

## AN ULTRASONOGRAPHIC STUDY OF CAROTID ARTERY PATHOLOGY IN ISCHAEMIC STROKE PATIENTS

Puthiya Maliyakkal Sinewraz<sup>1</sup>, P. Amjed<sup>2</sup>

<sup>1</sup>Associate Professor, Department of Radiodiagnosis, Kannur Medical College, Anjarakandy, Kannur, Kerala.

<sup>2</sup>Assistant Professor, Department of General Medicine, Kannur Medical College, Anjarakandy, Kannur, Kerala.

---

### ABSTRACT

---

#### BACKGROUND

Majority of ischaemic strokes are due to extracranial carotid artery disease. Ultrasonography of the carotid arteries is easily available, cost-effective noninvasive method of evaluation in preventing ischaemic strokes.

#### OBJECTIVES

To evaluate the carotid artery pathology, and grade the stenotic lesions by ultrasonography in ischaemic stroke patients.

#### MATERIAL AND METHODS

In 25 patients of clinically diagnosed cerebrovascular insufficiency, carotid and vertebral arteries on both sides were examined. The site, size, echogenicity, luminal narrowing and velocity changes at the site of atherosclerotic plaque was recorded. The observations in percentages were compared and analysed.

#### RESULTS

Hemiparesis was the commonest presenting complaint. Among these 25 patients, 58% of them had atheromatous plaque. Smoking had a strong association with the development of plaque. 64% of these patients with atheromatous plaque were males with a sex ratio of 1.8:1, 57% of plaques were found at carotid bifurcation predominantly on left side, 57% of these plaques had significant stenosis and one had complete occlusion. Predominant type of these plaque were strongly echogenic with calcification (52%), 35% of these patients had a PSV ratio of 2-4 and 14% >4.

#### CONCLUSION

The study showed atheromatous plaque changes with significant stenosis among cerebrovascular insufficiency patients. The findings were consistent with the other studies.

#### KEYWORDS

Doppler, Cerebrovascular disease, Carotid artery, Stenosis, Plaque.

---

**HOW TO CITE THIS ARTICLE:** Sinewraz PM, Amjed P. An ultrasonographic study of carotid artery pathology in ischaemic stroke patients. *J. Evid. Based Med. Healthc.* 2016; 3(32), 1532-1536. DOI: 10.18410/jebmh/2016/345

---

**INTRODUCTION:** Stroke or cerebrovascular disease represents 3<sup>rd</sup> most common cause of death in developed nations. In India, surveys have shown a crude prevalence rate for hemiplegia in the range of 200/100000 persons, nearly 1.5% of all urban hospitals admission, 4.5% of medial and 20% neurological cases.<sup>1</sup>

One of the main causes of ischaemic stroke is attributable to the carotid arteries which can be in the form of flow related stroke or thromboembolic aetiology from atherosclerotic plaque. Doppler ultrasound of the carotid arteries can be used to accurately study the carotid artery disease.

In symptomatic patients like those with hemisphere symptoms or TIA, carotid ultrasound may be the only

diagnostic imaging modality performed before carotid endarterectomy.<sup>2</sup> In asymptomatic patients with high risk of CVA i.e., HTN, DM, echolucent plaques, ultrasound can be used to guide the medical treatment and for further followup.

In spite of the angiography being 'gold standard' investigation for carotid stenosis it is associated with risks due to its invasiveness, cost, contrast associated complications and it does not give information regarding the plaque. This can be overcome by CDS which is non-invasive, accurate and cost-effective means of carotid artery evaluation. Carotid sonography has largely replaced angiography for suspected extracranial carotid atherosclerosis.<sup>3</sup>

If timely atherectomies of the carotid are performed, many strokes may be prevented or salvaged. This necessitates evaluation of extra-cranial carotid artery system. MRI angiography is currently developing rapidly and may ultimately give similar or better results, especially for flow quantification, though at a much higher cost.

