

Colour Doppler Ultrasonography of External Carotid Artery in Cases of Acute Ischemic Stroke and Association of Risk Factors: A Two year study at A Tertiary Care Hospital of South India

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Abstract

Context: Stroke is responsible for death and disability in developing low and middle income countries like India. Colour Doppler ultrasound is a safe, low economical and non invasive tool for evaluation of extra cranial insufficiency of carotid arteries.

Aims: To find the prevalence of carotid artery stenosis among acute ischemic stroke patients and to assess the association between carotid artery stenosis and modifiable risk factors like hypertension, smoking, diabetes and alcoholism.

Settings and Design: An observational study at a tertiary care hospital for a period of two years in department of neurology after ethical committee approval.

Methods and Material: Carotid Doppler ultrasonography and CT scan imaging was done in cases of acute ischemic stroke. Socio demographic data, risk factors, general and thorough clinical examination was done and findings were noted. Statistical package for social sciences (SPSS) version 20 for windows 8 was used for analysis.

Results: 175 cases with 108 males and 67 females were included. 42.29% were above 50 years and mean age was 65 ± 4 years. Hypertension and diabetes were major and significant risk factors. 27.43% of cases presented with pure motor hemiplegia and site of lesion was in Capsulo ganglionic area. Middle cerebral artery (MCA) site is the most common territory involved and infarct was the common finding on CT scan. 33.06% of cases demonstrated severe carotid stenosis (>70%). 35.5% of cases had plaque in the carotid bulb.

Conclusion: The role of colour Doppler Ultrasonography of carotid in assessing the carotid stenosis, plaque formation and atherosclerosis associated with multiple risk factors is justified.

Keywords: Acute Ischemic stroke; Carotid Doppler; Carotid stenosis; Plaque.

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Introduction

Stroke is one among the non communicable diseases responsible for death and disability in

developing low and middle income countries like India. The prevalence rate of acute ischemic stroke in India as per the data of India stroke factsheet updated in 2012, the age adjusted prevalence rate for stroke ranges from 84-262/100000 in rural and 334-424/100000 in urban areas.¹ As observed in the past two decades in India, a significant transition in economic, demographic and epidemiological pattern with a lot of modifiable risk factors has lead to drastic increase in the incidence of stroke. Hence an anticipated increase of incidence of stroke in the upcoming years, a greater need is required in focusing the prevention strategies and rapid diagnostic methods. Modifiable risk factors like hypertension, smoking, alcoholism and diabetes are significant risk factors in development of

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stroke.² Cerebral stroke caused by ischemia is identified to be more common than hemorrhagic stroke in various studies globally and also in India. Hence main focus on the early identification of atherosclerotic changes or stenotic process in major blood vessels among patients with significant risk factors, e.g. hypertension may help in reducing the death and morbidity associated with ischemic stroke. Extra cranial and intracranial carotid vessels are the most common sites of atherosclerosis in 80% of cases of stroke.³

Colour Doppler ultrasound a safe, low economical and non invasive tool for evaluation of extra cranial insufficiency of carotid arteries. Many studies suggest that contrast enhanced MR angiography and CT angiography may give similar and better results, but carries a risk of contrast defects and high cost. Besides the additional advantage of Doppler ultrasound is identification and characterization of plaque which carries a high risk if embolization. Many parameters in Doppler like pulsatility index (PI), resistive index (RI), and systolic- diastolic ratio are used to evaluate and classify the stenotic changes in the carotids. Most of the studies have estimated the intima media thickness (IMT) of the carotids as a vascular risk factor in cases of stroke.⁴

The objective of the present study was to correlate the nature, site and severity of lesions on clinical grounds with CT scan findings. The study also aims to find the prevalence of carotid artery stenosis among acute ischemic stroke patients and to assess the association between carotid artery stenosis and modifiable risk factors like hypertension, smoking, diabetes and alcoholism.

Materials and methods

The present observational study was conducted at a tertiary care hospital of south India in Department of Neurology in association with department of Radiology for a period of two years from January 2016 to December 2017. The study protocol was clearly explained to the institutional ethical committee and was approved. The study was conducted as per the guidelines of the committee. All the cases attending the emergency department with signs and symptoms of neurological deficit and suggestive of cerebro vascular accident (CVA) were included in the study. The study details were clearly explained to the cases or the relatives in local language and a written informed consent was obtained from all the cases included in the study.

