Color Doppler Study of Carotid Arteries in Transient Ishchemic Attack and Stroke

Avadhesh Pratap Singh Kushwah[1], Yogesh Patel[2], Sonjjay Pande[3]

ABSTRACT

Introduction: Stroke causing ischemia from flow limiting stenosis (20-30%) or thromboembolic events (70%) due to atherosclerotic disease at the carotid bifurcation is one of the leading causes of morbidity and mortality over the world. Color Doppler Ultrasound (CDU) has become a useful addition to the sonographic evaluation of stenotic areas in which abnormal velocities easily identified and sampled using CDU. Another important usefulness of CDU is its ability to detect narrowing produced by anechoic plaques, which missed by B mode US.

Material and methods: This prospective study was conducted on 50 patients, who were referred to the Radio diagnosis, Department of N.S.C.B. Medical College & Jabalpur over a period of one year (2012-2013). The scan was performed on a SIEMENS-SONOLINE G-50, B Loqic 3 Expert-Ay 15CUK-GE.High frequency linear transducer with a range 12 MHz's

Results: 32% presented with TIA and 68% with stroke. Age range of these cases was 18 to 80 years with overall mean range of 53(+_6.8) years. The most common risk factor was hypertension in 48% cases followed by smoking in 24.TIA showing the presence of plaque is 34.3 %, Similarly, in cases with stroke, we observed plaque in 45.5% and the overall prevalence of plaque in symptomatic cases was found to be 42%. The type I, II and III plaque are predominantly observed with significant stenosis (i.e. stenosis>50%). patients. We observed 56%of smooth plaques, 2.5% ulcerated plaque while irregular plaque were seen in 41% cases.smooth plaque were seen in 62% TIA and 54.8% stroke patients and irregular plaques were seen in 37% TIA and 41.9 stroke patients. n homogenous plaque category 77.7% plaques observed with <50% stenosis, 22.2% with 50-69% stenosis and no case for higher occlusion were found. While 34.9% cases were found with more than 50% stenosis and their corresponding PSV seen was 125cm/sec or more. There was a significant positive linear relationship of higher percentage stenosis for the non-lacunar infarct CT findings ($p<0.05$).

Conclusion: Color Doppler sonography is considered the first step in the diagnostic work up of carotid atherosclerosis and evaluation of plaque. CDU is not only noninvasive, widely available, accurately quantifies stenosis, but more importantly helps in characterization of plaques, We conclude by saying that there is definitely revolutionize the diagnosis, evaluation and management of cerebrovascular disease.

Keywords: Color Doppler, Stroke, Transient ischemic attack, Stenosis.

INTRODUCTION

Stroke causing ischemia from flow limiting stenosis (20-30%) or thromboembolic events (70%) due to atherosclerotic disease at the carotid bifurcation is one of the leading causes of morbidity and mortality over the world. A significant number of these ischemic can preventedbecauseof an extraordinary expansion in the approach to the diagnosis and the management of patients with carotid stenosis.

The blood that passes through the two internal carotid arteries nourishes about 75% of the brain substance. For anatomic and hemodynamic reasons alone, many strokes are in the carotid territory. Finally, the most common cause of arterial stenosis is atherosclerosis, which is most prevalent,in the carotid vasculature at the carotid bifurcation.

Conventional angiography continues to be the gold standard for the evaluation of stenosis. However, it has certain limitations such as invasive procedure, associatedmorbidity, High degree of training, and inaccurate measurement for carotid stenosis.

Therefore,clinicians and patients are reluctant for such an invasive procedure and would prefer a noninvasive procedure, which is diagnostic, has acceptable specificity, sensitivity and cost effective.

