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Evaluation of carotid arteries in patients of stroke using colour doppler.

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Abstract
Background *Stroke is common in inpatient populations and can be a significant cause of morbidity and mortality. Stroke is the main cause of disability, the second leading cause of mortality (after ischemic heart disease), and the second greatest cause of dementia. After ischemic heart disease and lung cancer, they are the third most common cause of mortality in males, while they are the main cause of death in women.*
Materials and Methods *The present study is a prospective, cross sectional diagnostic study undertaken to evaluate the role of colour doppler in evaluation of patients with signs and symptoms of stroke or transient ischemic attack in indoor and outdoor patients being referred to the department of Radiodiagnosis and department of neurology, NRI Medical College& GH, Chinnakakani. All the study patients were investigated on Affinity 50 Philips machine.*
Results *Of 102 patients examined, 60 patients showed carotid disease, and 42 patients showed normal extracranial carotid vasculature. The incidence of stroke was found to be more in patients with more age with highest incidence in age group of 50-60 years.The most common cause of carotid disease in our study is atherosclerotic plaques. Stroke is seen in 26 out of 41 female patients and in 34 male patients among 61 male patients. Stenosis of more than 40% is found in 20 patients and more than 60% is seen in 14 patients.Three patients had stenosis more than 70% in their vessels. There is complete occlusion in 3 patients.*
Conclusions *Carotid doppler is a significant advancement in diagnosis of pathology in carotid arteries. It is a non-invasive, cheaper, and faster modality for evaluating the extracranial course of carotid vessels.*
Keywords *Carotid doppler, extracranial carotid arteries, stroke.*

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I. Introduction:

Stroke is the main cause of disability, the second leading cause of mortality (after ischemic heart disease), and the second greatest cause of dementia.
After ischemic heart disease and lung cancer, they are the third most common cause of mortality in males, while they are the main cause of death in women. It can be graded as ischemic, hemorrhagic, or subarachnoid.
Among ischemic strokes, Trial Org 10172 in Acute Stroke Care (TOAST) classification is used to subdivide categories that include embolism, small vessel occlusion, extensive artery atherosclerosis, and stroke of undetermined etiology.[1]

Etiology:
The cause of an ischemic stroke is either a thrombotic or embolic event that triggers a decrease in blood flow to the brain.
In a thrombotic case, blood flow to the brain is obstructed inside the blood vessel due to dysfunction inside the vessel itself, typically secondary to atherosclerotic disease, arterial dissection, fibromuscular dysplasia, or inflammatory disorder.
In an embolic case, debris from elsewhere in the body blocks blood flow into the affected vessel. Whatever the reason, stroke affects both prognosis and outcomes.[2, 3]

Epidemiology of stroke in India[4]:

The incidence of stroke ranged from 105 to 152/100,000 persons per year in various parts of the country, and the crude prevalence of stroke ranged from 44.29 to 559/100,000 persons during the past decade. These values were more compared to high-income countries.

Diagnosis:

In the past, neuroimaging has primarily been done to exclude hemorrhagic, neoplastic, and infectious etiologies from the ischemic cause of strokes. With recent advancements, neuroimaging is a vital part of stroke treatment especially in acute ischaemic stroke patients, it plays a key role. It helps to distinguish between other causes of stroke (i.e., stroke mimics such as migraine headaches, cancers, epilepsy, metabolic disorders and peripheral or cranial nervous disorders), early detection of hemorrhagic stroke, the isolation of permanent infarcted tissues from regenerative tissue, the diagnosis of vascular malformations, treatment plan for intravenous thrombolysis and intra-arterial treatment.

Various available imaging modalities for stroke imaging CT, CT angiography (CTA), CT perfusion (CTP), CT venography (CTV), MRI, MR angiography (MRA), MR perfusion (MRP), ultrasonography, nuclear medicine and angiography are the critical different imaging modalities useful for stroke imaging. Each mode has its pros and cons.

Ultrasound is a cost-effective, non-invasive and highly reliable tool for diagnosing carotid stenosis. It helps to determine the morphology of the plaque. Angiography was replaced mainly by carotid artery Doppler as the primary screening tool for potential extracranial carotid artery atherosclerosis. Carotid ultrasound may be the only option before carotid endarterectomy is performed.[5]

If risk factors are recognized and detected early, effective treatment can be developed in asymptomatic patients with risk factors that will delay the progression of carotid artery disease

II. Materials and Methods

Method of data collection: The present study is a prospective, cross-sectional diagnostic study undertaken to evaluate the role of carotid doppler in evaluation of carotid arteries in patients of stroke being referred to the department of radiology and neurology, the NRI Medical College, and GH Chinnakakani.