Inclusion criteria

All patients with clinical signs & symptoms suggestive of ischemic stroke.

Exclusion criteria

Patients with hemorrhagic stroke, Known Rheumatic disease, connective disorders, Head injuries, recurrent strokes, primary and secondary brain tumours, vertebro-basilar insufficiency and patients on statin therapy were excluded from the study.

Detailed history of the enrolled patients including present and past history, history of drug addiction, smoking, alcoholism in males and a detailed menstrual and obstetric history in female cases was noted in a separate predesigned questionnaire form. Risk factor history included history and duration of hypertension, diabetes, hyperlipidemia (Serum cholesterol, triglyceride levels) and any medications. A detailed general and neurological examination was performed including carotid pulsation, peripheral vessels and nerves examination. A detailed fundus examination was done in all the cases. All the routine laboratory investigations including serum lipid profile, fasting and random blood sugar levels were performed. ECG, 2 dimensional Echo was performed and special attention was given for any valvular dysfunction, reduced LVEF and any regional wall motion abnormalities. Computed tomography of the brain was performed with Siemens third generation Spiral CT on all the patients within 24-48 hours and repeated if initial was negative or if the patient suddenly deteriorated or no expected recovery. Findings on CT were noted like presence of haemorrhage or infarct, location of lesion, size of lesion, and extent of brain damage and surrounding oedema, impending herniation and to identify neoplasm, abscesses or other conditions causing a stroke.

Carotid Doppler ultrasound: After stabilizing the patients Doppler ultrasound was performed with Philips Envisor ultrasound machine with 7.5 Mhz linear array transducer. The positions of the transducers were used accordingly to examine the carotid arteries in long axis planes, which show the CCA, ICA and carotid bifurcation best. Systolic and diastolic velocity of blood flow, presence of atheromatous plaque and thrombus was looked for and then the percentage of stenosis of the affected arteries was calculated.

Statistical analysis: All the data collected was entered in Microsoft excel spread sheet and corrected. Risk factors like smoking, alcoholism, hypertension,

hyperlipidemia and diabetes were analyzed in patients with and without carotid stenosis admitted for acute ischemic stroke. Statistical significance was calculated using chi-Square test and p -value <0.05 was considered significant. Statistical package for social sciences (SPSS) version 20 for windows 8 was used for analysis.

Results

In the present prospective observational study, a total of one hundred and seventy five cases

were enrolled who fulfilled the inclusion criteria. The study was clearly explained to the cases and informed consent was obtained from all the cases or relatives of the study. There was male preponderance in the study with 108 cases (61.71%) and females 67 cases (38.29%). Of the 175 cases in the study, 88 cases (50.3%) had stroke on right side, 77 (44%) on the left side and ten (5.7%) had bilateral involvement (Fig. 1). Majority of the cases (74/175, 42.29%) were above 60 years of age, 35.43% between 41–60 years and 22.29% less than 40 years (Table 1).

Table 1: Age distribution of cases in the study

Age (Years)	Male	Female	Total	Percentage (%)
<40 YEARS	24	15	39	22.29
41-60 YEARS	40	22	62	35.43
>60	44	30	74	42.29
Total Cases	108	67	175	100

