

Plaque Morphology in Adult Stroke Patients in North-Central Nigeria

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ABSTRACT

Background: Stroke is the leading cause of long-term disability and the second most common cause of death worldwide. It may however be preventable if pre-disposing factors such as carotid plaques are detected early and treated. Doppler Ultrasonography (USS) is excellent at detecting carotid plaques. This study was aimed at determining the frequency and the morphology of carotid plaques in adult stroke patients using Doppler USS. **Methodology:** This was a prospective study. Eighty-three adult ischaemic stroke patients at a tertiary hospital in North-Central Nigeria were included over a period of one year. For each patient, both carotid arteries were examined using Doppler ultrasonography and the findings documented. **Results:** Data was analyzed using SPSS version 21.0 and presented in tables and charts as appropriate. A total of 83 patients were evaluated with slight male predominance and a mean age of 60 years. Hypertension was the most common risk factor. Fifty-nine patients (71.1%) had abnormal carotid Doppler findings out of which 66.1% had carotid plaques with 6.8% having critical stenosis of >70%. **Conclusion:** Doppler ultrasonography is a very important non-invasive and readily available tool for depicting the morphology of carotid plaques. Screening carotid arteries of asymptomatic patients with known cerebrovascular risk factors will be beneficial towards primary stroke prevention.

Keywords: Stroke, Carotid, Plaque, Morphology, Doppler, Ultrasonography.

INTRODUCTION

Stroke is the second most common cause of death in developed countries^[1]. It is also the leading cause of serious long-term disability^[2]. It is estimated that about 795,000 people suffer from stroke each year of which 140,000 are said to die^[2]. Local data in Nigeria shows a crude prevalence rate of 6.7/1,000 population^[3]. Doppler

Ultrasonography (USS) of the carotid arteries can identify risk factors for ischaemic stroke such as plaques, luminal stenosis^[4] etc.

This study assessed the frequency and morphology of carotid plaques in adult stroke patients in a tertiary hospital in North-Central, Nigeria. It also compared previous related studies as seen in literature.



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Aim This study was aimed at determining the frequency and pattern of plaques in the carotid arteries of adult stroke patients using Doppler ultrasonography.

Specific objectives

1. To identify adult patients with ischaemic stroke who have carotid plaques.
2. To correlate the age and sex of patients presenting with stroke with the presence of carotid plaques and the morphology.
3. To identify other risk factors e.g. hypertension, diabetes etc. that may have contributed to the carotid plaque formation.

MATERIALS AND METHODS

Study setting

This was a prospective descriptive study carried out at a tertiary hospital in North-Central, Nigeria. The setting was the Doppler USS suite of the Department of Radiology of the hospital. The study was conducted over a period of one year.

Determination of sample size

The study assessed 83 consecutive adult patients with ischaemic stroke. This sample size was estimated using the Fischer's formula below^[5]:

$$N = z^2 pq / d^2$$

Where:

N = the desired sample size

z = standard normal deviation = 2.57 at 99% confidence interval

p = prevalence of stroke = 0.00114 = 0.114% (1.14/1000)^[6,7]

q = 1-p = 0.99886

d = degree of accuracy, set at 0.01

Therefore, $N = (2.57)^2 (0.00114) (0.99886) / (0.01)^2 = 75.2$

To make up for possible attrition error/non response, this number was adjusted using approximate response rate of 90%, making 83.

Inclusion Criteria

These include Adults (18 years and above), Males

and females and Diagnosed ischaemic stroke.

Exclusion criteria

These include Unstable patients, Children with stroke, Haemorrhagic stroke and stroke mimics.

Ethical consideration

Approval was obtained from the Ethics and Research committee of the institution prior to onset of study

Equipment

All studies were performed by the same operator (the Author). Phillips ultrasound scanner HD 11 XE, Netherlands, 2006 with Doppler capabilities and a 7.5MHz linear probe was used.

Sonographic technique

All patients were placed supine with the face turned away from the side to be examined. A soft pillow was placed under the neck to achieve neck extension and also for patient's comfort. Adequate exposure of the neck was ensured from the clavicle up to the ipsilateral ear. The coupling gel was applied and either the anterior, lateral or posterior approach was used as appropriate. Both CCAs in the neck were assessed in segments i.e proximal, mid, distal, bulb as well as the proximal Internal and External carotid arteries (ICA and ECA).

