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Original Article

Radiology Section

Correlation of Carotid Artery Doppler with Risk Factors and Computed Tomography Brain in Patients with Ischemic Cerebrovascular Accident

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ABSTRACT

Introduction: Ischemic Cerebrovascular Accident (CVA) is a leading cause of morbidity and mortality in the world. Atherosclerosis of blood vessels supplying the brain is one of the common reasons. The risk of patients with stroke due to atherosclerosis is closely associated with severity of the luminal stenosis. Carotid sonography without preoperative angiography is becoming increasingly common before carotid endarterectomy.

Aim: To correlate carotid artery Doppler and Computed Tomography- Brain findings in patients with Ischemic CVA and also to correlate carotid Doppler with individual risk factors for carotid artery disease in South Indian population.

Materials and Methods: This study was designed to evaluate patients with (Transient Ischemic Attack) TIA and ischemic CVA in 100 patients presented to hospital. Risk factors like hypertension, diabetes, smoking, hyperlipidemia, alcohol consumption, heart disease, previous history and present CT findings were recorded. Intima media thickness, plaque morphology, percentage of stenosis, luminal colour flow, the systolic and diastolic velocities were also calculated and recorded.

Results: In the present study there was a significant association (p-value of 0.001) between size of infarct and amount of stenosis in Internal Carotid Artery (ICA). There was also significant association (with p-value < 0.05) in risk factors profile among stroke and TIA subjects with respect to hypertension, smoking, alcohol, hyperlipidemia and previous history of stroke. There was significant association (p-value of 0.013) between plaque characterization and stroke/TIA. Most common characteristic of plaque was soft in both the groups. Most common site of plaque among stroke was right ICA and in TIA was Left bulb respectively.

Conclusion: There was high prevalence of carotid artery disease as evidenced by increased intima media thickness, plaques and significant stenosis of ICA as detected by colour doppler examination for stroke and TIA patients in this study. Also large infarcts in CT were seen in patients with significant stenosis. Hence, Carotid Doppler investigation plays an important role in prevention of stroke mainly in patients with risk factors like hypertension, smoking and hyperlipidemia although they are asymptomatic.

Keywords: Hyperlipidemia, Hypertension, Intima media thickness, Number of arteries showing significant stenosis, Smoking, Stroke

INTRODUCTION

WHO defines stroke as "the rapid development of clinical signs and symptoms of a focal neurological disturbance which lasts for more than 24 hours or leading to death with vascular origin as the cause" [1]. Stroke is the second most common cause of death worldwide. It is leading cause of disability in old age patients [1]. Ischemic stroke is more common and accounts for 50-85% of all the strokes worldwide [1]. Stroke is defined as ischemic if there is imaging (Computed Tomography or Magnetic Resonance Imaging within four weeks), surgical or autopsy evidence excluding haemorrhage, or in absence of such direct evidence if the indirect evidence (e.g., deficit limited to one limb or completely resolving within 72 hours, atrial fibrillation in persons not on anticoagulants) suggest ischemic rather than a haemorrhagic stroke [2].

Carotid artery disease is a major risk factor for Transient Ischemic Attack (TIA) and stroke. Carotid artery stenosis or atheromatous plaque formation is the major cause for stroke. For patients with stroke or TIA, sonological evaluation of carotids and Doppler helps to prevent further attacks in patients with stroke and also in preventing the occurrence of stroke in patients with TIA.

Ultrasound is an inexpensive, non invasive and highly accurate method for diagnosing carotid stenosis. It helps to assess the plaque morphology [3,4]. Angiography has been largely replaced by carotid artery Doppler as the principal screening method for suspected extra cranial carotid artery atherosclerosis. Carotid ultrasound can be the only modality of choice before performing a carotid endarterectomy [5].

If the risk factors are identified and detected early, appropriate management can be instituted in an asymptomatic patients with risk factors which will slow down the progression of carotid artery disease. This study was done to establish the carotid artery involvement in the patients with stroke and TIA and to study the most common non communicable risk factor associated with stroke and TIA in this population.