Study design: Prospective, Cross-sectional, observational study

Study location: Department of radiology, the NRI Medical College, and GH Chinakakani.

Study duration: December 2021 to December 2022

Sample size: 150

Around 150 patients visited the Radiodiagnosis dept. NRIMC with stroke requiring carotid doppler assessment during the study period.

After considering the exclusion criteria, 38 patients were excluded from the study based on exclusion criteria, and ten patients didn't provide informed consent. So, we have included 102 patients in our study.

INCLUSION CRITERIA:

Patients from all age groups, including men and women, with neurological signs and symptoms of stroke or TIA, were included in this study.

EXCLUSION CRITERIA:

1. Patients who suffered a stroke due to intracerebral haemorrhage.
2. Patients who suffered a stroke due to head injury, vasculitis, cardioembolic stroke.

Subjects and selection method: All the study patients were investigated using Affinity 50 Philips machine with transducer available in the department of Radiodiagnosis, NRI Medical College & GH.

Imaging Protocol:

Patient position:

Carotid arteries were assessed with the patient in the supine position with Neck exposure by tilting and rotating the head away from the side being examined

Transducer Position:The posterolateral and far posterolateral transducer positions are used to examine the carotid arteries in long axis (longitudinal). The carotid arteries' short axis (transverse) views are obtained from an anterior, lateral or posterolateral approach.

PROTOCOL FOR CAROTID DUPLEX EXAMINATION

1. Longitudinal Survey

Lateral transducer position

- Begin at the clavicle and move cephalad.

- Identify carotid bifurcation, ECA, and ICA.
- Localize plaque and areas of obstruction in arteries like CCA, ECA, and ICA.
Transducer position - Trace the ICA as far cephalad as possible to know the evidence of pathology.
1. Longitudinal evaluation of pathology
Lateral or posterolateral transducer position.
Documentextent of plaque deposition.
Document surface and internal characteristics of plaque.
Measure peak-systolic and end-diastolic velocities and compare them with proximal CCA velocities.
Note degree of post stenotic flow disturbance.
Anterior transducer position
Re-examine the entire carotid bifurcation to double-check the previous findings from a different perspective.
2. Transverse examination:
Begin at the clavicle and move cephalad.
Identify the carotid bifurcation, ECA, ICA.
Localize plaque and areas of obstruction to the CCA, ECA, or ICA.
Document surface and internal characteristics of plaque.
Measure the residual lumen size and diameter reduction.
Complete clinical workup was done for all the patients, which include-:

- A detailed history.
- General physical examination
- Vitals
- Systemic examination
- Study parameters

PARAMETERS COLLECTED:

- Age and Gender
- Presence of diabetes, hypertension
- History of Smoking, hyperlipidemia or ischemic heart disorders
- Artery involved yes or no
- Which artery involved
- Diagnosis
- Side of the lesion
- Peak Systolic velocity of common carotid artery
- Peak systolic velocity of internal carotid artery
- Velocity ratios between internal carotid artery and common carotid artery
- Plaque characteristics as seen on the real time image
- EDV
- % of stenosis