Besides estimating the degree of stenosis, the biggest advantage of sonography is its ability to identify and

---

*Financial or Other, Competing Interest: None.*

*Submission 14-03-2016, Peer Review 28-03-2016,*

*Acceptance 13-04-2016, Published 21-04-2016.*

*Corresponding Author:*

*Dr. Puthiya Maliyakkal Sinewraz,  
Associate Professor, Department of Radiodiagnosis,  
Kannur Medical College, Anjarakandy,  
Kannur-670612, Kerala.*

*E-mail: drsinuraz@gmail.com*

*DOI: 10.18410/jebmh/2016/345*

characterise plaque and identify plaques with higher risk of embolisation with the use of high resolution ultrasound, plaque can be characterised into relatively high risk groups for containing intra-plaque haemorrhage which is thought by many to be the precursor of plaque ulceration.<sup>4</sup>

**OBJECTIVES:**

- 1 To evaluate clinically suspected cases of cerebrovascular diseases referable to carotid artery diseases.
- 2 To evaluate patients who are at increased risk of carotid artery diseases.

**MATERIAL AND METHODS:** Carotid Doppler study was done on 25 patients with clinically diagnosed cerebrovascular insufficiency during the two years study period from September 2012 to August 2013. The patients were recruited from Kannur Medical College, Kannur. Detailed clinical history and central nervous system examination was done and findings were noted. Evidence of hypertension, diabetes mellitus, hyperlipidaemia, ischaemic heart disease and smoking were collected.

**Inclusion Criteria:**

- a) Clinically suspected cases of cerebrovascular diseases referable to carotid artery diseases.
- b) Patients who are at increased risk of carotid artery diseases.

**Exclusion Criteria:**

- a) Traumatic cases.
- b) Paediatric patients.

During the scan, carotid and vertebral arteries on both sides were examined and the parameters noted were PSV of CCA & ICA, PSV ratio of ICA/CCA, EDV of CCA & ICA. If the plaque is present then its site, size, echogenicity and luminal diameter reduction (stenosis) were recorded.

By using colour and spectral Doppler, presence of spectral broadening or turbulence were noted. The collected datas were analysed and tabulated. The findings in percentages were compared with similar previously done studies.

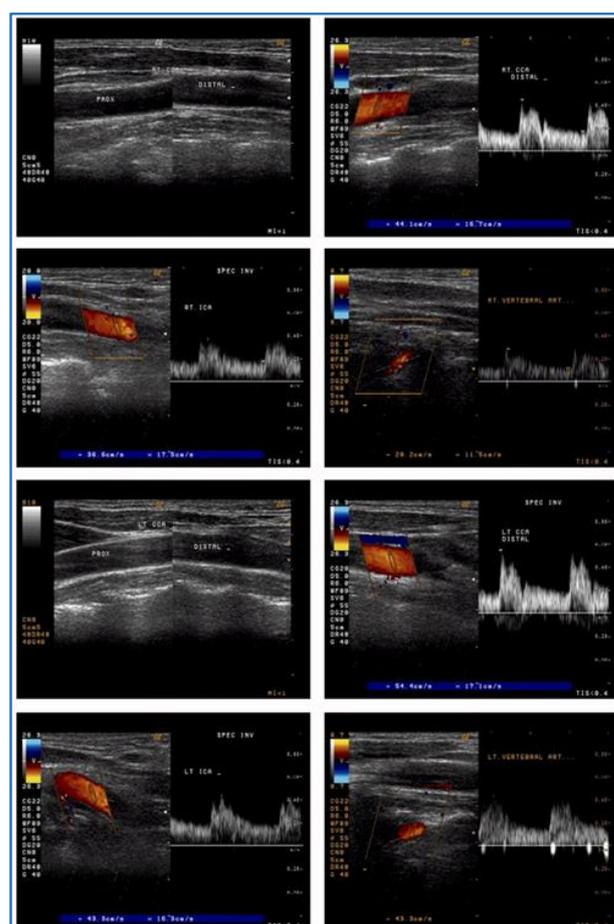
**Instruments Used in the Study:**



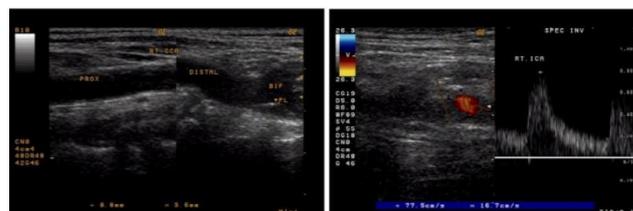
**Fig. 1: Philips Envisor CHD 7-12 MHZ**