MATERIALS AND METHODS

In this study a prospective analysis of 100 patients, who presented with clinical symptomatology of TIA and stroke and were referred to the Department of Radio-Diagnosis at Sri Manakula Vinayagar Medical College and Hospital, Puducherry, India, for CT-Brain from the period of September 2015 to September 2017. Patients with symptoms of stroke and TIA such as transient episodes of neurological dysfunction, sudden loss of consciousness, altered sensorium, aphasia, diminution of vision or loss of vision were included in this study. Patients with evidence of haemorrhagic stroke, stroke due

to any head injury or road traffic accident, stroke due to any pre-existing illness (e.g., mitral stenosis), patient with cardiac disease and uncooperative patients were excluded in the study. The clearance for study was obtained from research and ethical committee of the institution and informed consent was taken for the study.

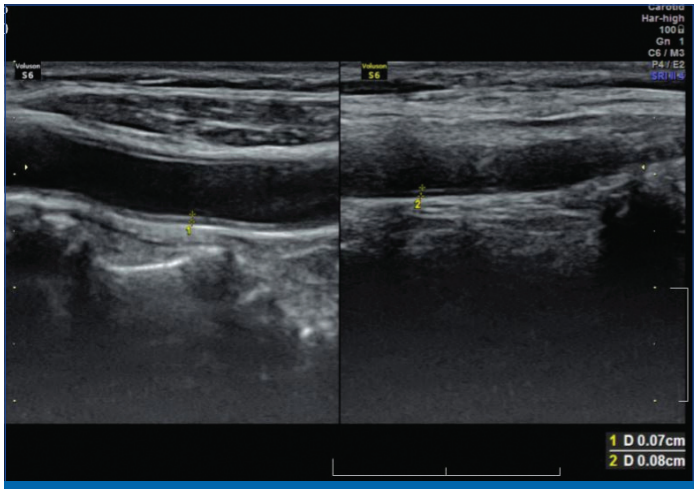
Imaging Technique

The scans were done using Philips 16-slice MDCT and carotid artery Doppler was done using Voluson s6 with linear probe 12Hz or Philips HD XE3 with linear probe 8-12Hz. Grey scale and colour Doppler was performed.

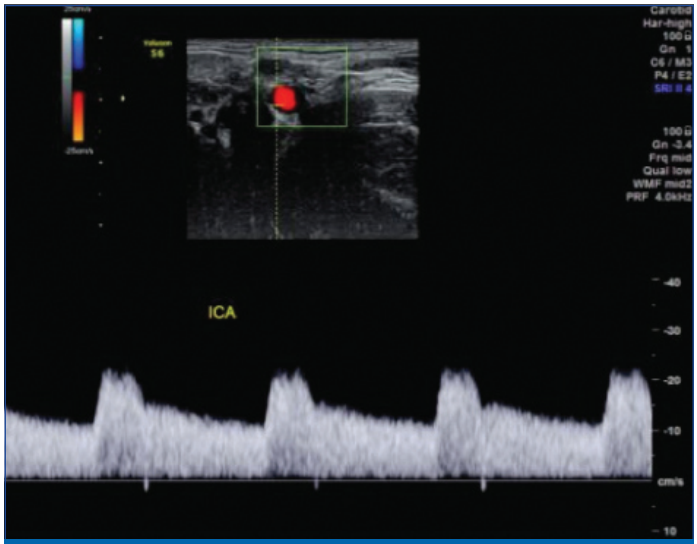
The Examination Sequence

Examination was conducted in systemic fashion: All the segments of bilateral carotid arteries were examined and recorded.

The basic steps were transverse scan from low in the neck up to the angle of mandible to locate carotid bifurcation, measurement of intima media thickness and identification of internal and external carotid arteries [Table/Fig-1]. Colour scan was done to identify the areas of abnormal flow and disease. Spectral Doppler was taken at Common Carotid Artery, ECA, ICA and Vertebral arteries [Table/Fig-2].