The examination started with the B mode in transverse scan of the carotid artery from the root of the neck to as high in the neck as possible behind the angle of the jaw. The probe was then aligned longitudinally and appropriate insonation angle selected. A general view of all segments was obtained. If a plaque is present, its site, length, width, surface (i.e smooth, irregular or ulcerated) as well as its echogenicity (i.e homogenous, heterogenous, calcified, hyperechoic or hypoechoic) were documented. Residual luminal diameter and the external diameter of the artery were measured at the same level using the in-built calipers. Percentage stenosis was calculated electronically and documented.

Colour Doppler mode was activated and areas of

abnormal flow identified and noted. This is followed by a Spectral examination where the waveforms, peak systolic velocity (PSV) and end-diastolic velocity (EDV) were assessed.

Statistical analysis

Data collected was entered on IBM SPSS Statistics for Windows, version 21.0. (IBM Corp. Armonk, NY, USA. 2011) and analyzed. Results were presented using tables, graphs, bar and pie charts where necessary. Correlation was done using chi-square, t-test and fisher's exact test as applicable. P value is considered significant when <0.01.

RESULTS

The study comprised of eighty-three (83) stroke patients. Forty-five (54.2%) were males and 38 (45.8%) were females, giving a male: female ratio of 1.2:1.

Carotid plaques were found in 39 patients (47%). Of this, 33.3% were on the right and 28.2% were on the left while 38.5% had bilateral plaques. Twenty-four (24) % of the plaques were found on the contralateral side to the stroke side. Of the 39 patients, 25 (64.1%) were males and (35.9%) were females. Thirty-six (36) patients (92.3%) were above 50 years of age and 30 (76.9%) were hypertensive. However, no statistically significant association was seen in relation to these risk factors (table 1). When correlated with age, the mean age of those with plaques was 62.44+/-12.37 years while that of those without plaques was 58.66+/-11.74 years. However, this difference was not statistically significant (t= -1.427, P=0.158).

The most common site of the plaques was the carotid bulb/bifurcation both on the right and left accounting for 23.6% and 40.0% respectively. On the left, this is followed by proximal CCA, mid CCA and proximal ICA accounting for 16.0% each. Four (4) % were in the distal CCA, while 8% were in multiple locations (figure 1). On the right, 28.5% were in the mid CCA, 21.4% in the distal CCA, 10.7% in proximal ICA, 3.6% in proximal CCA and 7.1% at multiple sites.

The plaques were predominantly hyperechoic accounting for 42.9% and 48.0% on the right and left respectively (figure 2). This is followed by hypoechoic plaques in 32.1% and 20.0% respectively. Mixed echogenicity was seen in 3.6% and 8.0% respectively, while 21.4% and 24.0% were calcified on the right and left respectively (figures 3 and 4).

Up to 80% of the plaques on the left had rough/ulcerated surface, while only 46.4% had rough surfaces on the right.

Table: Distribution of Risk Factors in Patients with and without Plaques

	Plaque Absent N (%)	Plaque Present N (%)	P Value
Gender			
Male	20 (44.4)	25 (55.6)	0.123*
Female	24 (63.2)	14 (36.8)	
Age Group			
Less than 50 Years	11 (78.6)	3 (21.4)	0.043*
50 Years and above	33 (47.8)	36 (52.2)	
Hypertension			
Yes	30 (50.0)	30 (50.0)	0.464*
No	14 (60.9)	9 (39.1)	
Diabetes			
Yes	12 (52.2)	11 (47.8)	1.000*
No	32 (53.3)	28 (46.7)	
Hyperlipidaemia			
Yes	14 (60.9)	9 (39.1)	0.406*
No	21 (55.3)	17 (44.7)	
Don't Know	9 (40.9)	13 (59.1)	
Family History of Stroke			
Yes	10 (55.6)	8 (44.4)	0.349*
No	33 (55.0)	27 (45.0)	
Don't Know	1 (20.0)	4 (80.0)	
Co-Morbidities			
Hypertension and Diabetes	5 (45.5)	6 (54.5)	0.664*
Hypertension and Hyperlipidaemia	10 (66.7)	5 (33.3)	
Hypertension, Diabetes and Hyperlipidaemia	4 (57.1)	3 (42.9)	