Carotid ultrasound is inexpensive, non invasive, and Widely available and can provide a reliable assessment of extra cranial carotid arteries. Apart from being able to assess the degree of stenosis US is probably the best modality available to visualize small atherosclerotic plaques and is also able to define the extent, location and characterization of the plaque. Heterogeneous and irregular surface plaques usuallyassociate with a higher risk of stroke.[1] the detection of plaques ulceration using US is controversial.[2]

US can help in assessing velocity of blood through the carotid vessels. In the presence of narrowing of the vessel lumen, velocity of blood flow increases. A number of studies,[3] have shown that the increase in velocity to assess the degree of luminal narrowing.

Color Doppler Ultrasound (CDU) has become a useful addition to the sonographic evaluation of stenotic areas in which abnormal velocities easily identified and sampled using CDU. Another important usefulness of CDU is its ability to detect narrowing produced by anechoic plaques, which

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missed by B mode US. The shortcoming of ultrasound is its inability to evaluate intracranial vasculature, missing tandem lesions and its inability to assess densely calcified plaque. Critical carotid bifurcation stenosis diagnose by CDU have higher sensitivity and specificity.[4]

Few recent studies have now showed that CDU is better or even superior to CT angiography.

In this study, an endeavor to document the cases of carotid artery plaque and to correlate the characteristics of the plaque and percentage of stenosis with that of neurological symptoms and/or infarcts on CT scan.

MATERIAL AND METHODS

This prospective study was conducted on 50 patients, who were referred totheRadio diagnosis,Department of N.S.C.B. Medical College& Jabalpur over a period of one year (2012-2013).The patientsevaluated with a history, clinical examination and basic investigation and the details documented in predesignedproforma.50 patients were taken up for CDU only, of this 29 patients showed varying degree of stenosis or occlusion of carotid arteries and these patients are further evaluated by CT scan brain whenever possible.Casesexcluded from the study in whom proper, complete examination of carotid artery was technically not possible and other non-cerebrovascular cause of TIA, and stroke was found.

Technical Consideration

The scan was performed on a SIEMENS-SONOLINE G-50, BLoqic 3 Expert-Ay 15CUK-GE.High frequency linear transducer with a range 12 MHz's

Technique of scanning

Patient position –Examination was done by sitting on the side of the patient who was in supine position. Tilting and rotating the head away from study side being examined, enhanced the neck exposure.

RESULTS

We studied 50 cases in which 32% presented with TIA and 68% with stroke. On this basis, we formed two groups i.e. Group I- TIA and Group II- Stroke.

In our study age range of these cases was 18 to 80 years with overall mean range of 53(+_6.8) years. The mean age of TIA cases were found to be 41.5 (+_8.5 years), in this category mean age of males was 43(+_9.6)years and for females it was 37(+_13.5) years. In cases with stroke the mean age observed was 58.5(+_8.4), in this category mean age of males and females were 58.4(+_10.5) years and 58.5(+_11.2) years respectively. The overall mean age of stroke cases 58.5(+_8.4) was significantly higher compared with TIA cases 41.5(+_8.5) years ($p<0.05$). Out of total cases, 64% of the cases were above 50 years of age and maximum cases (48%) were between 50-70years.

The most common risk factor was hypertension in 48% cases followed by smoking in 24%, IHD in 20%, diabetes in 16% and alcohol in 12 %cases. The risk factor of alcohol and hypertension was found to be more significantly associated with TIA ($p<0.05$).

TIA showing the presence of plaque is 34.3 %(11arteries out of the total 32). Similarly, in cases with stroke, we observed plaque in 45.5% (31 arteries out of the 68 arteries) and the overall prevalence of plaque in symptomatic cases was found to be 42%. (In 13 bilateral cases,26 arteries had plaques). However, there was no significant difference between TIA and stroke cases.

Further, we observed that 48%of plaque was bilateral, 44% wereipsi-lateral and only 7% were contra-lateral. These findings show that the probability of plaque on the same side i.e. ipsi-lateral compared with contra-lateral was significantly higher ($p<0.0001$).