[Table/Fig-1]: Sagittal ultrasound image showing normal intima media thickness (<0.07mm) in right and left common carotid arteries.



[Table/Fig-2]: Colour Doppler sonography showing normal spectral pattern of left internal carotid artery.

STATISTICAL ANALYSIS

Data was collected using prescribed proforma and entered into Microsoft excel data sheet and analyzed using Epi Info 7 software. Categorical data was represented in the form of Frequencies and proportions. Chi-square test was used as test of significance for qualitative data. Continuous data was represented as mean and SD. Independent t-test was used as test of significance to identify the mean difference between two quantitative variables. ANOVA (Analysis of Variance) or Kruskal Wallis test was the test of significance to identify the mean difference between more than two groups for quantitative and qualitative data respectively. The p-value of <0.05 was considered as statistically significant.

RESULTS

Hundred patients had presented with stroke and TIA during the study period. Of these 100 patients, 64 patients presented with stroke and 36 patients presented with TIA. Forty one patients (64.5%) presented with right sided stroke, 19 patients (29.4%) presented with left sided stroke and 4 patients (6.2%) presented with bilateral stroke. There were 69 males and 31 females in our study.

Majority of subjects with stroke were in the age group 61 to 70 years (37.5%). There was no significant difference in age distribution between stroke and TIA. Both were common after 50 years [Table/Fig-3].

	Diagnosis			
	Stroke (n=64)		TIA (n=36)	
	Count	%	Count	%
<40 years	3	4.7%	1	2.8%
41 to 50 years	7	10.9%	6	16.7%
51 to 60 years	16	25.0%	13	36.1%
61 to 70 years	24	37.5%	11	30.6%
>70 years	14	21.9%	5	13.9%

[Table/Fig-3]: Age distribution of subjects with stroke and TIA.
χ^2=2.863; df=4; p=0.581

*A total of 82% of vessels in stroke subjects and 62.5% of vessels in TIA subjects had IMT >0.8 mm. This difference in IMT between Stroke and TIA subjects was statistically significant [Table/Fig-4].

	Diagnosis			
	Stroke (n=128 vessels)		TIA (n = 72 vessels)	
	Count	%	Count	%
<0.8 mm	23	18.0%	27	37.5%
>0.8 mm	105	82.0%	45	62.5%

[Table/Fig-4]: Distribution of increased Intima Media Thickness (IMT) values in extra cranial course of carotid arteries with stroke and TIA.
χ^2=9.375; df=1; p=0.002*

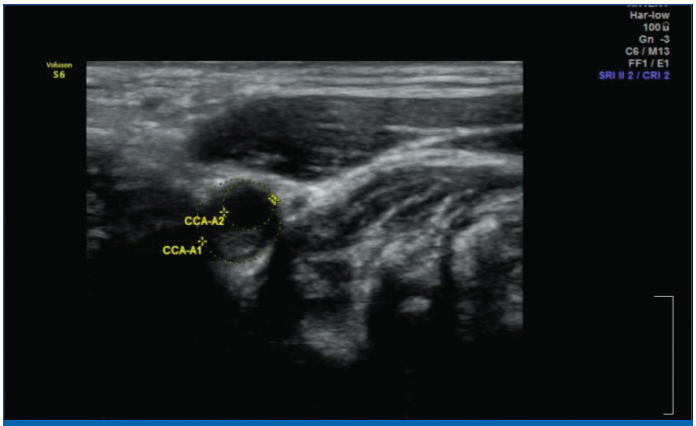
*In the study there was a highly significant difference in percentage of stenosis in ICA between stroke and TIA subjects on both the sides. 89.1% of stroke subjects had >70% stenosis and 4.2% of TIA subjects had stenosis >70% [Table/Fig-5-7].

