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ULTRASOUND EVALUATION OF EXTRACRANIAL CAROTID ARTERIES IN PATIENTS PRESENTING WITH ACUTE ISCHAEMIC STROKE AND CORRELATION WITH VARIOUS RISK FACTORS IN A TERTIARY CARE HOSPITAL

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ABSTRACT:

INTRODUCTION: The sudden deficit of neurological loss brought on by a focal vascular aetiology is what defines a stroke. Since 6 thromboembolic strokes account for 80% of all strokes, early detection of atheromatous alterations in the carotid artery can reduce stroke-related morbidity and mortality. An accurate diagnosis is crucial for effective stroke treatment. ultrasound can adequately supplement other acute imaging modalities, such as computed tomography angiography (CT/CTA) or magnetic resonance imaging/magnetic resonance angiography (MRI/MRA). **AIM:** To study the role of Carotid Doppler Ultrasonography in the diagnosis and management of stroke patients. To study retrospectively the various abnormalities ie; determine the various velocities, characterize plaque, and assess intimate media thickness in Carotid arteries in patients who had suffered a stroke and to find association between carotid artery doppler changes and risk factors such as diabetes mellitus, hypertension, hyperlipidemia, smoking, and age to determine the usefulness of doing Carotid Doppler Ultrasonography as a screening procedure in predicting the chances of developing stroke in persons having risk factors for stroke. **MATERIALS AND METHODS:** Data: Department of Radiodiagnosis in a tertiary care centre. Type of study: Descriptive Cross Sectional Study.. Study Duration: 18 months. Sample size: 90. Statistical Analysis: Done by SPSS Package version 20. Graphical representation was done in MS Excel 2010. **RESULTS:** Hypertension and diabetes were the most common risk factors for cerebral ischemic stroke in the study. Out of 90 patients, 59 (64%) had hypertension, and 55 (44%) had diabetes. The R-value was used to determine statistical significance and indicated a positive correlation between various risk factors, CIMT, and percentage stenosis. Hypertension was the most

frequently associated risk factor with stenosis and increased CIMT, followed by hyperlipidemia, which also showed a positive correlation with both stenosis and increased CIMT. **CONCLUSION:** The findings support the use of Doppler ultrasound as the initial diagnostic approach for patients with suspected cerebrovascular insufficiency, with its effectiveness demonstrated in detecting significant stenosis and monitoring risk factors for stroke. This method is particularly valuable for screening asymptomatic high-risk individuals, facilitating early intervention to prevent stroke occurrence. Given its efficiency, safety, and repeatability, carotid artery Doppler ultrasound should be prioritized in stroke prevention strategies, with complementary imaging techniques reserved for more complex cases.

KEY WORDS: Acute ischaemic stroke, Risk factors, Ultrasound.

INTRODUCTION

The sudden deficit of neurological loss brought on by a focal vascular aetiology is what defines a stroke. One of the main subtypes of acute stroke is acute ischaemic stroke, which is caused due to blockage in an artery supplying blood to the brain, often due to a thrombus or embolus. Since 6 thromboembolic strokes account for 80% of all strokes, early detection of atheromatous alterations in the carotid artery can reduce stroke-related morbidity and mortality. An accurate diagnosis is crucial for effective stroke treatment. ultrasound can adequately supplement other acute imaging modalities, such as computed tomography angiography (CT/CTA) or magnetic resonance imaging/magnetic resonance angiography (MRI/MRA).[1-5]

Every acute stroke unit's diagnostic workflow includes both transcranial doppler sonography and ultrasound of the carotid and vertebral arteries (cervical duplex 7 ultrasonography, or CDU). These procedures have several important benefits, including high temporal and spatial resolution, real-time evaluation, low cost, and bedside application of an exam that can be repeated multiple times during the patient's hospitalisation without putting them at risk for serious complications.[6-10]

Therefore, the purpose of the current study was to analyse the extracranial carotid artery ultrasound examination in patients who presented with acute ischaemic stroke of anterior circulation and its correlation with different risk factors in a tertiary care hospital.

AIMS AND OBJECTIVES OF THE STUDY:

- To study the role of Carotid Doppler Ultrasonography in the diagnosis and management of stroke patients.
- To study retrospectively the various abnormalities ie; determine the various velocities, characterize plaque, and assess intimate media thickness in Carotid arteries in patients who had suffered a stroke.
- Find association between carotid artery doppler changes and risk factors such as diabetes mellitus, hypertension, hyperlipidemia, smoking, and age to determine the usefulness of doing Carotid Doppler Ultrasonography as a screening procedure in predicting the chances of developing stroke in persons having risk factors for stroke.