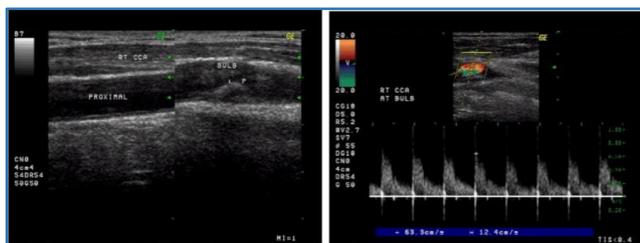
**Fig. 2: Wipro GE logiq 400 MD 8-12 MHZ**



**Fig. 3: Normal B-mode, colour, spectral flow pattern of carotid & vertebral arteries**



**Fig. 4: B mode and colour Doppler imaging showing hypochoic plaque at carotid bifurcation with luminal narrowing of <50% (case no.1)**



**Fig. 5: B mode and colour Doppler imaging showing moderately echogenic plaque at carotid bifurcation with luminal narrowing of <50% (case no.2)**

**OBSERVATIONS AND RESULTS:** The study was carried out on 25 patients of clinically suspected cerebrovascular insufficiency.

Age (years)	Patients (N=25)	
	With plaque	without plaque
< 40	0	1
40- 50	1	2
50 - 60	3	3
60 – 70	7	3
70 – 80	3	2
Total	14	11

**Table 1: Age wise distribution of patients (N=25)**

Out of 25 clinically diagnosed cerebrovascular insufficiency patients majority were above 60 years of age (60%).

Among atheromatous plaque patients (Total 14), 7(50%) patients were in the age group of 60-70 years.

Sex	Patients (N=25)	
	With plaque	Without plaque
Males	9	8
Female	5	3
Total	14	11

**Table 2: Sex wise distribution of patients**

Maximum number of patients with atherosclerotic plaque were males i.e. 9(64%).

Symptoms	Males	Females	Total
Hemiparesis	8	2	10
Hemiplegia / Stroke	5	3	8
Hemisensory disturbance	3	2	5
Amaurosis fugax	0	1	1
Aphasia	1	0	1

**Table 3: Symptom wise distribution of patients**

Maximum number of patients presented with hemiparesis 10(40%) followed by Hemiplegia/stroke 8(32%), hemisensory disturbances 5(20%), Aphasia 1(4%) and Amaurosis fugax 1(4%).

Risk Factor	With plaque (N=14)		Without plaque (N=11)	
	No.	%	No.	%
Smoking > 10 years	8	57	5	45
Hypertension	7	50	4	36
Diabetes Mellitus	5	35	3	27
Hyperlipidaemia	3	21	2	18
IHD	1	7	1	7

**Table 4: Risk factor wise distribution of patients**

Among atheromatous plaque patients, smoking was the most common risk factor 8(58%), followed by hypertension 7(50%), diabetes mellitus 5(35%), hyperlipidaemia 3(21%) and IHD 1(7%).

Plaque Site	Bifurcations	CCA	ICA	ECA	Total	
					No.	%
Right	2	1	2	0	5	35
Left	4	1	1	0	6	42
Bilateral	2	0	1	0	3	21

**Table 5: Distribution of plaque (N=14)**

Among atheromatous patients, 8(57%) had plaque at carotid bifurcation, 4(28%) at ICA, 2(14%) at CCA and none in ECA. Bilateral carotid artery involvement was found in 3 (21%) patients.

Percentage of Stenosis %	Patients (N=14)	
	No.	%
<50	6	42
50-70	5	35
>70	2	14
Near occlusion	0	0
<b>Total Occlusion</b>	<b>1</b>	<b>7</b>

**Table 6: Distribution of plaque patients based on percentage of stenosis**

Among Atheromatous plaque patients, 8 (57%) had significant stenosis (Significant stenosis is diameter reduction of >50%).