	Diagnosis			
	Stroke (n=128 vessels)		TIA (n=72 vessels)	
	Count	%	Count	%
<70%	14	10.9%	69	95.8%
>70%	114	89.1%	3	4.2%

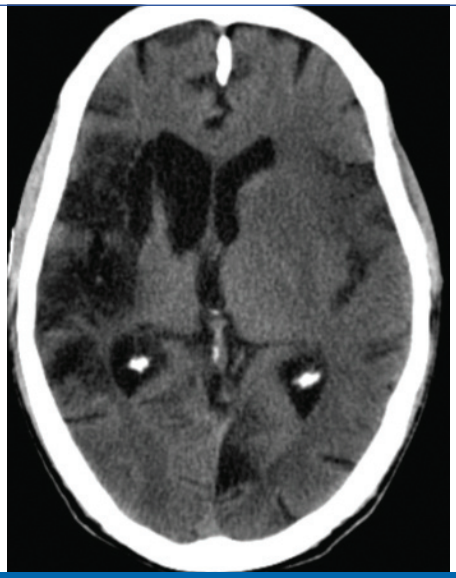
[Table/Fig-5]: Prevalence of significant stenosis (>70%) in internal carotid arteries in subjects with stroke and TIA.
χ^2=136.7; df=1; p<0.001*

There was a significant difference in risk factors profile among stroke and TIA subjects with respect to hypertension, smoking, hyperlipidemia and previous history of stroke [Table/Fig-8].

*In the study there was significant association between Side and site of infarct with respect to stroke and TIA [Table/Fig-9]. Most Common site of infarct among stroke and TIA patients was left Middle cerebral artery respectively [Table/Fig-10].



[Table/Fig-6]: Ultrasonography shows axial 2D images of the right common carotid artery showing a soft tissue plaque causing stenosis of around 70%.



[Table/Fig-7]: Corresponding patient Axial CT scan image shows infarct in the right MCA territory.

		Diagnosis				p-value	Odds Ratio	95% Confidence Interval
		Stroke		TIA				
		Count	%	Count	%			
HTN	Present	54	85.7%	24	66.7%	0.008*	3	1.313, 6.855
	Absent	10	14.3%	12	33.3%			
DM	Present	53	82.9%	31	86.7%	0.560	0.743	0.2741, 2.017
	Absent	11	17.1%	5	13.3%			
Smoking	Present	54	85.7%	17	46.7%	<0.001*	6.85	3.078, 15.28
	Absent	10	14.3%	19	53.3%			
Alcohol	Present	37	58.1%	15	42.2%	0.074	1.897	0.9353, 3.848
	Absent	27	41.9%	21	57.8%			
Hyperlipidemia	Present	61	95.2%	29	80.0%	0.003*	5	1.571, 15.91
	Absent	3	4.8%	7	20.0%			
Coronary artery disease	Present	34	53.3%	15	42.2%	0.212	1.564	0.7728, 3.165
	Absent	30	46.7%	21	57.8%			
Previous history of stroke	Present	18	28.6%	2	4.4%	0.001*	8.6	1.959, 37.76
	Absent	46	71.4%	34	95.6%			

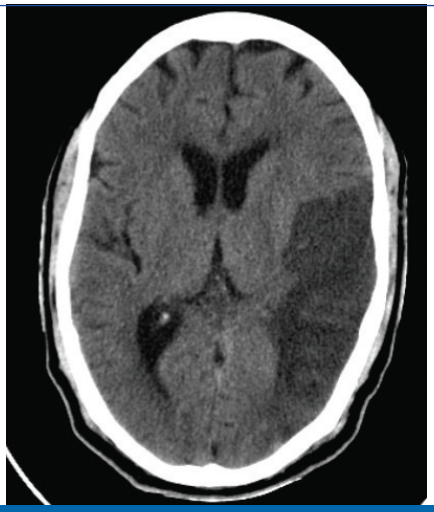
[Table/Fig-8]: Association between increased IMT (>0.8mm) with risk factors among stroke and TIA subjects.

*In the study there was significant association between side and site of plaque with respect to stroke and TIA. Most common site of plaque among stroke was right ICA and in TIA patients was left bulb respectively [Table/Fig-11].