MATERIALS AND METHODS:

● **Study Design-** Descriptive Cross Sectional Study.

● **Place of Study -** Radiology department of a tertiary health care centre.

● **Study Duration -** 18 months

● **Sample Size:**

Formula used:

Sample size = 4PQ/L^2, where p is the prevalence, Q=1-P

L is the permissible error rate which is taken to be 5 %

P is taken to be 94 calculated from a similar study by Jaman k.et al.[11]

Q=100-P=100-94=6

Substituting P and Q In the equation

n=4PQ/L^2 n=4*94*6/5*5

n=90

Data source: Obtained on a predesigned proforma (Case Record Form) and study questionnaire.

● **INCLUSION CRITERIA:**

Patients who suffered an ischemic stroke in the anterior circulation of the brain as confirmed by CT scan of brain.

● **EXCLUSION CRITERIA:**

- Patients who suffered a stroke due to intracerebral hemorrhage.
- Patients who suffered a stroke due to head injury.

Ethical clearance:

- ✓ This study obtained ethical approval from the Institutional ethical committee.
- ✓ First written informed consent was taken from patients included in the study.

Data Collection Methodology Equipment Utilized: Grayscale and color Doppler sonography were conducted using the Philips Affiniti 70 G, Hitachi Aloka F37 and Mindray ultrasound systems, equipped with 9-3 MHz and 12- 5 MHz high-frequency linear transducers.

Study Design: The research involved 90 patients. Individuals over 18 years of age, admitted with sudden onset neurological symptoms, underwent CT scans of the brain, with findings documented. Patients diagnosed with ischemic stroke in the anterior circulation were selected for further analysis

Stenosis was assessed using two methods:

- **North American Symptomatic Carotid Endarterectomy Trial (NASCET) Method:** % ICA stenosis = (1 - (narrowest ICA diameter/diameter normal distal cervical ICA)) x 100

- **European Carotid Surgery Trial (ECST) Method:** % ICA stenosis = (1 - (diameter of the most stenotic part/estimated original diameter at the site of the stenosis)) x 100

Acoustic estimation methods for stenosis includes:

- Measurement of peak systolic and end-diastolic velocities.
- Measurement of ratios, such as the peak systolic velocity of the internal carotid artery compared to the common carotid artery.

Statistical analysis: Quantitative data was presented with the help of Mean and Standard deviation. Comparison among the study groups was done with the help of unpaired t test as per results of normality test. Qualitative data is presented with the help of frequency and percentage tables. Association among the study groups was assessed with the help of Fisher test, student 't' test and Chi-Square test. 'p' value less than 0.05 was taken as significant.

Appropriate statistical software, including but not restricted to MS Excel, SPSS ver. 20 was used for statistical analysis.

Graphical representation was done in MS Excel 2010

OBSERVATION AND RESULTS:

DEMOGRAPHICS

GENDER DISTRIBUTION: In our study, the majority of the participants were male, with 71 patients (82%) being male and 19 patients (18%) being female.

AGE DISTRIBUTION: In our study, the largest number of stroke patients were in the 61-70 year age group, which is 28 patients (32.5%). This was followed by 27 patients (31.2%) in the 51-60 year age group. Eighteen patients (19.5%) were aged 40-50 years, eleven patients (10.4%) were in the 71-80 year age group, and six patients (6.5%) were over 80 years old.

DISTRIBUTION OF STROKE

In present study, out of 90 patients who presented with signs and symptoms of stroke 36 patients (40%) had right sided stroke and 32 patients (36%) had left sided stroke. Bilateral involvement was seen in 4 patients (4%). Eighteen patients (20%) had transient ischemic attack.

TABLE 1: CT / MRI FINDINGS

CT / MRI FINDINGS	NUMBER OF PATIENTS	PERCENTAGE
RIGHT MCA	27	30%

RIGHT ACA	8	7.27%
LEFT MCA	25	27.77%
LEFT ACA	7	7.77%
RIGHT MCA/ACA	4	4.44%
LEFT MCA/ACA	3	3.33%
LACUNAR INFARCT	16	17.77%
TOTAL	90	100%

RISK FACTORS ASSOCIATED WITH STROKE CORRELATION WITH CT/MRI FINDINGS

Out of 90 patients,59 patients had hypertension, 55 patients had diabetes mellitus and 53 patients (had a history of smoking. 45 patients (58.4%) had a family history of stroke. None of the patients in the study had a history of ischemic heart disease. The risk factors associated with stroke were compared with CT/ MRI findings of stroke and following p-values were obtained.

