Ultrasonographic Evaluation of Carotid Luminal Diameter and Plaques Morphology in Stroke Patients

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The aim of this study is to evaluate carotid stenosis and plaque morphology in stroke patients.

High resolution carotid ultrasound of bilateral carotid artery was done in 110 clinically proven stroke patients. Intimomedial thickness (IMT) was assessed 1-1.5 cm proximal to the bulb. For plaques the near and far walls of the arterial segments were scanned both longitudinally and transversely. Plaques were classified as low, moderate and strongly echogenic with shadowing (calcified).

Carotid luminal diameter was measured in transverse plane perpendicular to the long axis of the vessel at the end of the diastole. Percentage of stenosis was calculated using both cross sectional and velocimetric criteria.

Plaques were more common in the carotid bulb (43.6% on right side and 53.6%on left side) and most common was calcified type (29.1%) which was predominant on left side. In internal carotid artery (ICA) moderately echogenic plaques (8.1%) were more common. Plaques were less common in common carotid artery (CCA).

Duplex color Doppler sonography of the carotid artery is a noninvasive, accurate and cost effective screening modality in stroke patients.

Key words: Carotid stenosis, Doppler sonography, intimomediathickness, plaques

Stroke is a world wide major health problem. It is one of the leading causes of morbidity, mortality and disability in developed as well as developing countries.

Stroke due to atherosclerotic disease is the third leading cause of death in western countries. One third of cases are fatal and survivors of stroke victims usually have prolonged or irreversible neurological impairment [4]

More than 500,000 new cases of cerebrovascular accidents are reported annually.[6]

I Ischemia from severe, flow limiting stenosis due to atherosclerotic disease involving the extra cranial carotid arteries is implicated in approximately 20% to 30% of stroke patients.[6]

An estimated 80% of strokes are thromboembolic in origin, often with carotid plaque as the embolic source.[8]

In 1951 Fisher observed atherosclerotic stenosis at the origin of the ICA.Since then it has been known as an important cause of cerebral infarction.[5,7]

Although contrast injection cerebral angiography has been considered gold –standard technique for diagnosis and operative planning of carotid disease but it carries its own risk and expense.[9]

Introduction of duplex ultrasonography is the upcoming modality for evaluation of extra cranial carotid arteries and now a days it being listed as single independent preoperative test, Besides calculating calculating the degree of stenosis, detail plaque evaluation including morphology

Male	0.85	1.0
Female	0.77	0.88

Table 1. Mean IMT thickness in 110 patients.

and surface characteristics can be performed with this modality, which is thought to play an important role in the pathogenesis of stroke.

Materials and Methods

A total of 110 consecutive clinically proven stroke patients were (CVA cases) referred from neurosurgery and medicine department of Kathmandu model hospital between 2005 and 2007 were studied. Patients with symptomatic valvular heart disease which was severe enough to affect flow and also semiconscious patients producing enough artifacts in image were excluded.

A high resolution carotid ultrasound examination was performed with 7.5MHz linear probe for evaluation of the morphology of plaques and velociometric characteristics. Commercially available ultrasound (TOSHIBA Nemio 30 Japan) machines with Doppler facilities were used for the same.

Carotid artery examinations were performed with the patient supine, neck slightly extended, and head turned away from the side being examined. The probe was placed on the medial side of the sternocleidomastoid muscle.

The hand-held probe was positioned first over the CCA in the lower part of the neck. By moving the probe distally and scanning in various planes, carotid bifurcation, ICAs, and external carotid arteries were identified. The vessels were scanned in both transverse and longitudinal planes. The carotid bulb was identified as mild widening of common carotid artery near the bifurcation. Intima media thickness was assessed at about 1-1.5cm proximal to the carotid bulb in longitudinal plane, The area had to be free of plaque.

The near and far wall of these arterial segments were scanned both longitudinally and transversely for the presence of plaques. Distribution of the plaques and it's relation to vessel walls were recorded. Plaques were classified as low – echogenic, moderately echogenic plaque and strongly echogenic plaque with shadowing.[18]

Carotid luminal diameter was measured in transverse plane perpendicular to the long axis of the vessel at the end of diastole color Doppler examinations were performed with angle of insonation below 60degrees. Percentage of stenosis was calculated using both cross sectional and velociometric criteria. In ICA at the level of maximum stenosis, the PSV and EDV were recorded. Flow velocity of CCA was also recorded. PSV ratio of ICA/CCA was calculated.