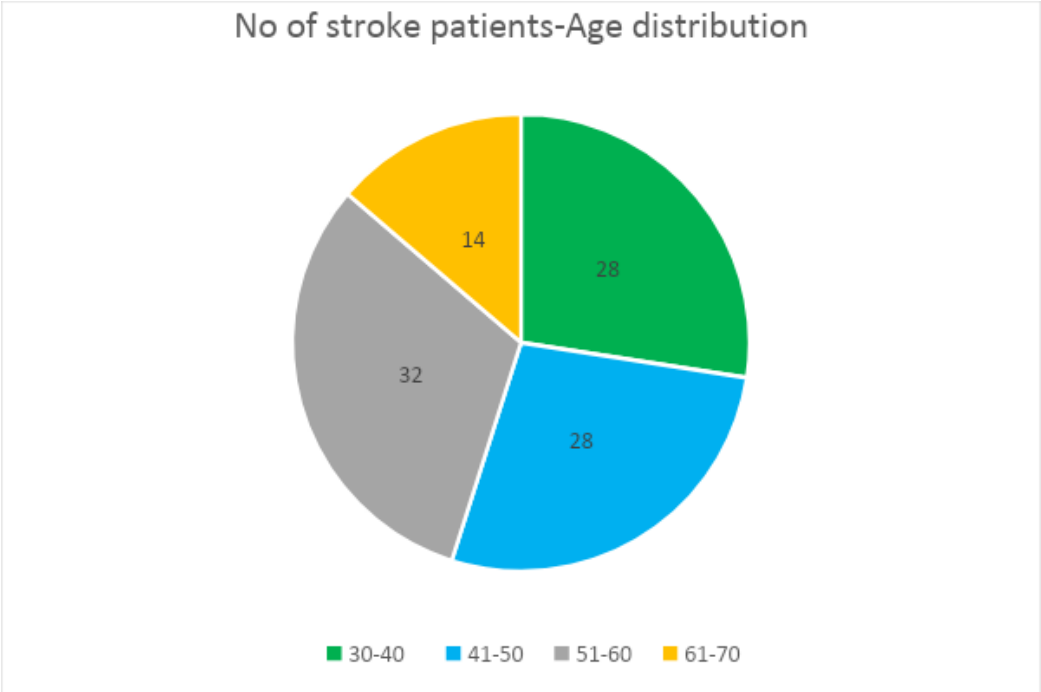
Statistical analysis The data collected was entered in MS Excel 2019 and analysis was done using statistical software named Statistical Package for the Social Science version 20.0.0 (SPSS Inc., Chicago, Illinois, USA). The results were expressed in the form of descriptive statistics. All categorical variables (qualitative data) are expressed in percentage.
Frequencies, percentages were used.

III. Results

Age distribution: The age of patients involved in this study ranged from 33-70 years.Most common age of stroke patients found to be 51-60 years

Table 1: Age distribution

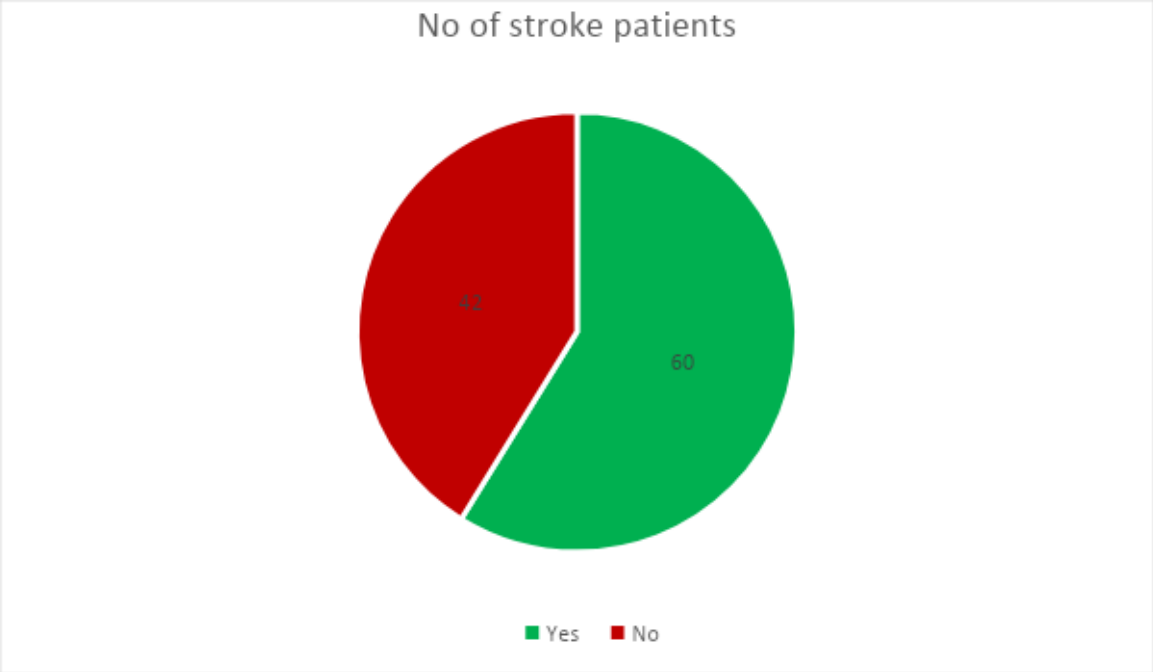
Age in years	No of patients	Percentage of patients
30-40	28	27.4%
41-50	28	27.4%
51-60	32	31.3%
61-70	14	12.7%



Graph 1: Age distribution

Incidence of stroke:
In the current study, 60 patients had stroke among 102 patients.