TABLE 2: COMPARISON OF RISK FACTORS WITH CT / MRI FINDINGS

RISK FACTORS ASSOCIATED WITH STROKE	PRESENT	PERCENTAGE	P-VALUE
HYPERTENSION	59	65.55%	<0.001
DIABETES MELLITUS	55	61.11%	<0.001
SMOKING	53	58.8%	<0.001
FAMILY HISTORY	45	50%	<0.001

INTIMA MEDIA THICKNESS OF COMMON CAROTID ARTERY INTIMA MEDIA THICKNESS OF RIGHT CCA

In this study, of the 180 vessels examined, 137 vessels (76%) exhibited increased carotid intima-media thickness (CIMT), while 43 vessels (24%) had normal CIMT. There was a strong correlation between increased IMT and stroke, with a p-value of <0.001, indicating a significant association. Additionally, when comparing increased IMT with plaque formation, a significant result was found, with a p-value of 0.002.

DISTRIBUTION OF PLAQUE

Out of 90 patients examined,78 patients (87%) had plaques in the carotid system and 12 patients (13%) showed no plaques. Out of 78 patients who had plaques, 23 (26%) had plaques on the right side, 20 (22%) had plaques on the left side and 35 (39%) had bilateral involvement.

TABLE 3: CHARACTERIZATION OF PLAQUE

TYPE OF PLAQUE	PLAQUE ON THE RIGHT	PLAQUE ON THE LEFT
CALCIFIED PLAQUE	7 (7.77%)	9 (10%)
HOMOGENEOUS PLAQUE	12 (13.3%)	11(12.22%)
HETEROGENEOUS PLAQUE	39 (43.33%)	35 (38.88%)
TOTAL	58 (64.44%)	55 (61.11%)
NO. OF PT WITH NO PLAQUES ON THE RIGHT	32(35.55%)	35 (38.88%)
	90(100%)	90 (100%)

PEAK SYSTOLIC VELOCITY OF ICA

In this study, a total of 180 vessels were examined. Of these, 103 vessels had velocities of less than 125 cm/sec, indicating normal conditions or stenosis of less than 50% (54 on the right and 49 on the left). Forty-nine vessels had velocities ranging from 125 to 230 cm/sec, reflecting stenosis of 50-69% (23 on the right and 26 on the left). Fourteen vessels exhibited velocities of 230 cm/sec or higher, signifying stenosis greater than 70% (6 on the right and 8 on the left). Eight vessels showed variable velocities, suggesting near-total occlusion (4 on the right and 4 on the left). In 6 vessels, peak systolic velocity (PSV) could not be detected, indicating total occlusion (3 on the right and 3 on the left). The overall findings were statistically significant, with a p-value of <0.001

TABLE 4: END DIASTOLIC VELOCITY OF ICA

END DIASTOLIC VELOCITY OF ICA (cm/sec)	RIGHT	LEFT
<40 VELOCITY	54(60%)	49(54.44%)
40-100 VELOCITY	23(25.55%)	26(28.89%)
>100 VELOCITY	6(6.67%)	8(8.89%)
VARIABLE	4(4.44%)	4(4.44%)
NOT APPLICABLE	3(3.33%)	3(3.33%)
TOTAL	90(100%)	90(100%)

TABLE 5 : PEAK SYSTOLIC VELOCITY RATIO

PSV RATIO	RIGHT	LEFT
RATIO <2	54(60%)	49(54.44%)
RATIO 2-4	23(25.55%)	26(28.89%)
RATIO >4	6(6.67%)	8(8.89%)
VARIABLE	4(4.44%)	4(4.44%)
NOT APPLICABLE	3(3.33%)	3(3.33%)
TOTAL	90(100%)	90(100%)

Out of 180 vessels totally examined, 103 vessels (54 in the right and 49 in the left) showed a PSV ratio of less than 2 which indicates normal to less than 50% stenosis. 37 vessels (23 in the right and 26 in the left) showed a PSV ratio between 2 to 4 which indicates stenosis more than 50% but less 69%. 14 vessels (6 in the right and 4 in the left) showed a PSV of more than 4 which is an indicator of more than 70% stenosis and 8 vessels (4 in the right and 4 in the left) showed variable PSV ratio which indicates near total occlusion. In 6 vessels (3 on the right and 3 on the left) PSV ratio could not be measured as flow was not detected which indicates total occlusion. It showed a significant result with a p-value of <0.001.