Statistical analysis was done with the help of SPSS 11.5 Software. P values were calculated using chi-square test for statistical significance.

Results

A total of 110 patients with clinical symptoms of CVA were studied. Among them 71 were male and 39 were female. The age ranged from 38 to 90 years (median age 65). Male median age was 63 and female median age was 68.

Mean Intimomedial thickness in male was 0.85mm on right side and 1.0mm on left side. In female it was 0.77mm on right side and 0.88mm on left side. There was no statistical significance difference in right and left side of IMT thickness (p>0.688 right side and p>0.805 left side).

Plaques were seen in 65 patients (59.1%). In the carotid bulb, 58 patients (53.6%) had it on the left and 48(43.6%)

Sn		CCA		Carotid Bulb		ICA	
		Rt	Lt	Rt	Lt	Rt	Lt
1	Low echoic plaque	1(0.9%)	1(0.9%)	9(8.2%)	8(7.3%)	2(1.8%)	1(0.9%)
2	Moderately echogenic plaque	3(2.7%)	7(6.3%)	12(10.9%)	18(16.3%)	9(8.1%)	8(7.3%)
3	Strongly echogenic plaque with shadowing	3(2.7%)	3(2.9%)	27(24.5%)	32(29.1%)	3(2.7%)	7(6.4%)
4	Total	7(6.3%)	11(10.1%)	48(43.6%)	58(52.7%)	14(12.6%)	16(14.6%)
5	p-value	0.687		0.688		0.393	

Table 2. Distribution and morphology of plaques. Abbreviation, CCA = common carotid artery, ICA = Internal common artery, Lt = left, Rt = right.

Sn	% Stenosis	CCA		Carotid Bulb		ICA	
		Rt	Lt	Rt	Lt	Rt	Lt
1	<59%	2(1.8%)	4(3.6%)	26(23.6%)	21(19.1%)	-	4(3.6%)
2	60-79%	1(0.9%)	-	4(3.6%)	5(4.5%)	4(3.6%)	3(2.7%)
3	80-99%	-	-	-	-	2(1.8%)	-
4	Complete occlusion	2(1.8%)	1(0.9%)	2(1.8%)	1(0.9%)	6(5.5%)	4(3.6%)

Table3: Percentage of stenosis in different site of carotid artery. Abbreviation, CCA = common carotid artery, ICA = Internal common artery, Lt = left, Rt = right.

had on right. Regarding the type, strong echogenic with shadowing (calcified) plaques was seen in 27 patients (24.5%) on right bulb and 32 patients (29.1%) on left. Two patients (1.8%) had right sided complete occlusion of CCA, carotid bulb and ICA.

On the right ICA, 14 patients (12.6%) had plaques. Among them, low echogenic plaques were found in two patients (1.8%), moderately echogenic in nine patients (8.1%) and strongly echogenic plaque with shadowing (calcified) in three patients (2.7%). Five patients (4.5%) had complete occlusion of the right ICA.

On the left ICA, 16 patients (14.6%) had plaques. Among them one patient (0.9%) had low echogenic, eight patients (7.3%) had moderately echogenic and seven patients (6.4%) had calcified plaques. Two patients (1.8%) had complete occlusion of the left ICA.

Plaques were less common in CCA on both sides with seven patients (6.3%) showed on right side. Among them, one patient (0.9%) had low echogenic, three patients (2.7%) had moderately echogenic and three patients (2.7%) had calcified plaques. Eleven Patients (10.1%) had left CCA plaques. Among them one patient (0.9%) had low echogenic, seven patients (6.3%) had moderately echogenic and three patients (2.9%) had calcified plaques.

On the right side, <59% of CCA stenosis was found in two patients (1.8%), 60-79% stenosis in one patient (0.9%) and complete occlusion in two patients (1.8%).

In the carotid bulb <59% stenosis was found in 26 patients (23.6%), 60-79% stenosis in four patients (3.6%) and complete occlusion in two patients(1.8%) on right side.

Right ICA stenosis of 60-79% was found in four patients(3.6%), 80-99% stenosis in two patients (1.8%) and complete ICA occlusion in six patients (5.5%).Left CCA showed <59% stenosis in 4 patients (3.6%) and complete occlusion in 1 patient (0.9%).