Out of 14 plaque patients, 6(42%) had a stenosis of <50%, 5(35%) had 50-70% of stenosis, 2(14%) had >70% stenosis and 1(7%) patient had total occlusion.

Plaque characteristic	No.	%
Low Echogenicity	3	17
Moderate Echogenicity	5	29
Strong Echogenicity	9	52

**Table 7: Plaque characterisation (N=14)**

Note: 3 plaques were Bilateral.

Among 14 patients with Atheromatous plaque, majority of the plaque were strongly echogenic i.e., 9(52%), moderately echogenic in 5(35%) and low echogenic in 3(21%).

Peak systolic velocity ratio of ICA/CCA	Patients (N=14)	
	No.	%
<2	6	42
2-4	5	35
>4	2	14
<b>Total block</b>	<b>1</b>	<b>7</b>

**Table 8: Distribution of plaque patients based on PSV ratio of ICA/CCA**

Among 14 plaque patients, 6(42%) had a PSV ratio of the ICA/CCA of <2, 5(35%) had a ratio of 2-4, 2(14%) had PSV ratio >4. One patient had total block.

**DISCUSSION:** Identifying the degree of stenosis is important in the management of symptomatic patients, those with < 50% stenosis have no benefit from carotid endarterectomy (CEA), those with 50–70% stenosis have moderate benefit from CEA as compared to medical line of treatment alone. Patients with 70–90% stenosis have the highest therapeutic index with CEA.

**Age and Sex Distribution:** Among 25 clinically diagnosed cerebrovascular insufficiency patients who underwent carotid Doppler study, 17(68%) were males and 8(32%) were females.

Out of these, 14 had atheromatous plaque changes in the carotid arteries and the rest 11 were normal studies. Among 14 plaque patients, 9(64%) were males and 5(35%) were females, majority of these patients were in the age group of 60-70 years.

These findings were consistent with NASCET and ACAS studies where NASCET had 72% males and 28% females. ACAS study had 50% of patients above the age of 60 years. In our study, male to female ratio of plaque patients was 1.8:1 which is comparable to the study of Paivansalo et al.<sup>5</sup>

**Risk Factors:** Out of 14 patients with plaque, cigarette smoking was the common factor (57%) followed by hypertension (50%), diabetes mellitus (35%), hyperlipidaemia (21%) and IHD (7%).

Henning & Mast et al<sup>6</sup> reported smoking as an independent determinant of severe carotid artery stenosis in patient with cerebral ischaemia. George Howard et al<sup>7</sup>, showed that the magnitude of the association with smoking is substantial compared with the effect of hypertension and other traditional cerebrovascular risk factors and most risk factors continue to be associated with increased atherosclerosis at older ages and suggested controlling of risk factors at older ages. Wishnant et al<sup>8s</sup> (1990) reported cigarette smoking of long duration to the strongest predictor of severe extracranial carotid atherosclerosis.

#### Plaque:

- In our study, we found atherosclerotic plaque most commonly on left side in 6(42%) patients, 5(35%) patients on right side and bilateral in 3(21%).
- 8(57%) had plaque at carotid bifurcation, 2(25%) on right side, 4(50%) on left side and 2(25%) on both sides.

- 2 patients had plaque in CCA one on each side (50%).
- 3 patients had plaque in the ICA, 2(50%) on right side, 1(25%) on left side and 1 (25%) on both sides.
- None of patients had plaque in the ECA.

Out of 14 plaque patients, 9 had strongly echogenic plaque with areas of calcification, 5 moderate echogenicity and 3 low echogenicity.

Colour flow Doppler was used in patients with low echogenic plaque to exactly measure the diameter reduction, as well to outline surface characteristic of the plaque. This is comparable to study done by Michelle J. Hallamet et al.<sup>9</sup>

In 1 patient, total occlusion of ICA by hypoechoic thrombus was confirmed by using colour Doppler which showed absence of flow.

**Percentage of Stenosis:** Among 25 patients of cerebrovascular insufficiency, 14(56%) had atherosclerotic plaque changes suggesting that significant number of patients had carotid artery disease.