Graph 2: Incidence of stroke



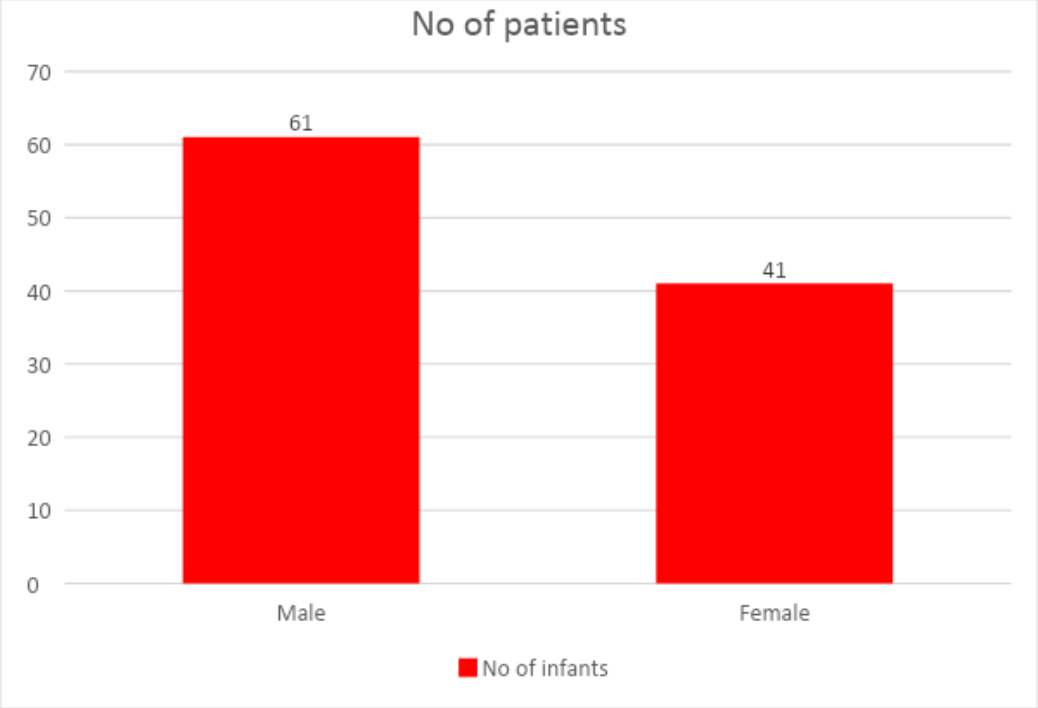
The mean age of stroke patients in this study is 52.8 ±9.28 and non stroke patients is 47.2±12.3. There is significant differences in mean ages, indicating that stroke incidence increases with age. The difference is significant p value: 0.02. For the analysis purpose, we are considering stroke patients as cases and non-stroke patients as controls.

Table 2: Mean age and Stroke:

Patients	Mean Age	P value
Controls	47.2±12.3	0.02
Cases	52.8 ±9.28	

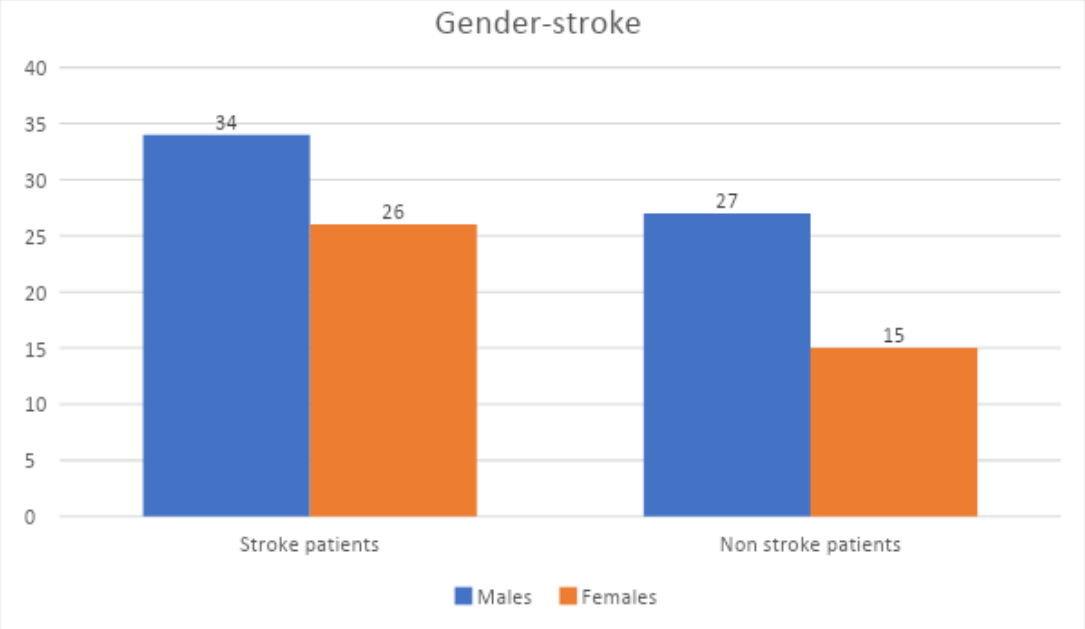
Gender of patients:
In the current study, 41 patients are females and 61 are male patients.
Graph 2: Gender distribution of Patients.