Key: * Not statistically significant

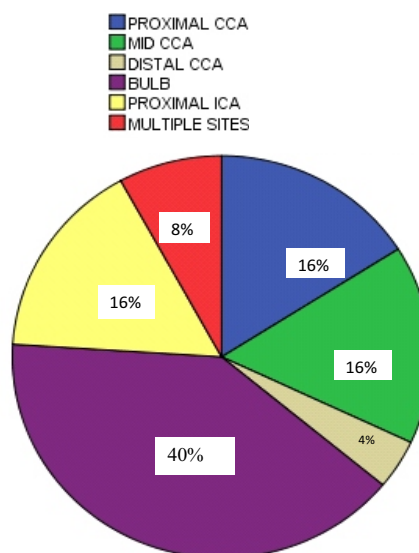


Figure 1: Pie chart showing distribution of site of plaque on the left

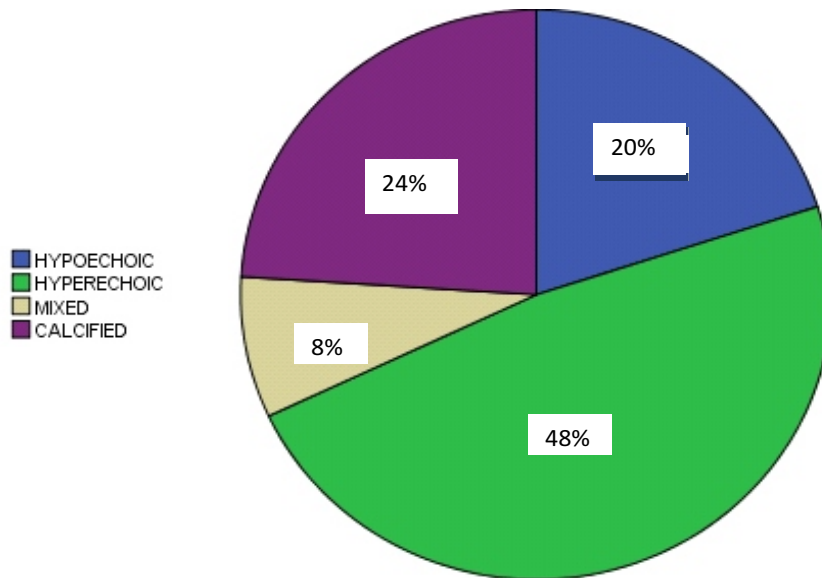


Figure2: Pie chart showing distribution of plaque echogenicity on the left.