Out of 14 plaque patients, 8 had significant stenosis (significant stenosis means a diameter reduction of >50%) i.e. 5 had <50-70% stenosis, 2 were <70% stenosis and 1 complete occlusion. Rest of the 6 had < 50% stenosis.

The findings of 8(57%) significant stenosis out of 14 patients, were consistent with observations made by Carroll,<sup>10</sup> who found significant involvement of extracranial carotid artery disease between 30-60%.

**Peak Systolic Velocity ratio of ICA/CCA:** Among 14 plaque patients, 6(42%) had a PSV ratio of the ICA/CCA of <2, 5(35%) had a ratio of 2-4, 2(14%) had PSV ratio >4. One patient had total block.

According to 'N' North American method used in ACAS and NASCET trial, they defined PSV ratio of ICA/CCA of > 2 as indicative of greater than 50% stenosis a ratio of >4 as indicative of greater than 70% stenosis.

Garth KE<sup>11</sup> and colleagues found PSV ratio of ICA/CCA more accurate than PSV alone.

**Age and Stenosis:** Among 14 plaque patients majority of patients with significant stenosis i.e. 6(42%) were in the age group 60-70 years.

**EDV:** During the study, it was observed that EDV of ICA consistently increased above 40 cm/sec in patients with >50% stenosis. Among studied patients vertebral arteries showed normal flow pattern.

**CONCLUSION:** Old age is associated with increased risk of carotid artery disease. Males are more commonly affected than females. Smoking is the commonest risk factor for the development of carotid artery stenosis. Multiple risk factors are associated with increased chances of carotid artery stenosis. Commonest site of pathology is in the carotid bifurcation. Doppler study is a safe, non-invasive and effective method for evaluating carotid artery disease. Peak systolic velocity ratio of ICA/CCA helps in identification of

degree of stenosis which will help in management. B-mode real time ultrasound with colour and spectral Doppler helps in identifying patients with carotid artery stenosis and in categorising them depending on percentage of stenosis, which will help in management.

#### REFERENCES:

1. Dalan PM. Cerebrovascular disorders. In: Shah SN ed. API text book of Medicine. Mumbai: The association of physicians of India 2003;7<sup>th</sup> edn:796-797.
2. Tahmasebpour HR, Buckley AR, Cooperberg PL. Sonographic Examination of the carotid arteries. Radiographics 2005;25(6):1561-1575.
3. Caroll BA. Carotid Ultra Sound. Neuro imaging clinics of North America 1996;6(4):875-897.
4. Fontenelle LJ, simper SC, Hanson TL. Carotid duplex scan versus angiography in evaluation of carotid artery diseases. AJS 1994;60(11):864-868.
5. Paivansalo M, Leiononen S, Jurumen J Tikkakoski, et al. Quantification of Carotid artery stenosis with various Doppler velocity parameters. ROFO 1996;164(2):108-113.
6. Mast H, Thompson JLP, Lin IF, et al. Cigarette smoking as a determinant of high grade stenosis in Hispanic, Black & White patients with stroke or TIA. Stroke 1998;29(5):908-912.
7. Howard G, Wagenknecht LE, Lai J, et al. Cigarette smoking and other risk factors for silent cerebral infarction in general population. Stroke 1998;29(5):913-917.
8. Whisnant JP, Homes D, Ingall TJ, et al. Duration of cigarette smoking is strongest predictor of severe extra-cranial carotid artery atherosclerosis. Stroke 1990;21(5):707-714.
9. Hallam MJ, Raid JM, Cooper Berg PL. Color-flow Doppler and conventional duplex scanning of the carotid bifurcation: prospective – blind, correlative study. AJR 1989;152:1101-1105.
10. Caroll BA. Duplex sonography in patients with hemispheric stroke patients J. Ultrasound medicine 1989;8(10):535-539.
11. Garth KE, Caroll BA, Sommer FG, et al. Duplex ultrasound scanning of the carotid arteries with velocity spectrum analysis. Radiology 1983;147(3):823-827.