*There was significant association between plaque characterization and stroke and TIA [Table/Fig-12]. Most common characteristic of plaque was soft in both the groups [Table/Fig-13]. A 21.1% of stroke subjects had calcified plaque [Table/Fig-14,15].

	Diagnosis			
	Stroke		TIA	
	Count	%	Count	%
Normal study (No)	68	53.1%	67	93.1%
Left ACA	4	3.1%	1	1.4%
Left MCA	34	26.6%	2	2.8%
Right ACA	5	3.9%	1	1.4%
Right ACA and Right MCA	3	2.3%	1	1.4%
Right and Left MCA	2	1.6%	0	0.0%
Right MCA	12	9.4%	0	0.0%

[Table/Fig-9]: Side and site of infarct in patients with stroke and TIA.
χ^2=34.98; df=6; p<0.001*



[Table/Fig-10]: Axial CT scan shows large infarct in the left MCA territory.

	Diagnosis			
	Stroke		TIA	
	Count	%	Count	%
No plaque	42	32.8%	34	47.2%
Left Bulb	14	10.9%	14	19.4%
Left CCA	7	5.5%	0	0.0%
Left ECA	1	0.8%	0	0.0%
Left ICA	18	14.1%	6	8.3%
Right Bulb	15	11.7%	10	13.9%
Right CCA	10	7.8%	3	4.2%
Right ICA	21	16.4%	5	6.9%
Right ECA	0	0.0%	0	0.0%

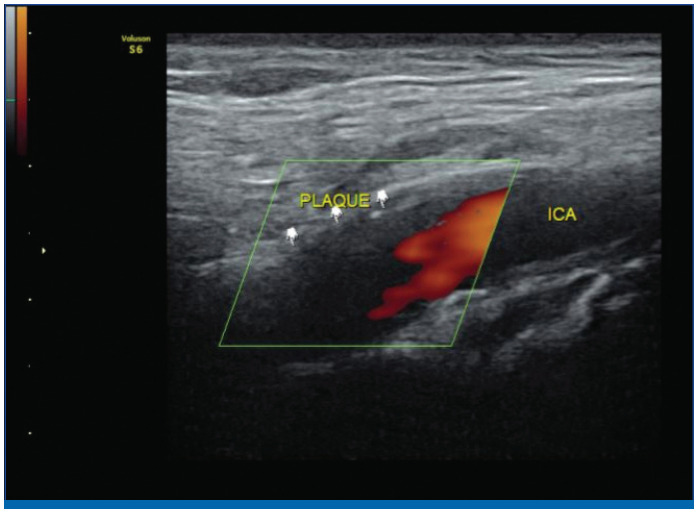
[Table/Fig-11]: Site of plaque in stroke and TIA subjects.
χ^2=14.95; df=7; p=0.037*

	Diagnosis			
	Stroke		TIA	
	Count	%	Count	%
No plaque	36	28.1%	35	48.6%
calcified	27	21.1%	9	12.5%
Soft	65	50.8%	28	38.9%

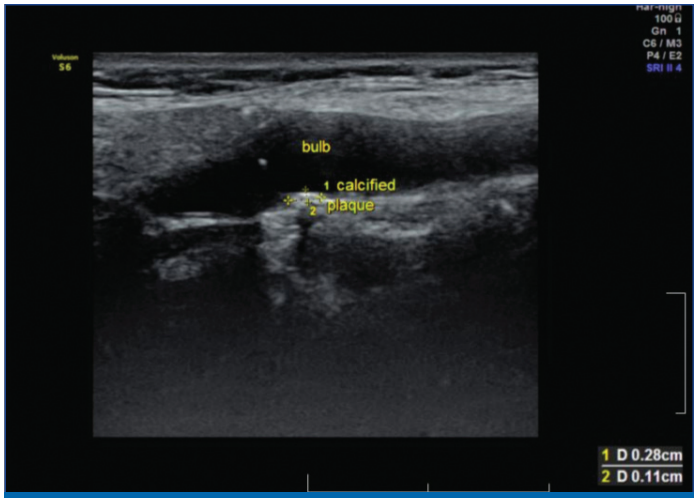
[Table/Fig-12]: Plaque characterization in stroke and TIA patients.
χ^2=8.74; df=2; p=0.013*

*In the study there was significant association between IMT grades between stroke and TIA subjects. A total of 69 vessels in Stroke patients had >1mm compared to 25 vessels [Table/Fig-16].