The type I and II plaque were more prevalent having 40%, 25.9%, 20% and 33.3% respectively for both TIA and stroke. Type III was found in 10% and 14.8% of both categories (Table 1).The proportion of type I and II plaque was considerably higher 59.4% as compared to other type of plaque in symptomatic cases ($p<0.001$). The type I, II and III plaque are predominantly observed with significant stenosis (i.e. stenosis>50%) while the type IV and V plaques were mainly found with less degree of stenosis (i.e. less than 50%). Thus, we can say that the type I, II and III are highly associated with significant stenosis (Table 2).

We observed 43% of homogenous plaques, while heterogeneous plaques were seen in 57 % cases.We also observed that heterogeneous plaque were 44 % in TIA and 53.5% in stroke patient and Homogenous plaque were in 55.6% TIA and 57.1% stroke patients.

We observed 56%of smooth plaques, 2.5% ulcerated plaque while irregular plaque were seen in 41% cases.The proportion of smooth plaque was slightly higher than irregular and ulcerated plaque. We also observed that smooth plaque were seen in 62% TIA and 54.8% stroke patients and irregular plaques were seen in 37% TIA and 41.9 stroke patients (Table 3).

In homogenous plaque category 77.7% plaques observed with<50% stenosis, 22.2% with 50-69% stenosis and no case for higher occlusion were found. In heterogeneous plaque category 47.3% plaques observed with <50% stenosis, and 21% cases were with 50-69% stenosis, 21%cases with>70% to near occlusion and 5% cases with near occlusion and with total occlusion each. The heterogeneous plaques were seen associated with higher percentage stenosis compared to homogenous plaques. Statistically this finding shows significancewith $x2=3.95$ and $p<0.05$.

It is clearly evident that <50% stenosis cases show 83.3% smooth plaque surface and only 16.6% were found with irregular surface. In50-69percentage stenosis category 62.5% was found with irregular surface. In >70% to near occlusion stenosis category 83.3% plaque were observed with irregular surface and in both near occlusion and total occlusion category 100% were seen with irregular surface. This finding is statistically highly significant $x2=13.45$, at pdfp<0.001. It shows that the percentage stenosis increases the chances of irregular surface increase.

Out of the total 41 arteries 65.1 % were observed with less

than 125 cm/sec and the corresponding stenosis was <50%. In 18.6 % cases the PSV was seen in 125-230 cm/sec range and the stenosis was found 50-69%. 11.6% case were with more than 230cm/sec giving >70% to near occlusion stenosis.

While 34.9% cases were found with more than 50% stenosis and their corresponding PSV seen was 125cm/sec or more. IMT for cases with <50% stenosis was found 0.88+_0.19, for 50-69% it was 1.17+_0.83, for >70%to near occlusion IMT was 1.3+_0.063, the IMT for near occlusion was 1.36+_0.065 and for total occlusion it was 1.43+_0.158. The mean IMT was significantly higher for significant stenosis i.e. more than 50% ($p<0.05$)(Table 4).

We observed 16 cases with lacunar infarct, 12 cases with non-lacunar infarct and 3 cases were normal. Majority of lacunar infarct were observed with stenosis <70% and all the cases with normal CT findings were reported with <50% stenosis, while the majority of non-lacunar findings show stenosis >70% (75% of total). There was a significant positive linear relationship of higher percentage stenosis for the non-lacunar infarct CT findings ($p<0.05$).

CT findings have been correlated with percentage stenosis. There were 7 CT reports with bilateral carotid stenosis, and we observed 3 cases with lacunar infarct, 2 cases with non-lacunar infarct and 2 cases were normal. The lacunar infarct and normal CT findings were primarily seen in <50% stenosis, while all the cases with non-lacunar infarct category were found with >50% stenosis. Statistically, significant findings of x2=4.00, $p<0.05$ show that there are high chances of increased percentage stenosis i.e. more than 50% with non lacunar infarct findings of CT.

DISCUSSION

Total 50 cases, which presented with either recent TIA or ischemic stroke, were studied. The proportion of ischemic stroke and TIA was 68% and 32% respectively.

