodynamically significant carotid artery stenosis.

MATERIALS AND METHODS

This study was carried out at Katuri Medical College and hospital, Guntur in the department of Radiodiagnosis from 2011 to 2013. Total 90 cases of cerebrovascular accident were studied.

Inclusion Criteria

All cases referred to the Radiology Department with history and clinical findings consistent with cerebrovascular insufficiency for color Doppler of carotid arteries.

Exclusion Criteria

1. Symptoms suggestive of vertebro-basilar insufficiency.
2. All cases of head injuries.
3. Cases of primary and metastatic brain tumors.

Protocol for Color Doppler Carotid Examination

Patient position

Carotid arteries are examined with patient in the supine position and with the examiner seated at the patient's head. Exposure of the neck is maximized by having the patient drop the ipsilateral shoulder as far as possible. Neck exposure also enhanced by tilting and rotating the head away from the side being examined.

Transducer position

Generally the postero lateral and far postero lateral positions are most useful for showing the carotid bifurcation and the internal carotid artery (ICA) in longitudinal axis, short axis (transverse) view of the carotid arteries are obtained from an anterior, lateral, or postero lateral approach, depending on which best shows the vessels. The far postero lateral approach often provides the best images of the distal reaches of ICA, and to use this, turn the patient's head far to the contralateral side and place the transducer posterior to the sternomastoid muscle.

Image Orientation

Longitudinal images are taken with the patient's head on the left side of the display screen. Transverse images are oriented as if viewed from the patient's feet. Hence, the patient's left appears on the right of the screen.

RESULT

Distribution of cases are shown in Tables 1-8.

Table 1. Sex-wise distribution of cases

Sex	No. of cases	Percent
Male	58	64
Female	32	36

Table 2. Age- and sex-wise distribution of cases

Age	Male (%)	Female (%)
<40 years	8 (13.7)	4 (12.5)
41-50 years	8 (13.7)	6 (18.7)
51-60 years	22 (37.8)	5 (15.6)
61-70 years	10 (17.2)	12 (37.5)
71-80 years	6 (10.3)	3 (9.3)
>80 years	4 (6.8)	2 (6.2)

Table 3. Risk factor wise distribution of cases

Risk factor	No. of cases	Percent
Hypertension	40	44.4
Smoking	27	30
Diabetes mellitus	25	27.7
Ischemic heart disease	8	8.8
Others	0	0

Table 4. Symptoms wise distribution of cases

Symptom	Male	Female	Total	Percent
Hemiparesis	22	10	32	35.5
Hemiplegia	15	8	23	25.5
Tia	5	8	13	14.4
Altered sensorium	3	6	9	10
Others	13	0	13	14.4

Table 5. Side wise distribution of plaques among cases

Side	Male	Female	Total	Percent
Right	10	12	22	24.5
Left	22	6	28	31
Bilateral	15	7	22	24.5
None	11	7	18	20

Table 6. Cases distribution on side and site of plaque

Site	Right	Left	B/L	Total	%
Bifurcation	9	11	9	29	40
CCA	4	8	6	18	25
ICA	9	9	7	25	35
ECA	0	0	0	0	0

ICA: Internal carotid artery, CCA: Common carotid artery, ECA: External carotid artery

Table 7. Percent stenosis wise distribution

Distribution (%)	Right	Left	Total	Percent
<40	30	17	47	50
40-60	5	15	20	21.2
60-80	4	6	10	10.6
80-90	2	4	6	6.3
Total occlusion	3	8	11	11.7

Table 8. Cases distribution based on plaque morphology

	Male	Female	Total	Percent
Moderately echogenic	27	15	42	58.3
Calcific plaque	10	6	16	22.2
Strongly echogenic	6	2	8	11
Low echogenic	4	2	6	8.3

DISCUSSION

The main role of color Doppler sonography is detection of occlusive lesions in the extra cranial course of common carotid and ICA. Two randomized clinical trials, the North American symptomatic carotid Endarterectomy trail (NASCET)¹ and European carotid surgery trail (ECST)² have clearly shown the benefit of Endarterectomy in symptomatic patients with >70% carotid stenosis.³ The same reports showed lack of any benefit for surgery on lesions of 30% diameter.

The study comprised of 90 cases of which 58 were males representing 64% and 32 females representing 36% of cases. The majority of male patients belonged to age group of 51-60 years (37.8%) and females 61-70 years (37.5%).

The risk factors included hypertension, smoking, diabetes mellitus, and ischemic heart disease. The patient's clinical symptoms included hemiparesis, hemiplegia, TIA and altered sensorium.