Graph 3: Gender distribution of patients



Gender-wise presence of stroke:
In our study, stroke is seen in 26 female patients out of 41. It is seen in 34 male patients among 61.

Graph 4: Gender wise distribution of cases and controls:

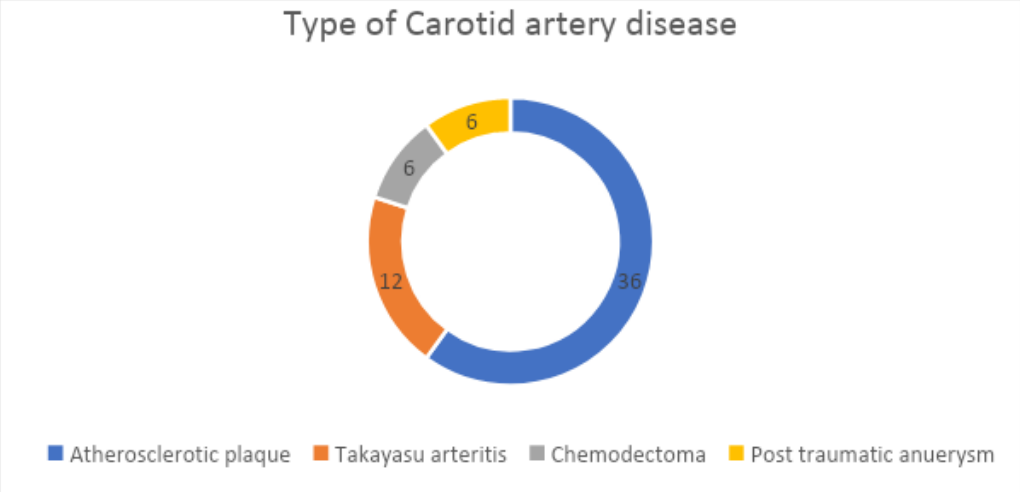


Carotid artery disease:
Carotid artery disease is seen in 60 patients. Atherosclerotic plaque was found to be the commonest lesion in carotid artery followed by takayasu arteritis in the current study.