Sempere et al[5] did a similar study in Spanish population from 1992 to 1994 and found incidence of 56% and 43% ischemic stroke and TIA respectively.In our study majority of patients were between 50 to 70 years of age group with overall mean age of53(+_9.6) years. This is similar to study ofP.AivAnasalo M, LeinineuS.Turuneu J et al.[6]

The mean age of TIA and stroke was 41.5(+_8.5) and 58.5(+_8.4) respectively, this shows that mean age of stroke was significantly higher compared with TIA ($p<0.05$).In present study, by analyzing various risk factors, hypertension(48%) and smoking(24%) were the most common risk factors among the studied population followed by IHD (20%),diabetic (16%) and alcohol(12%). In a similar study in Jordan population,[7] hypertension was present in 76%, diabetes mellitus in 43%, smoking in 35% and hyper-lipidemiain 33% of the study population.

In the present study, 44% had unilateral ipsi-lateral plaque, 48% cases had bilateral plaque and 7% had unilateral contra-lateral plaque. Our present study shows that incidence of type I and II plaques are considerably higher (59.4%) compared to other types of plaques in symptomatic cases ($p<0.001$). We also found that type I, II and III plaques were predominantly observed with significant stenosis. Our observations are comparable to Mathiesen et al.[8]

Out of the total plaques in our study, 16(43%) were homogenous and 21(56%) were of heterogeneous type. Meskauskiene A et al[9] 2005 has examined Operative specimens of 262 carotid plaquesmacroscopically. Heterogeneous plaques were present in 198 (75%) of 262 arteries. Heterogeneous plaques were found in 121 symptomatic and 77 asymptomatic patients ($p<0.001$).

In the present study smooth plaque (56%) were slightly higher than irregular(41%) and ulcerated plaque (2.5%) and there was hardly any difference between prevalence of irregular and smooth surface plaque between cases of TIA and stroke. Shyamprabhakaranetal[10] studied1939 stroke-free subjects Plaque surface was categorized as regular or irregular

The prevalence of heterogenous plaque was 47.3% in <50% stenosis, 21% in 50-69% stenosis, 21% in >70 to near occlusion, 5% in near total and 5% in total occlusion andHomogenous plaque prevalence was 77.7% in <50% stenosis, 22.2% in 50-69% and no case for higher percentage stenosis was found. Heterogenous plaque causes higher percentage stenosis as compared to homogenous plaque.Gerulakos et al[11] in1993 reported that in plaques causing more than 70% stenosis of the carotid artery, type I and II plaques (heterogeneous plaque) are statistically predominant in the symptomatic group as compared to type III and IV plaque (Homogenous plaque).

Type of plaque	TIA (%)	Stroke (%)	Total(%)
Type I	4(40)	7(25.9)	11(29.7)
Type II	2 (20)	9(33.3)	11(29.7)
Type III	1(10)	4(14.8)	5(13.5)
Type IV	1(10)	3(11)	4(10.8)
Type V	2(20)	4(14.8)	6(16.2)

Table-1: Distribution of type of plaques in studied cases

Percentage of stenosis	Type of plaque(%)				
	I	II	III	IV	V
<50% (n=27)	9(64)	7(50)	2(40)	4(100)	6(100)
50-69% (n=6)	3(21)	3(15)	2(40)	0	0
>70% to near occlusion (n=5)	2(15)	3(21)	0	0	0
Near occlusion (n=2)	0	1(7)	0	0	0
Total occlusion (n=2)	0	0	1(20)	0	0
	14	14	5	4	6

Table-2: Distribution of type of plaque vs degree of stenosis

Plaque surface	<50% (%)	50-69% (%)	>70% to near occlusion (%)	Near occlusion	Total occlusion
Smooth	20 (83.3)	3 (37.3)	0	0	0
Irregular	4 (16.6)	5 (62.5)	5 (83.3)	1 (100)	1 (100)
Ulcerated	0	0	1 (16.6)	0	0
	24	8	6	1	1