GRADING OF STENOSIS

We observed that more than >70% STENOSIS was present in 7 (7.77%) vessels in right side and 9 (10%) in left side

ASSOCIATION OF RISK FACTORS WITH CIMT AND STENOSIS

Hypertension and diabetes were the most common risk factors for cerebral ischemic stroke in the study. Out of 90 patients, 59 (64%) had hypertension, and 55 (44%) had diabetes. The R-value was used to determine statistical significance and indicated a positive correlation between various risk factors, CIMT, and percentage stenosis. Hypertension was the most frequently associated risk factor with stenosis and increased CIMT, followed by hyperlipidemia, which also showed a positive correlation with both stenosis and increased CIMT.

TABLE 6: ASSOCIATION OF RISK FACTORS WITH CIMT AND STENOSIS.

Risk Factors	Total patients having specified risk factors	Patients having stenosis (percentage)	Increased IMT	R-value (Multiple Logistic Regression)
Hypertension	59	43(72.88%)	36 (61.01%)	0.278
Familial History	45	24(53.33%)	17(37.77%)	0.050
Diabetes	55	42(76.36%)	37(67.27%)	0.036
Smoking	53	38(71.69%)	31(58.49%)	0.029

DISCUSSION:

In our study, the largest number of stroke patients were in the 61-70 years age group, which was 28 patients (32.5%). This was followed by the 51-60 years age group, which included 27 patients (31.5%). The 40-50 years age group had 18 patients (19.5%), while the 71-80 years age group had 11 patients (10.4%). The age group over 80 years comprised 6 patients (6.5%). These findings align with results from similar studies. As cerebrovascular disease affects predominantly the older and middle age group, its prevalence increases with the increase in age [12].

In this study family history of stroke was present in 45 patients (50%). It showed an excellent result with p-value of <0.001, on comparing it with the CT/MRI findings of stroke.This is similar to a study conducted by Schulz U.G.R et al., who studied family history of stroke and found that 23% of stroke patients had positive family history [13].

In the current study, CT and MRI findings from 90 patients presenting with stroke symptoms were analyzed. On the right side, 27 patients (30%) exhibited infarcts in the MCA territory, 8 patients (7.2%) had ACA territory infarcts, and 4 patients (4.4%) showed involvement in the watershed zones. On the left side, 25 patients (27.7%) had MCA territory infarcts, 7 patients (7%) had ACA territory infarcts, and 3patients (3.3%) had watershed zone involvement. Additionally, lacunar infarcts were observed in 16 patients (17.77%). The MCA territory was the most frequently affected area in strokes involving the anterior circulation. This was similar to study by Chamarthi et al. and Bhagat H et al which also showed MCA territory infarct to be most common[14].

In the present study 53 patients (58.8%) had a history of smoking. On comparing history of smoking with the CT/MRI findings of stroke, it showed an excellent result with p- value of <0.001. Hence, smoking is also considered as an important risk factor associated with stroke in the present study. This was similar to a study conducted by Toshifumi Mannami et al., who confirmed a positive relationship between smoking and risk of stroke. They estimated that 22% of stroke were attributable to smoking [15].

Out of 90 patients examined,78 patients (87%) had plaques in the carotid system and 12 patients (13%) showed no plaques. Out of 78 patients who had plaques, 23 (26%) had plaques on the right side, 20 (22%) had plaques on the left side and 35 (39%) had bilateral involvement. This was similar to a study conducted by Chamarthi et al conducted on 75 patients, showing that 57 patients had atheromatous plaque [14].

In ultrasound studies, various Doppler parameters—peak systolic velocity, end diastolic velocity, and peak systolic velocity ratio—have been assessed for predicting clinically significant internal carotid artery (ICA) stenosis. Initially, peak systolic velocities were used to estimate stenosis, but their accuracy is limited by physiological variability and obstructive lesions. The peak systolic velocity ratio, which accounts for patient and instrument variability, has been found to be the most reliable measure, as confirmed by Zwiebel William J.et al.[16]

CONCLUSION:

The research underscores the effectiveness of carotid artery Doppler ultrasound as a critical tool in the management of stroke. Carotid artery Doppler, including both grayscale ultrasound and color Doppler examination, proves to be a non-invasive, cost-effective, and reliable method for assessing carotid artery pathology. Its ability to accurately identify and quantify carotid stenosis—whether through peak systolic velocity, end diastolic velocity, or peak systolic velocity ratio—enables precise risk stratification and informs clinical decision-making.