Left carotid bulb had <59% stenosis seen in 21 patients (19.1%), 60-79% stenosis in 5 patients (4.5%) and complete occlusion noted in 1 patient (0.9%).

Left ICA had <59% stenosis in 4 patients (3.6%), 60-79% stenosis in 3 patients (2.7%) and complete occlusion in 4 patients (3.6%).

Discussion

Polak JF, et al., found that greater than 0.8mm IMT thickness is abnormal and represent the earliest changes of atherosclerotic changes.[14] The mean thickness of the IM complex is related to cardiovascular risk factors, including age, smoking, and systolic blood pressure. Thickening of the I-M complex or focal plaque correlated with an increased risk for the development of cardiovascular symptoms in asymptomatic patients.[17]

O'Leary, et al., measured intima and media of the common and internal carotid artery in 5858 subjects 65 years of age or older and followed over a median period of 6.2 years. They found that the intima-media thickness of the common carotid artery and the the internal carotid artery were strongly associated with the risk of myocardial infarction and stroke in asymptomatic older adults.[13]

Bots et al found a graded association of common carotid intima- media thickness with stroke.IMT was measured in 1373 subjects free from myocardial infarction and stroke that were followed up to for 2.7 years. Stroke risk increased gradually with increasing IMT.[3]

In our study mean intemomedial thickness in male on right side was 0.85mm and left side was 1.0mm. In female it was 0.77mm on right side and 0.88mm on left side.

Plaque is the one of the major risk factors for the development of stroke. Kitamura et al found that plaque more than 1.5mm thickness in the ICA had a 3 fold higher risk of stroke than those without a plaque, and the plaque surface irregularity further increased the stroke risk.[10]

The Northern Manhattan Study was done in 1939 stroke free subjects. Among them, carotid plaque was visualized in 56.3%.During a mean follow up of 6.2 years after ultrasound examination, 69 ischemic strokes occurred. They found the unadjusted cumulative 5-year risks of ischemic stroke as: 1.3%, 3.0% and 8.5% for no plaque, regular plaque, and irregular plaque respectively.[15]

Langsfield et al studied 419 patients for 15-22 months and they found the echolucent or heterogeneous plaques to be at increased risk of becoming symptomatic compared with dense , echo rich plaques($p<0.02$).[11]

Bock et al showed that echolucent plaques were associated with a 5.7% incidence of TIA and stroke, compared with 2.4% for echogenic plaques.[2]

In our study 69(62.5%) plaques were found on right side and 85(78.1%) on left side.

It was more common in carotid bulb (right 43.6% and left (53.6%) . Regarding type, strongly echogenic plaque with shadowing (Type IV) was more common right side 27(24.5%)

and left was 32(29.1%). After carotid bulb plaques were common in ICA and least in both CCA (6.3% on right and 9.9% on left).

Carotid artery stenosis plays a considerable part in the evolution of ischemic cerebrovascular disease. In patient with minor stroke or TIA having carotid artery stenosis of over 50% there is 20-30% risk of ipsilateral stroke within the first 30days.[16]

Endarterectomy is known to reduce the stroke risk in symptomatic patients with >= 50% carotid stenosis for years. The guidelines of American Heart Association recommend endarterectomy in symptomatic patients with 50-99% stenosis and in asymptomatic patients with 60-99% stenosis.[1]

North American Symptomatic Carotid Endarterectomy Trial (NASCET) and the European Carotid Surgery Trail demonstrated definite benefit of carotid endarterectomy in symptomatic patients with narrowing of the internal carotid artery lumen diameter by 70% to 99%.[12]

In our study common site for stenosis was found in carotid bulb followed by ICA and less commonly in CCA. Complete occlusion was more in ICA with right sided predominance.

Conclusions

Duplex color Doppler sonography is a noninvasive imaging modality to evaluate the carotid artery for atherosclerosis. It is the 'Road Map' for the identification of ICA origin, its course, relation of tortuosity and high bifurcation. Thickness of the IMT in CCA and plaques morphology are the important predictors for Cardiovascular and cerebrovascular complications. It is highly useful for differentiate between severe stenosis and complete occlusion. It is noninvasive, accurate and cost effective tool for screening of carotid artery for associated complications like stroke.

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