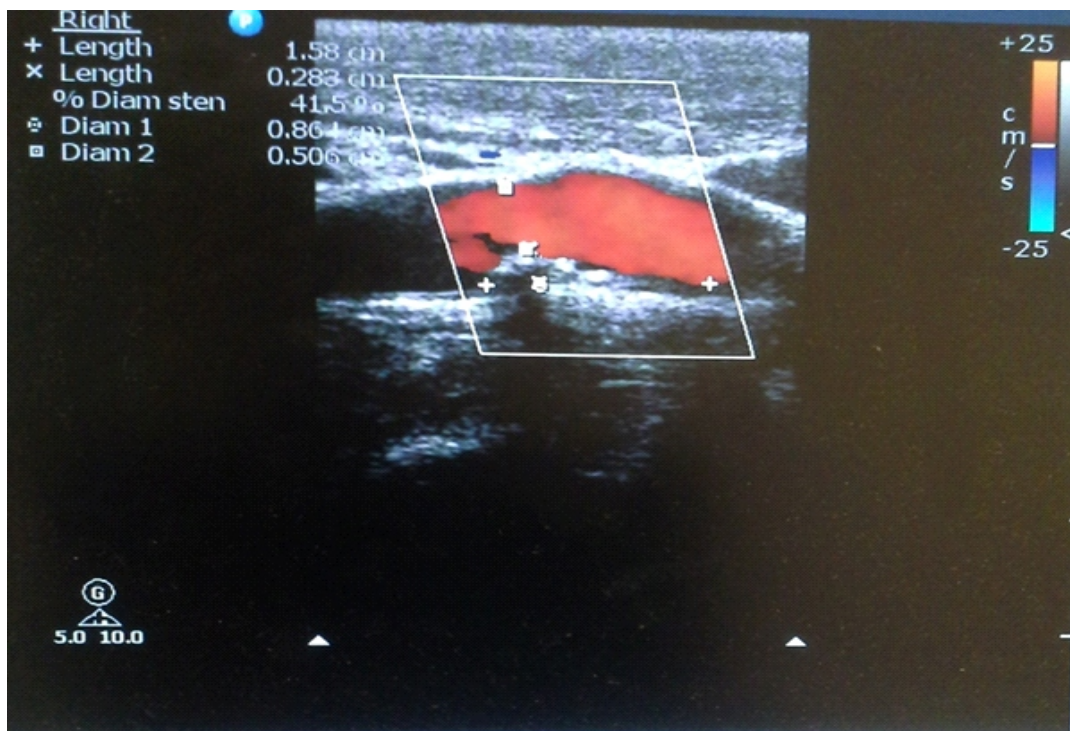


Figure 3: Colour doppler USS of a 54-year-old female in longitudinal plane showing a hyperechoic plaque with irregular/rough surface in the posterior/far wall of the distal right CCA with resultant 41.5% diameter stenosis.

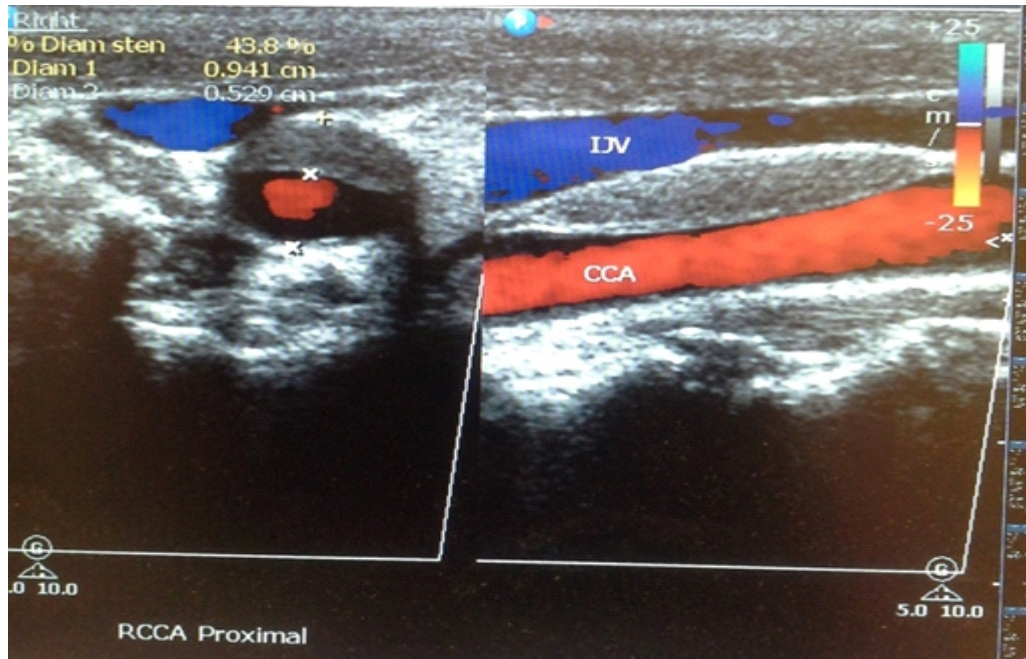


Figure 4: Colour doppler USS of a 74-year-old female in transverse and longitudinal planes showing a large hypochoic plaque with smooth surface in the proximal segment of the right CCA (anterior/near wall) causing 43.8% diameter stenosis.