The findings support the use of Doppler ultrasound as the initial diagnostic approach for patients with suspected cerebrovascular insufficiency, with its effectiveness demonstrated in detecting significant stenosis and monitoring risk factors for stroke. This method is particularly valuable for screening asymptomatic high-risk individuals, facilitating early intervention to prevent stroke occurrence. Given its efficiency, safety, and repeatability, carotid artery Doppler ultrasound should be prioritized in stroke prevention strategies, with complementary imaging techniques reserved for more complex cases

LIMITATIONS:

- This study was a cross sectional study done on a small sample size hence larger sample size is necessary for its extrapolation to the general population, additionally longitudinal studies are needed to assess the correlation between findings and long term outcome.

- Another limitation of the study is that the posterior circulation was not assessed. Carotid artery doppler is not helpful in management of patients with other causes of ischemic stroke like embolism due to cardiac causes like atrial fibrillation, air and fat embolism, perforator thrombosis causing lacunar infarcts.

REFERENCES :

1. Halliday A, Harrison M, Hayter E, Kong X, Mansfield A, Marro J, Pan H, Peto R, Potter J, Rahimi K, Rau A. 10-year stroke prevention after successful carotid endarterectomy for asymptomatic stenosis (ACST-1): a multicentre randomised trial. The Lancet. 2010 Sep 25;376(9746):1074-84.

2. Bulbulia R, Halliday AW. The Asymptomatic Carotid Surgery Trial-2 (ACST- 2): An ongoing randomised trial comparing carotid endarterectomy with carotid artery stenting to prevent stroke. Health Technology Assessment. 2017 Nov 10;21(57).

3. Fontenelle LJ, Simper SC, Hanson TL. Carotid duplex scan versus angiography in evaluation of carotid artery disease. The American surgeon. 1994 Nov;60(11):864- 8.

4. Imparato AM, Riles TS, Mintzer RO, Baumann FG. The importance of hemorrhage in the relationship between gross morphologic characteristics and cerebral symptoms in 376 carotid artery plaques. Annals of Surgery. 1983 Feb;197(2):195-203.

5. Bluth EI, Kay D, Merritt CR, Sullivan M, Farr G, Mills NL, Foreman M, Sloan K, Schlater M, Stewart J. Sonographic characterization of carotid plaque:detection of hemorrhage. American Journal of Roentgenology. 1986 May 1;146(5):1061-5.

6. Sethi SK, Solanki RS, Gupta H. Color and duplex doppler imaging evaluation of extracranial carotid artery in patients presenting with transient ischaemic attack and stroke: a clinical and radiological correlation. Indian Journal of Radiology and Imaging. 2005 Feb 1;15(1):91-8.

7. Fernandes M, Keerthiraj B, Mahale AR, Kumar A, Dudekula A. Evaluation of carotid 145 arteries in stroke patients using color Doppler sonography: A prospective study conducted in a tertiary care hospital in South India. International Journal of Applied and Basic Medical Research. 2016 Jan;6(1):38-44.

8. Catanese L, Tarsia J, Fisher M. Acute ischemic stroke therapy overview.Circulation Research. 2017 Feb 3;120(3):541-58.

9. Vert C, Parra-Fariñas C, Rovira À. MR imaging in hyperacute ischemic stroke.European Journal of Radiology. 2017 Nov 1;96:125-32.

10. Chalela JA, Kidwell CS, Nentwich LM, Luby M, Butman JA, Demchuk AM, Hill MD, Patronas N, Latour L, Warach S. Magnetic resonance imaging and computed tomography in emergency assessment of patients with suspected acute stroke: a prospective comparison. The Lancet. 2007 Jan 27;369(9558):293-8.

11. Jaman K.(2007) Carotid Doppler ultrasonography evaluation in patients with stroke.(Tamil Nadu Dr. MGR Medical university)

12. Feigin VL, Forouzanfar MH, Krishnamurthi R, et al. Worldwide stroke incidence and early case fatality reported in 56 population-based studies: a systematic review. Lancet Neurol. 2009 Apr;8(4):355-69

13. Schulz UG, Flossmann E, Rothwell PM. Heritability of ischemic stroke in relation to age, vascular risk factors, and subtypes of incident stroke in population-based studies. Stroke. 2004 Apr 1;35(4):819-24.

14. Chamarthi M, Lava Kumar B, Nirusha R, Pravallika I, Kejriwal GS. Color Doppler Evaluation of Carotid Arteries in Stroke Patients: A Study Conducted in A rural Tertiary Care Medical College Hospital in South india. atherosclerosis.;3:4.

15. Fontenelle LJ, Simper SC, Hanson TL. Carotid duplex scan versus angiography in evaluation of carotid artery disease. The American surgeon. 1994 Nov;60(11):864- 8.

16. Zwiebel WJ. Introduction to Vascular Ultrasonography. 4th ed. Philadelphia: W.B. Saunders Company; 2000. ISBN: 0-721-66949-2.