Table 3: Type of carotid artery disease in stroke patients

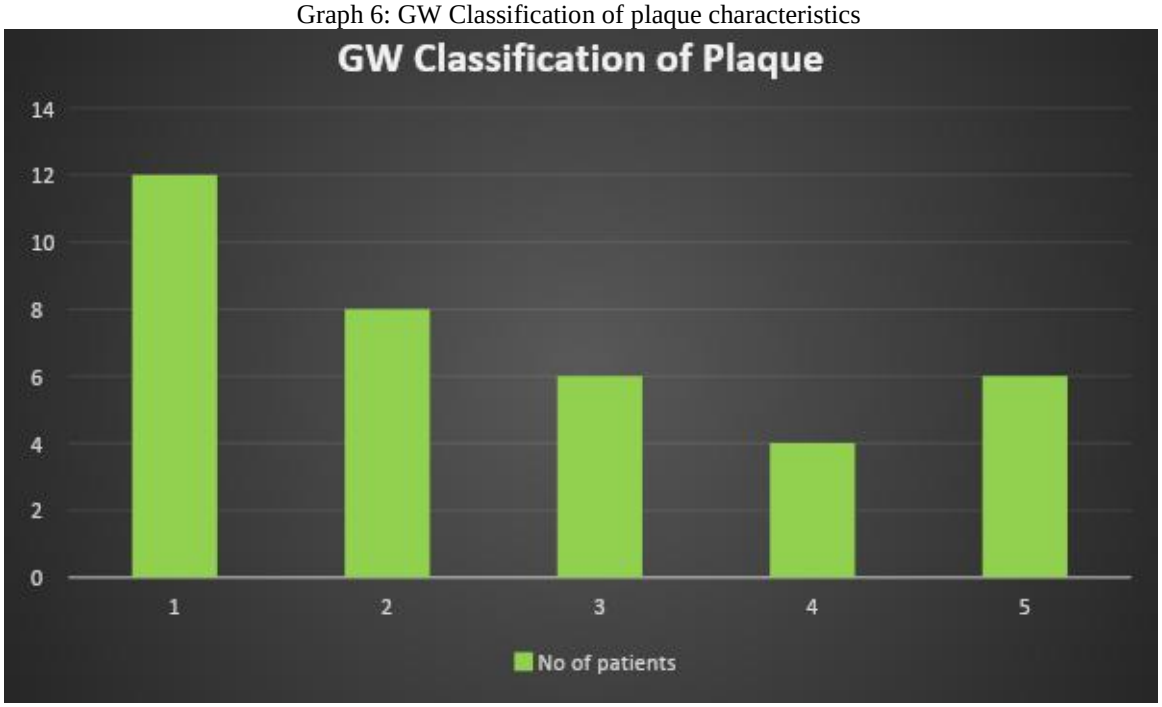
Carotid artery disease	No of Patients	% of stroke patients
Atherosclerotic plaque	36	60%
Takayasu arteritis	12	20%
Chemodectoma	6	10%
Post traumatic anuerysm	6	10%

Graph 5: Carotid artery disease among patients:



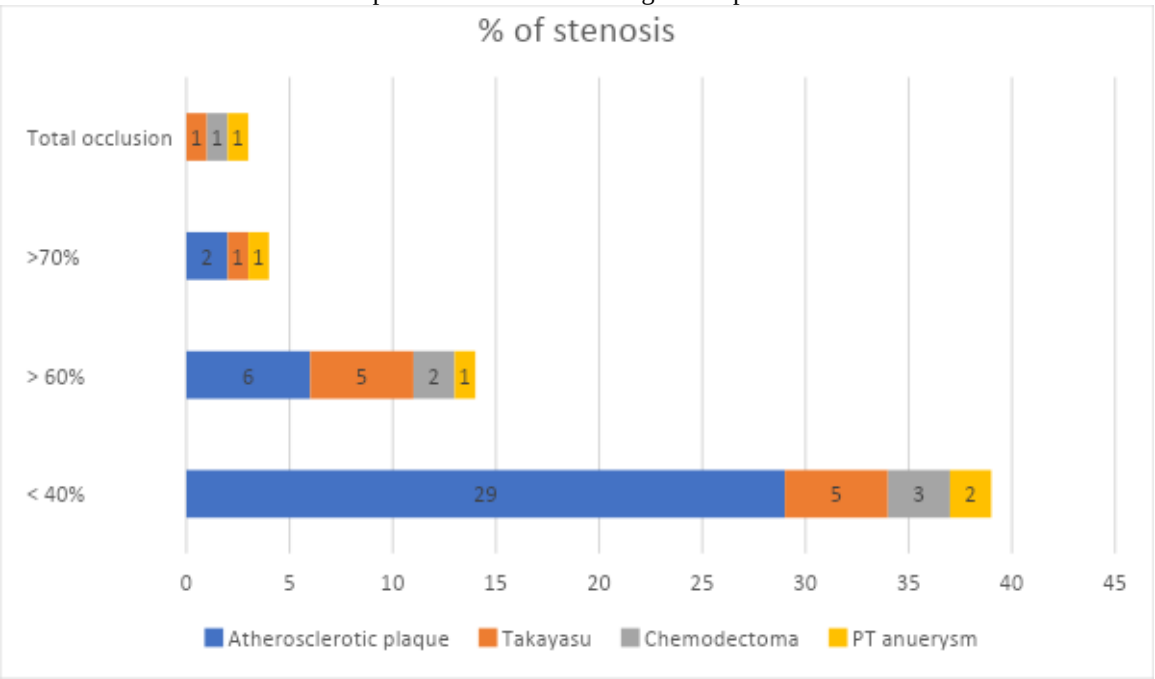
Type of atheroslerotic plaque in carotid vessel.
Atherosclerotic plaque is seen in 36 patients in the current study.
As per the GW classification, the distribution of type of plaque is shown in the below picture.
Type 1 is found to be more common among stroke patients.