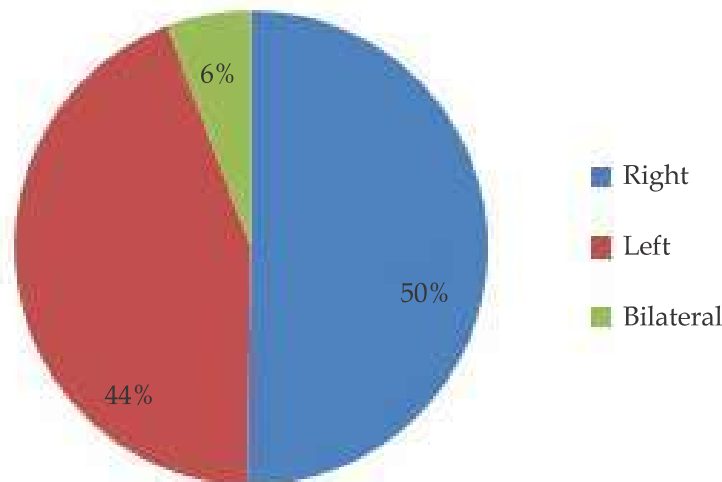


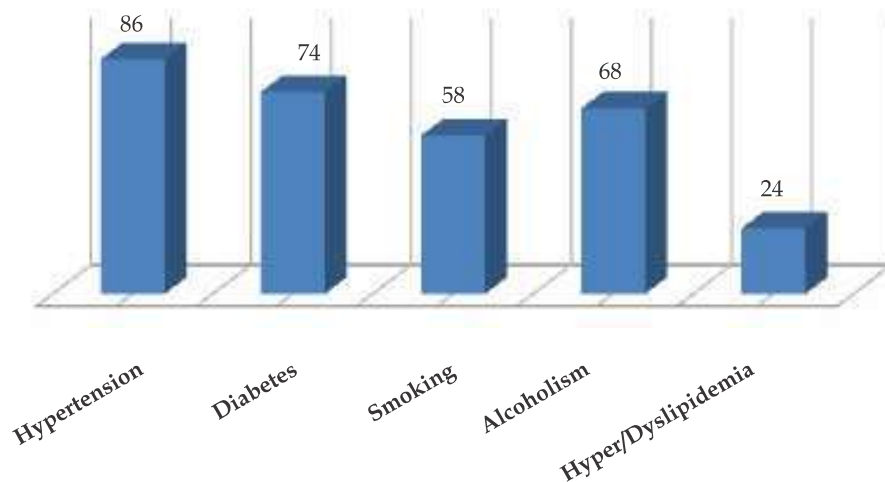
Fig 1: Distribution of stroke in %

The age range of cases in the study was 42–84 years and the mean age of the study group was 65 ± 4 years. Hypertension (49.14%) and diabetes (42.29%) were the more prevalent risk factors associated in the study. Other factors less commonly involved were smoking (33.145), alcoholism (38.86%) and hyperlipidemia (13.71%) (Fig. 2). Computed tomography findings of 175 cases demonstrated normal findings in 24% of cases, 48% with infarct without midline shift, 21.14% with lacunar infarcts and in 6.86% cases massive infarct with midline shift was observed. On clinical examination, 27.43% of cases presented with pure motor hemiplegia, 18.29% with brain stem defects, 17.71% with motor

hemiplegia with cortical deficits and 3.43% with cerebellar strokes (Table 2). Regarding the site of the lesion capsulo ganglionic region (Sub cortical region) was the most common area of localization of infarct in CT scan findings and normal CT findings were observed in cases with Brain stem defects. Majority of cases in our study demonstrated lesions in sub cortical white mater i.e. capsulo ganglionic area. In Cases with hypertension and diabetes the site of lesion was the same i.e capsulo ganglionic area. In the present study, middle cerebral artery (MCA) site is the most common territory involved and correlated clinically, except in cases with normal CT scan findings.

Table 2: CT Scan findings & Clinical Presentation of cases in the study

Ct Scan Findings		
Findings	No.	Percentage (%)
Massive Infarct with Midline Shift	12	6.86
Infarct Without Midline Shift	84	48.00
Lacunar Infarcts	37	21.14
Normal CT	42	24.00
Clinical Presentations in the Cases		
Pure Motor Hemiplegia	48	27.43
Motor Hemiplegia with Cortical Deficits	31	17.71
Pure Sensory Deficits	0	0.00
Brain Stem Defects	32	18.29
Cerebellar Strokes	6	3.43