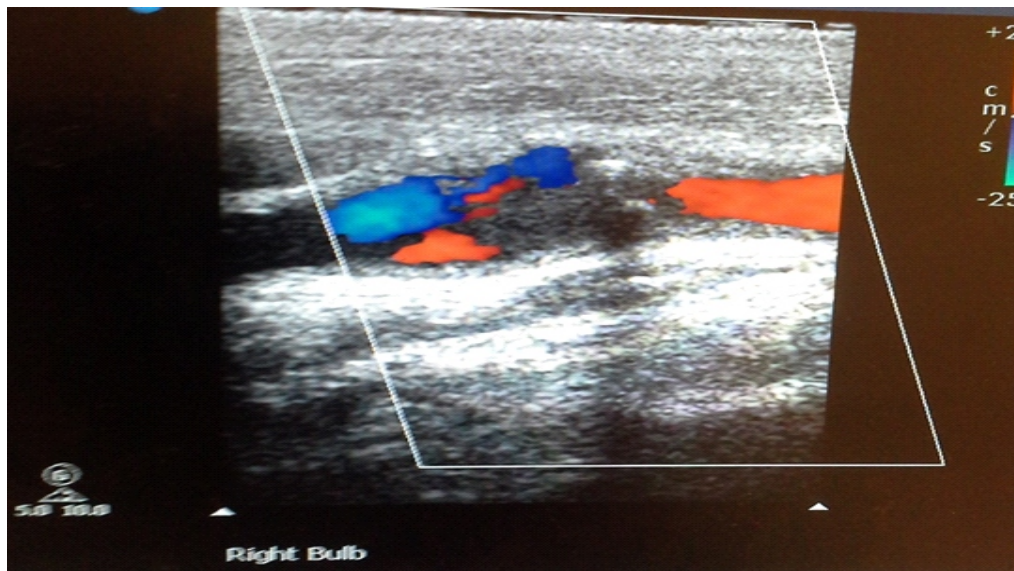


Figure 5: Colour Doppler USS image in longitudinal plane showing critical stenosis at the right carotid bulb from a calcified plaque (P)

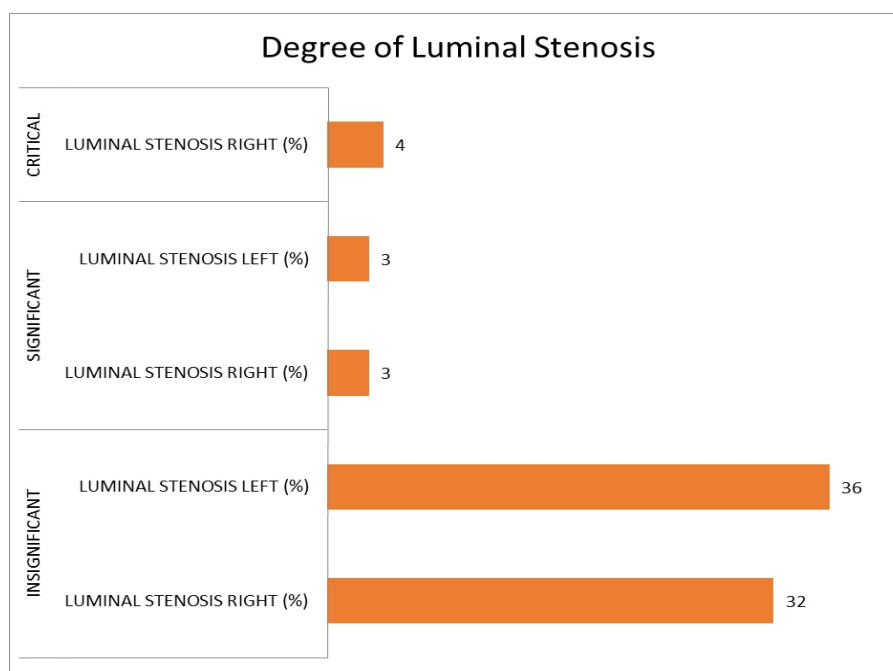


Figure 6: Degree of luminal stenosis on the right and left

Out of the 39 patients who had plaques, 4 patients (10.2%) had critical stenosis of >70% (figure 5). These were all on the right side. All of them were above 50 years of age and had intimal thickening. Three out of the 4 patients (75%) were males. Six (6) patients (15.4%) had significant stenosis of 50-70%, while the remaining 29 patients (74.4%) had insignificant stenosis of 0-49% (figure 6).

DISCUSSION

It has been reported that about 30-60% of stroke are caused by atherosclerotic disease of the extracranial carotid arteries usually within 2 cm of the carotid bifurcation^[8]. Carotid Doppler sonography is a non-invasive and readily available procedure that can assess plaque composition/morphology. Plaque characteristics may have prognostic value and may be useful for selection of medical and surgical therapy^[9]. Furthermore, its major role is to detect occlusive lesions in the extracranial CCA and ICA^[10,11].