Graph 6: GW Classification of plaque characteristics



Percentage of stenosis in patients:
60 patients had their carotids involved in the current study. Most of the patients had the stenosis less than 40%. Most of the atherosclerotic plaques also had a stenosis of less than 40%. Significant stenosis – more than 60% is seen in 14 patients. 3 patients had complete block in this study. 3 patients had more than 70% blockade.

Graph 7: % of stenosis among stroke patients



PSV:
Most of the patients had a peak systolic velocity less than 110 cms in the current study.
Few patients had this velocity ranging from 150 to 200cms.

Table 4: PSV and % of stenosis

PSV in cm/sec	% Stenosis	No of Patients	% of stroke patients
< 110	< 40%	40	66.66%
150 – 210	> 60%	14	23.33%
>210	>70%	3	5%
Occlusion	Total block	3	5%

Table 5: PSV Ratio and % of stenosis

PSV ratio	% Stenosis	No of Patients	% of stroke patients
< 1.5	< 40%	40	66.66%
>1.8	> 60%	14	23.33%
>3	>70%	3	5%
Occlusion	Total block	3	5%

END DIASTOLIC VOLUME IN CMS/SEC:
Most of the patients had EDV less than 40% in the current study.
Few patients had more than 70%.

Table 6: EDV and % of stenosis

EDV in cm/sec	% Stenosis	No of Patients	% of stroke patients
<40	< 40%	40	66.66%
40 TO 70	> 60%	14	23.33%

>70	>70%	3	5%
Occlusion	Total block	3	5%

Table 7: EDV Ratio and % of stenosis

EDV ratio	% Stenosis	No of Patients	% of stroke patients
< 2.6	< 40%	40	66.66%
>2.6	> 60%	14	23.33%
>3.3	>70%	3	5%
Occlusion	Total block	3	5%

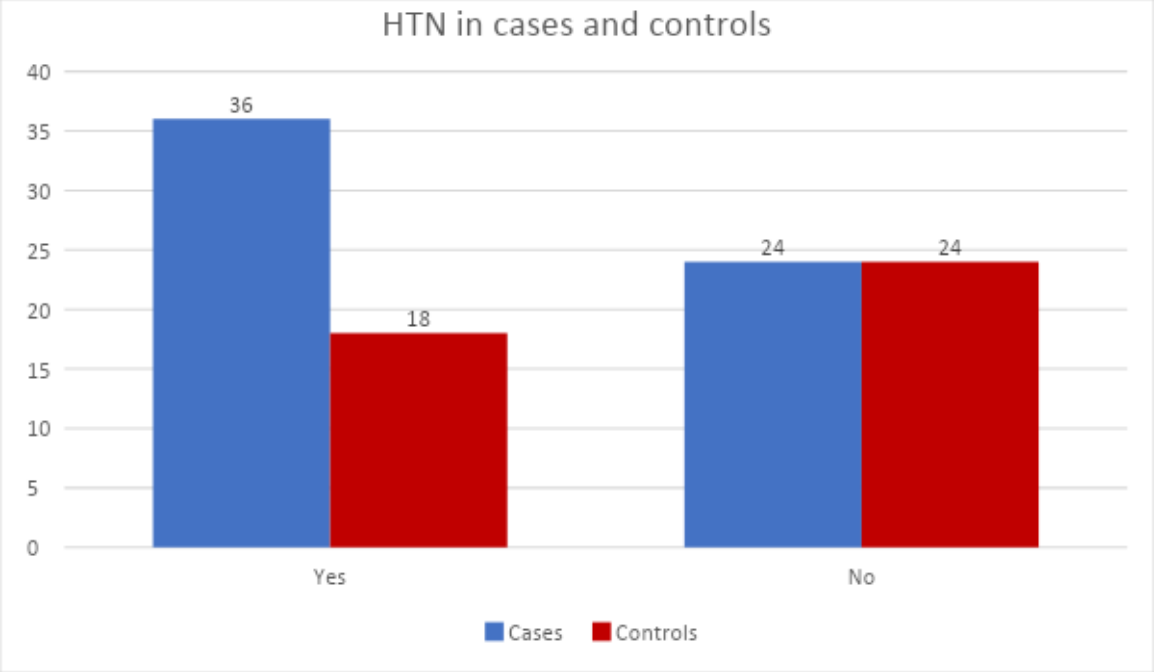
HTN and stroke:
Among 60 patients with stroke, 36 patients are having hypertension.
In 102 patients, total 54 patients had hypertension

Table 8: HTN in cases and controls

HTN	Stroke present or cases	No stroke patients or controls	Total Patients
Yes	36(66.67%)	18(33.33%)	54
No	24(50%)	24	48

Hypertension is found to be more common in cases (66.67%) compared to controls (33.33%), indicating that HTN plays a vital role in the development of stroke.