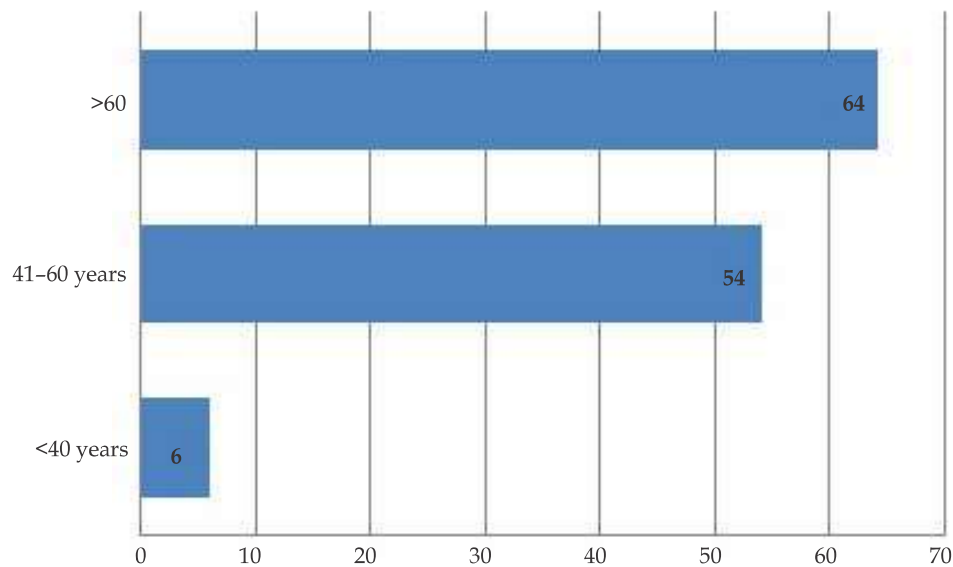
**Fig 2:** Risk factors among the cases in the study (No)**Carotid Doppler Observations:**

Doppler ultrasonography was performed in all the 175 cases in our study. Carotid stenosis was observed in 124 cases (70.9%) with more in males 84 (67.7%) than females 40 cases (32.3%) and this difference was found statistically significant (p -value <0.01). A statistically significant association was observed between increasing age and percentage of patients with stenosis. (p -value <0.01) Maximum cases were observed in the age group of >60 years with 86.49% followed in order by 41–60 years (87.10%) and least in less than 40 years with 15.38%. Mild stenosis ($<50\%$) was observed in 19 cases (15.32%), moderate stenosis (51–69%) was seen in 64 cases (51.61%) and Severe stenosis ($\geq 70\%$) was observed in 41 cases (33.06%) in the present study (Fig. 3). The prevalence of carotid stenosis in the present study was 70.9%

and prevalence of moderate stenosis was higher than mild and severe stenosis in our study. 48 cases of hypertension (55.81%), 58 cases of diabetes (78.38%), 28 cases with smoking (48.28%), 24 cases with alcoholism (35.29%) and 11 cases with hypercholesterolemia (45.83%) developed carotid stenosis in our study. We observed statistically significant correlation with all risk factors in our study. (p -value <0.01) Plaques were identified in all the 124 cases with stenosis. Most common site of plaque was carotid bulb with 35.5% followed in order by common carotid artery (30.6%), internal carotid artery (17.7%), common carotid bifurcation (9.7%) and external carotid artery (4.8%). Majority of these plaques (59.7% were echogenic, 29% were hypoechoic and 11.3% were echogenic calcified). No ulceration or plaque haemorrhages were observed in the present study (Table 3).

Table 3: Plaque characters in the study

Location of Plaque	No.	Percentage (%)
Common Carotid Artery	38	30.6
Carotid Bulb	44	35.5
Common Carotid Bifurcation	12	9.7
Internal Carotid Artery	22	17.7
External Carotid Artery	6	4.8
Characterization		
Hypochoic	36	29.0
Echogenic	74	59.7
Echogenic Calcified	14	11.3

**Fig 3:** Distribution of cases with carotid stenosis on color Doppler ultrasonography

Discussion

Acute ischemic stroke is one of the severe clinical entities which cause death and morbidity in cases of survival. Hence it is very essential to understand the risk factors in causation and measures to be taken in modification or prevention of risk factors. In the present observational study, 175 cases were enrolled with male predominance which is similar to the findings in the study of Sethi SK *et al.* who reported the incidence of 68% of males in his study.⁵ In the present study, 50.3% of cases had stroke on the right side which is on par with the findings of Tagelsir S who reported a slightly higher incidence with 68% in his study.⁶ However few studies reported higher incidence of stroke on left side and are more common in females before menopause and the incidence was equal after menopause in

females, this may be due to the hormonal variations before and after menopause. In the present study, 43% of the cases were above 60 years of age which is similar to the findings in the study of, Iemolo F who reported 54% in his study.⁷ Few studies in the western countries reported higher incidence of stroke in age group of 40–50 years and this may be due to the difference in the racial group, study population involved and multiple variable risk factors involved in the study.