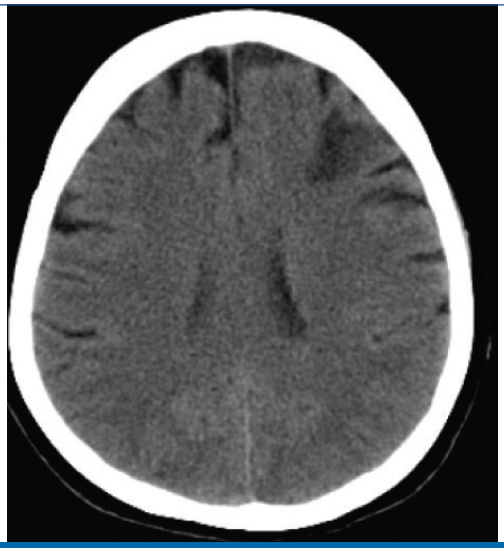
*In the study there was significant association between grades of stenosis between stroke and TIA subjects on both the sides [Table/Fig-17]. Total occlusion was seen only in stroke patients [Table/Fig-18].



[Table/Fig-13]: Colour Doppler Ultrasonography shows sagittal image of the left internal carotid artery showing a soft tissue plaque noted in the anterior wall of the left ICA showing no colour flow.



[Table/Fig-14]: Sagittal Ultrasonography showing 2D image of calcified plaque measuring 0.28 x 0.11cm (length X thickness) in left carotid bulb.



[Table/Fig-15]: Corresponding patient axial CT shows infarct in the left ACA territory.

*In the study there was significant association between size of infarct and amount of stenosis in ICA. Subjects with >3mm infarct had 91.4% of >70% stenosis [Table/Fig-19].

DISCUSSION

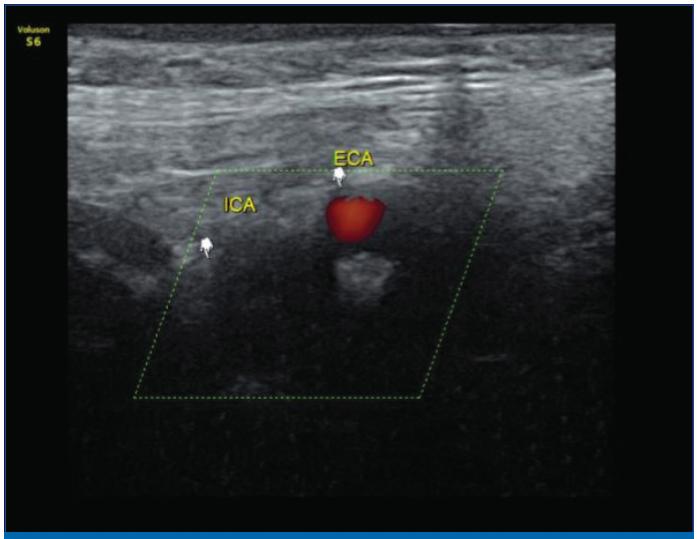
This study was done to evaluate extra cranial course of carotid artery by duplex and colour Doppler and correlate with individual risk factors and also with CT brain findings in patients with ischemic stroke and TIA.