Side and Site of Plaque

In the present study, the atheromatous plaques were most commonly found on left side in 28 patients (31%), 22 patients (24.5%) had right side plaque, 22 patients (24.5%) had bilateral plaques and 18 patients (20%) had no plaque. Most of the plaques are found at bifurcation, 9 (31%) patients had on the right side, 8 (44.4%) patients had on the left side and 9 (31%) patient had bilaterally.

18 patients had plaques in common carotid arteries (CCA), 4 (22.2%) patients had on right side, 8 (44.4%) patients had on left side and 6 (33.3%) patients had bilaterally. 25 patients had plaques in ICA, 9 (36%) patients had on the right side, 9 (36%) patients had on the left side and 7 (28%) patients had bilaterally.

Plaque Morphology

In 90 patients studied 72 atheromatous plaques were found in different carotid vessels. Zweibel *et al.*⁴ have classified the plaques as follows:

1. Low echogenicity plaque
2. Moderately echogenic plaque
3. Strongly echogenic plaque
4. Calcified plaque with acoustic shadowing.

Moderately echogenic plaques were found in 42 (58.3%) vessels, followed by calcific plaque in 16 (22.2%) vessels. Strongly echogenic plaques were found in 8 (11%) vessels and low echogenic plaques were found in 6 (8.3%) vessels.

Low Echogenic Plaque

Polak *et al.*⁵ explained the low echogenicity plaque is due to lipid rich material or hemorrhage or possibly smooth muscle proliferation. This type of plaques may have a rim of hyper-echogenicity presumed due to fibrous cap. Lusby *et al.*⁶ have found that intra plaque hemorrhages occur commonly in symptomatic patients. Low echogenic plaque either homogenous or heterogenous has a greater risk of stroke according to Seeger *et al.*⁷

Strongly Echogenic (Hyperchoic Plaque)

According to Zweibel *et al.*⁴ the plaque becomes echogenic when it becomes retracted and fibrosed. Hyper-echogenicity suggests the chronic nature of the plaque.

Heterogenous Plaques

Plaque heterogeneity is due to presence of moderately echogenic collagen and fat content which is of low echogenicity according to Zweibel *et al.*⁴, Polak *et al.*⁵ further classified plaques into heterogeneously hyper-echoic and heterogeneously hypoechoic.

Calcified Plaques

Calcification occurs in the plaque in the areas of hemorrhage and necrosis. These foci may be focal or diffuse. No correlation exists between presence of calcification and symptomatology according to Carroll *et al.*⁸ and Taylor *et al.*⁹

Percent Stenosis

Among the study group of 90 patients, 67 patients had <60% diameter stenosis with no significant hemodynamic changes and 23 patients had more than 60% diameter stenosis with significant hemodynamic changes, which is correlating with ICA/CCA ratio of more than 1.8.

In evaluating >60% stenosis the criteria published by Carroll *et al.*⁸ Carpenter *et al.*¹⁰ by evaluating all the four cardinal velocity measurements we are able to quantify into three grades i.e. 60-69%, 70-79%, 80-99%. The 11 patients in the study group had total occlusion.

Peak Systolic Velocity Ratio

Bluth *et al.*¹¹ defined a velocity ratio >1.8 as an indicator of 60% or greater and a ratio of 3.7 as an indicator of more than 80% diameter stenosis. Granth *et al.*¹² Carroll *et al.*¹³ confirmed the validity of 1.5 ratio of peak. Systolic velocity ratio of ICA/CCA is as an indicator of 50% or greater stenosis. They found the ratio more accurate than peak systolic velocity measurements. These features correlated in our patients with significant stenosis with hemodynamic changes.

End Diastolic Velocity (EDV) of ICA:

According to Zweibel *et al.*⁴ EDV <40 cm/s do not yield any accurate information about degree of stenosis. If the EDV is more than 40 cm/s but <100 cm/s we can estimate the stenosis to be ranging from 50% to 80%. If the EDV is >100 cm/s it corroborates to the stenosis >80%. These

features correlated in our patients with significant stenosis with hemodynamic changes.

EDV Ratio

Bluth *et al.*¹¹ found EDV of ICA to ECA ratio >5.5 predicts 80% or greater stenosis. In this study, peak systolic velocity ratio of ICA/CCA have been used to define the percentage of significant stenosis as this is more accurate according to a study conducted by Bluth *et al.*¹¹ These features correlated in our patients with significant stenosis with hemodynamic changes.

CONCLUSION

Color Doppler of carotid artery plays an important role in identification of plaques and quantification of degree of stenosis and identification of “at risk” patients who may develop further stroke.

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PEER REVIEW

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CONFLICTS OF INTEREST

None

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