Hypertension and diabetes were the most common associated risk factors which demonstrated statistically significant association with stroke and stenosis in the carotid arteries in our study. Most of the studies conducted universally reported the same but with minor differences in the range of association with stroke. Hypertension accelerates the continuous trauma to the endothelium resulting

in plaque formation and contributes to plaque growth. In diabetic patients, plasminogen activator antigen and plasminogen activator inhibitor-1 levels have been significantly associated with stroke. Results of our study were comparable with reports of Garg *Set al.* and Sethi SK *et al.*^{8,9} Most of the studies established a positive correlation between stroke and smoking, which was also observed in our study. In our study, 33% of cases with stenosis and stroke had smoking however in few studies the association was recorded to be 22–28%, which may be due to cultural traditions and the study group involved.¹⁰ Hyperlipidemia accelerates the formation of plaque and atherosclerosis which is also a significant risk factor in our study. In our study we strongly observed that presence of multiple risk factors significantly increases the chances of acute ischemic stroke and carotid artery stenosis.

In the present study, 24% of cases demonstrated normal findings on computed tomography which indicates missing findings which can be evaluated further by MRI. The major finding in our study was infarct without midline shift in 48% of cases, and in only 7% of cases massive infarcts with midline shift was observed. Findings of our study were similar to the finding in the study of Wintermark M *et al.*¹¹ few studies reported lacunar infarcts as the major findings in their study. Pure motor hemiplegia was the most common clinical presentation in our study, without any cortical lobar dysfunction or brainstem or cerebellar signs. Other presentations were 18% with brain stem defects, 18% with motor hemiplegia with cortical deficits and 3.43% with cerebellar strokes, findings of our study corroborated with the findings of Rajesh M *et al.*¹² Capsulo ganglionic region was the most common site of the lesion in CT scan finding among the cases of pure motor hemiplegia and the middle cerebral artery site was the most common territory involved. This can be explained by the “Phenomenon of cortical subcortical diaschisis”.¹³ Most of the patients (about 18%) with brainstem stroke (posterior Circulation Stroke) showed normal CT possibly due to bony artefact and lack of sensitivity of CT in detecting posterior fossa lesions. These findings are similar to the findings in various studies globally.

In the present study, mild stenosis (<50%) was observed in 16% of cases, moderate stenosis (51–69%) was seen in 52% and Severe stenosis ($\geq 70\%$) in 33%. The results of the present study were in accordance with the results of Villwock MR *et al.* who reported 6% of cases with complete occlusion.⁴ In our study the prevalence of carotid artery

stenosis was 71% which is higher than the findings of O'Brien M who reported only 56% in his study findings.¹⁵ the most site of plaque formation in present study was carotid bulb, 35% and followed by common carotid artery. Findings of our study correlate with the findings of Wannarong T *et al.*¹⁶ The characteristics of the plaque were also studied and none of them showed ulceration or hemorrhage which is a significant different point in our study. Findings of our study were consistent with the findings of Petrov *et al.*¹⁷ A sudden and rapid change in the velocity and direction of blood in the bulb region leading to increase in stress faced by the arterial walls and thus, having higher propensity to get damaged with increased chances of plaque formation at carotid bulb.

Conclusion

To conclude, in the present study hypertension and diabetes are predominant risk factors in development of acute ischemic stroke. Doppler carotid Ultrasonography can be made as a screening tool in cases associated with multiple risk factors. Carotid Doppler Ultrasonography is a valuable tool in assessment of carotid stenosis, plaque characteristics and complications in extracranial carotid vessels. Assessing the carotid intima thickness provides a major clue in predicting the cerebrovascular incidents in all cases above 50 years of age and associated with multiple risk factors. Presence of intimal thickening dictates surgical intervention in cases of stroke. In light of the above findings in the study the role of colour Doppler Ultrasonography of carotid in assessing the carotid stenosis, plaque formation and atherosclerosis associated with multiple risk factors is justified.

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