	Diagnosis			
	Stroke		TIA	
	Count	%	Count	%
<1 mm	59	46.1%	47	65.3%
1 to 1.9 mm	63	49.2%	22	30.6%
2 to 2.9 mm	3	2.3%	3	4.2%
>3 mm	3	2.3%	0	0.0%

[Table/Fig-16]: Comparison of IMT between stroke and TIA subjects.
χ^2=9.174; df=3; p=0.027*

	Diagnosis			
	Stroke		TIA	
	Count	%	Count	%
<50	7	5.5%	53	73.6%
50 to 69	7	5.5%	16	22.2%
70 or More	102	79.7%	3	4.2%
Total Occlusion	12	9.4%	0	0.0%

[Table/Fig-17]: Comparison of percentage of stenosis between stroke and TIA subjects.
χ^2=139.37; df=3; p<0.001*



[Table/Fig-18]: Colour Doppler Ultrasonography shows axial image of the left internal carotid artery showing no colour flow in ICA suggestive of complete occlusion.

	Size of Infarct			
	<3mm		>3mm	
	Count	%	Count	%
<70%	4	50.0%	5	8.6%
>70%	4	50.0%	53	91.4%

[Table/Fig-19]: Comparison of percentage of stenosis and size of infarct among subjects with infarct.
χ^2=10.22; df=1; p=0.001*

The incidence of carotid artery disease evidenced by increased intima media thickness and significant stenosis of ICA is gradually increased in 61-70 years patients and slightly decreased in patients more than 70 years. Among the arteries with increased intima media thickness in stroke patients, 4 arteries (3.8%) in patients less than 40 years, 13 arteries (12.4%) in patients between 41-50 years, 26 arteries (24.8%) between 51-60 years, 39 arteries (37.1%) between 61-70years, 23 arteries (21.9%) in patients more than 70 years. Among patients with TIA 2 arteries (4.4%), 7 arteries (15.6%) between 41-50 years, 16 arteries (35.6%) between 51-60 years, 14 arteries (31.1%) between 61-70 years, 6 arteries (13.3%) in patient more than 70 years. In comparison to study by Weitzel L et al., was found that the prevalence of carotid artery disease increased with age i.e., 31.2% in patients until 54-year-old, 66.3% in patients between 55 to 76 years and 88% in patients older than 77 years [6].

The difference is explained by the fact that more number of patients in this study was from 6th to 7th decade compared to 8th decade. There were 75 patients with hypertension in our study. Sharma P et al., conducted a case control study to evaluate carotid intima media thickness by ultrasound in hypertensive and normotensive patients and found mean IMT was significantly higher in hypertensive (IMT in right side 0.968mm and that of left side 0.969mm) compared to normotensive patients (IMT of right side was 0.551mm and that of left side 0.555 mm) [7]. Mean IMT of hypertensive patients was 1.2mm. Furthermore, 90 arteries (85.7%) showed increased intima media thickness in hypertensive compared to 15 arteries (14.3%) in normotensives. In the present study p-value is 0.008 and odds ratio is 3, confidence interval 1.313, 6.855, thus showing significant association between hypertension and increased intima media thickness.

In the present study 86.8% hypertensive had significant stenosis compared to 13.2% normotensives. (p-value 0.009, odds ratio 13.2 and confidence interval 1.127-154.7). There is correlation between significant stenosis of internal carotid artery and hypertension.

Shinton R et al., in their study found that smoking increases risk of ischemic stroke nearly two times [8]. In the present study there were 62 smokers. There is significant association between increase intima media thickness and smoking in stroke patients (p-value <0.001, odds ratio 6.8 and confidence interval 3.078, 15.28). A total of 105 arteries (92.1%) of internal carotid arteries have significant stenosis. This was found to be statistically significant (odds ratio 23.33, p-value 0.001 and confidence interval 1.925, 282.5).

There were 49 alcohol consumers in present study. Sethi S et al., found that carotid artery lesion in stroke and TIA patients were significantly correlated with alcohol consumption [9]. Consistent with this, in the present study, 60.5% of arteries of alcoholic patients had significant stenosis compared to 39.5% of arteries in non alcoholic patients. A 58.1% of arteries had increased intima media thickness in stroke patients. However, in this study there is no significant association between alcohol consumption and carotid artery disease in stroke patients.