In this study, 47% of the patients had plaques in the carotid arteries. Alkali et al reported presence of plaques in 36.2% of patients^[12]. This is also corroborated by other studies in Asia (Pakistan) showing plaques in 30-50% of cases.^[13,15] However, findings here are at variance with studies of Pasupuleti et al^[11] and Fernandes et al^[8] in India who demonstrated high proportion of plaques of 80% and 78% in their respective studies. These variations may be due to the difference in geographical location, race and diet. Similarly, there is recent marked improvement in access to healthcare in India and it may be implied that more people access health services than in Nigeria and they may have better diagnostic efficiency to demonstrate these changes.

More plaques were found in males than females, which is also corroborated in other studies^[11,16]. Majority of the plaques were unilateral and ipsilateral to the side of stroke. This is expected and similar to findings in other studies^[11,13,15]. However, Fernandes et al reported bilateral plaques in 59% of

cases^[8]. This study further found that 24% of plaques were on the contralateral side to the side of the stroke, similar to findings of Alkali et al that showed 17.6%^[12]. These may be incidental findings. In these cases, source of cerebral ischaemia on the affected side may be cardiac related or due to small vessel disease (vasculitis) which are beyond the scope of carotid Doppler USS. However, vascular (carotid) abnormalities are usually age related and hence can affect both sides. Contralateral plaques are important to note because they indicate that the patient is at risk of a repeat stroke on the contralateral side. The commonest site of plaques in this study was the carotid bulb/bifurcation bilaterally, similar to other findings^[10,11,16]. However, other studies showed more plaques at the CCA and ICA respectively^[8,13]. The carotid bulb is the bulbous dilatation at the origin of the ICA where there is turbulent flow. This increases the risk of plaque formation. The plaques were predominantly hyperechoic, as seen in other studies^[8,11,16].

Hyperechogenicity of plaque suggests its chronic nature^[11]. This is because plaque becomes echogenic when it becomes retracted and fibrosed^[17]. This study showed more hyperechoic plaques probably due to late presentation. Hypoechoic plaques were seen in 32.1% and 20% of plaques on the right and left respectively. Some studies showed predominant hypoechoic plaques^[8,13,15]. The low echogenicity is due to lipid rich material or haemorrhage within the plaque^[18]. They may show an echogenic fibrous cap^[19], and are generally more prone to embolization and subsequently stroke^[10,20,21].

Presence of intimal plaque may cause luminal narrowing (stenosis). Diameter stenosis was used in this study. It is widely considered to be the gold standard for decision-making because this was the method chosen for the two randomised clinical trials; North America Symptomatic Endarterectomy Trial (NASET)^[22] and European Carotid Surgery Trial (ECST)^[23]. The stenosis was classified as insignificant (<50%), significant (50-70%) and critical (>70%). This classification was

also informed by the findings of these randomised clinical trials^[22,23] that clearly showed the benefit of endarterectomy in symptomatic patients of >70% stenosis and the lack of benefit of surgery on lesions of 30% or less. This classification was also used in other studies^[13]. However, some other studies considered >60% as significant stenosis^[8,11,14]. All patients with stenosis are over 50 years of age. Lemolo et al, showed that women have more stenosis but less plaque than men, suggesting that differences in sex hormones may affect remodelling of atherosclerosis^[9]. They also suggested that plaque area was a stronger predictor of outcomes than was stenosis^[9]. This study, however found more incidence of stenosis and plaques in males than females.

The management of carotid plaque /stenosis depends on the degree of stenosis and also the morphology of the plaque. Non calcified or partially calcified plaques are usually termed high-risk morphology plaques and they are found to respond more statins^[24]. Carotid endarterectomy (CEA) in addition to medical therapy significantly reduces the absolute risk of ipsilateral stroke by 17% and major or fatal stroke by 10.6% in patients with high grade (>70%), symptomatic carotid artery stenosis^[25]. Carotid artery stenting (CAS) is a minimally invasive interventional radiological technique for treating carotid artery disease. It is especially useful in asymptomatic patients at high risk of complication with CEA^[26].

CONCLUSION

A significant proportion of stroke patients have plaques in their carotid arteries. Doppler ultrasonography is a very important non-invasive and readily available tool for depicting the morphology of carotid plaques. Nature of carotid plaques can help in determining the mode of treatment. Screening carotid arteries of asymptomatic patients with known cerebrovascular risk factors will be beneficial towards primary stroke prevention.

Acknowledgement

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Conflict of Interest

Nil

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