Table-3: Relationship between surface characteristic of plaque and percentage stenosis

Percentage stenosis	Mean IMT(mm)
Normal	0.74 ± 0.196
<50% (n=28)	0.88 ± 0.19
50-69% (n=6)	1.17 ± 0.83
>70 % to near occlusion (n=5)	1.3 ± 0.063
Near occlusion (n=2)	1.36 ± 0.065
Total occlusion (n=2)	1.43 ± 0.158

Table-4: Correlation of intima media thickness with percentage stenosis

The present study show that with the increase in the degree of stenosis there was a steady increase in the number of plaques with irregular surface (16.6% in <50%, 62.5 % in 50-69%, 83.3% in >70% to near occlusion and 100% in near and total occlusion), whereas this association was reversed with the presence of smooth plaque (83.3% in <50% occlusion, 37.5 % in 50-69% and 0% in >70% occlusion). This finding was statistically significant (x^2 =13.45 at 4pdf p< 0.001) showing that as percentage of stenosis increased, chances of irregular surface plaques also increases.Baris Kanberet al[12] 2013, studied Parameters significantly correlated with the presence ofcerebrovascular symptoms were the degree of stenosis (p = 0.01), plaque greyscale median (p = 0.02) and the plaque surface irregularity index (p = 0.02).

In the present study PSV was calculated for all degree of stenosis corresponding with stenosis standard criteria.[13] We found that 65.1 % with <50% stenosis and 34.9% stenotic artery with more than 50% stenosis and according to category each category has its recommended therapeutic approach according to NASCET[14] and ACAS.[15]

Our finding of mean IMT according to percentage of stenosis, normal cases show mean IMT at 0.74+_0.196, mean IMT for cases with <50% was found 0.88+_0.19, for 50-69% it was 1.17+_0.83, for >70% to near occlusion IMT was 1.3+_0.063, for near occlusion IMT was 1.36+_0.065 and for total occlusion it was 1.43+_ 0.158mm. The mean IMT was significantly higher for all arteries with stenosis>50% (p<0.05). Mean IMT shows a steady growth in relation with increase in stenosis, and this linear trend was found to be positively significant and it shows a positive correlation.

Lorenz MW et al[16] 2007, showed a consistent, positive association between common carotid artery intima media thickness and incidence of stroke.All of the non lacunar infarct occur in patients with stenosis>70%, while lacunar infarct occurred with stenosis<70%. In addition patients (100%) with normal CT scan head insignificant stenosis(<50%). In literature, the presence of carotid stenosis>50% was significantly higher in patients with non-lacunar infarct for both the artery ipsi-lateral and contra-lateral to ischemic brain damage.Tejada et al[17] 2003 investigates the relationship between LI and ICAS in a large prospective study of 330 patients, including 205 with LI and 125 with NLI.

CONCLUSION

This study evaluated CDU findings in 50 cases of TIA and stroke to assess the degree of carotid artery stenosis and an attempt was also made to compare the parameters which constitute the basic of plaque morphology i.e. plaque echogenicity, plaque texture, plaque surface.

Incidence of TIA and stroke was more in age group of 50-70 yrs with overall mean age of 53+6.8.Overall mean age of stroke (58.5+8.4) was higher than TIA (41.5+_8.5).Hypertension and smoking are the most common risk factors present in all degree of stenosis.Prevalence of carotid plaque ipsi-lateral to brain hemisphere involved is significantly higher than contra-lateral side.Prevalence of smooth plaque is more in TIA;however, irregular plaques were more prevalent in stroke patients.

We conclude by saying that there is a significant untapped, potential in Doppler analysis of carotid artery disease, and that developing noninvasive radiological characterization of various lesion characteristics would definitely revolutionize the diagnosis, evaluation and management of cerebrovascular disease.

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