There were 77 patients with hyperlipidemia in the study. Gnasso A et al., in their study found that IMT value ranged from 0.54 to 1.24mm in hyperlipidemic and 0.46 to 0.82mm in controls and concluded that intima media thickness in common carotid artery is increased in patients with hyperlipidemia [10]. In the present study, the intima media thickness value is 1mm in stroke and 1.1mm in TIA patients. A 95.2% of arteries showed increased intima media thickness in hyperlipidemic stroke patients which is statistically significant in this study (p-value = 0.003, odds ratio 5 and confidence interval 1.571, 15.91). Kerenyi L et al., in their study found that cholesterol was an independent predictor of internal carotid atherosclerosis [11]. Similarly, in the present study also hyperlipidemia was found to be associated with significant internal carotid artery stenosis i.e., 96.5% of internal carotid arteries examined for hyperlipidemic patients had significant stenosis (p-value 0.001, odds ratio 165 and confidence interval 7.031, 387.2).

There were 19 patients in the study who had previous CVA. Tsivgoulis G et al., in their study found that patients who experienced recurrent cerebrovascular events had significantly higher common carotid artery IMT (1.01mm) than who were free of stroke recurrence [12]. In our study also patient with recurrent stroke had increased IMT in 28.6% of arteries examined in patients with recurrent stroke. In studies by Sethi S et al., carotid lesions in stroke patients were significantly correlated with previous history of stroke [9]. In the present study it is found that 28.1% of arteries have significant stenosis.

In this study most common site of plaque is right ICA in stroke and in TIA is left carotid bulb.

In the study by Li R et al., 721 and 715 plaques were found in right and left CCA respectively. 2597 and 2741 plaques were found in the right and left carotid bifurcation, respectively [13]. A total of 1102 and 1226 plaques were found in the right and left ICA. Of the total 121 plaques detected in this study, 50 of them were located in ICA, 53 of them were located in the carotid bulb and 20 plaques in CCA and 1 plaque in ECA. No plaques were found in vertebral artery. In this study, the most common site of plaque is in carotid bulb similar to other studies.

Singh A et al., found that 44.11% of plaques were echogenic and 55.88% plaques were echolucent in their study [14]. In the present study 36 plaques were echogenic (calcified) and 93 plaques are echolucent (soft) plaques. In both the studies the most common plaque is echolucent plaque. No ulcerated plaques were found in the study.

In the study by Rajesh M et al., 75% of patients with <50% stenosis had small infarct in CT brain while only 25% had large infarct [15]. A 70% of patient with >50% stenosis had large infarct in CT brain and 30% had small infarct. In this study, also 91.4% had large infarct in patient with more than 70% stenosis.

The relationship of risk factors for stroke with carotid artery stenosis and/or carotid intima-media thickening especially if multiple, makes carotid doppler absolutely essential [16].

Thus, patients between 60 to 70 years of age and with smoking history, hypertension, hyperlipidemia and previous history of cerebrovascular accident has increased risk of developing carotid artery stenosis.

LIMITATION

The limitation of this study is that no histopathological correlation was done because none of the patients underwent surgery as all patients were managed conservatively. And also smaller sample size can have an effect over the overall outcome of the study. A higher sample size gives much more effective results.

CONCLUSION

In our study there was significant association (p-value of 0.001) between the size of infarct in CT Brain and amount of stenosis in ICA on colour doppler. There was also significant association (with p-value <0.05) in risk factors profile among stroke and TIA patients with respect to hypertension, alcohol, smoking, hyperlipidemia and previous history of stroke.There was high prevalence of carotid artery disease as evidenced by increased intima media thickness, plaques and significant stenosis of internal carotid arteries in stroke and TIA patients in this study. Also, large infarcts in CT are seen in patients with significant stenosis. Hence, carotid Doppler investigation plays an important role in prevention of stroke mainly in patients with risk factors like hypertension, smoking and hyperlipidemia although they are asymptomatic. Early detection of plaque helps in treating patients with either medical or surgical management for stroke and TIA in south Indian population.

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