Graph 8: HTN in cases and controls



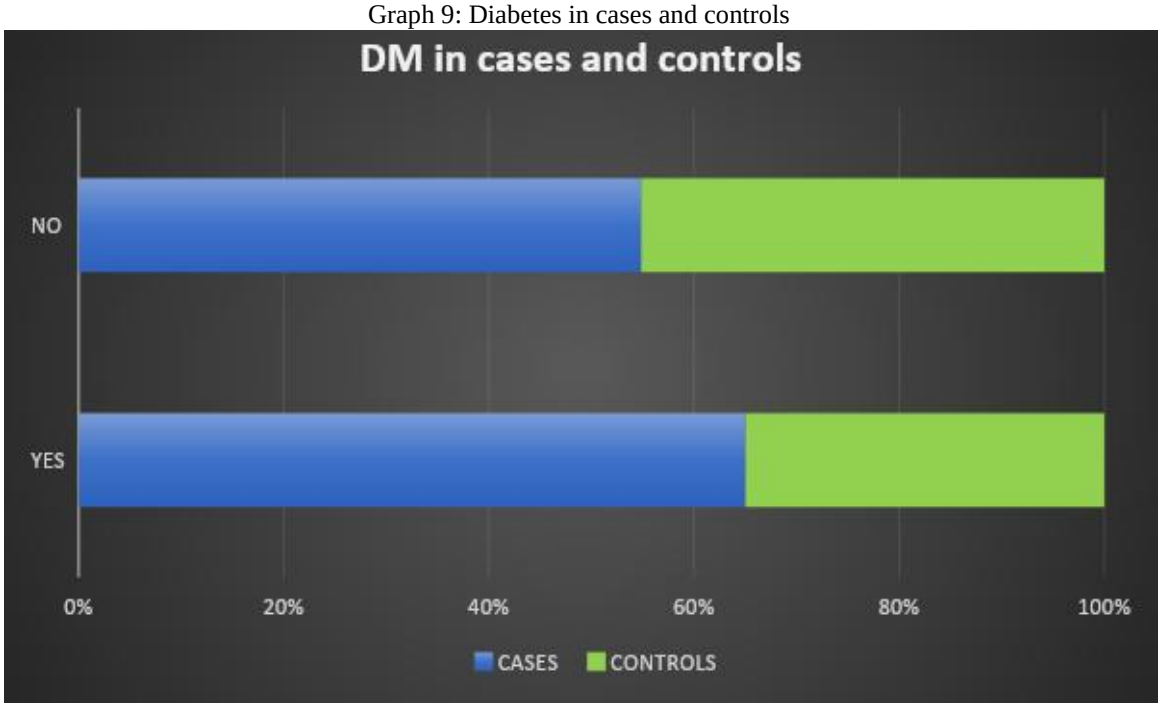
DM and stroke:
Among 60 patients with stroke, 26 patients are having diabetes mellitus.
In 102 patients, total 40 patients had diabetes.

Table 9: DM in cases and controls

DM	Stroke present or cases	No stroke patients or controls	Total Patients
Yes	26 (65%)	14(35%)	40
No	34(55%)	28(45%)	62

Diabetes is found to be more common in cases (65%) compared to controls (35%), indicating that DM plays a vital role in the development of stroke.

Graph 9: Diabetes in cases and controls



Hyperlipidemia and stroke:
Among 60 patients with stroke, 23 patients are having hyperlipidemia.
In 102 patients, total 36 patients had hyperlipidemia.

Table 10: Hyperlipidemia in cases and controls

Hyperlipidemia	Stroke present or cases	No stroke patients or controls	Total Patients
Yes	23 (63.8%)	13(26.8 %)	36
No	37(56%)	25	66

Hyperlipidemia is found to be more common in cases (63.8%) compared to controls (26.8%), indicating that lipid levels play a vital role in the development of stroke.

IHD and stroke:
Among 60 patients with stroke, 19 patients are having ischemic heart disease.
In 102 patients, total 30 patients had IHD.

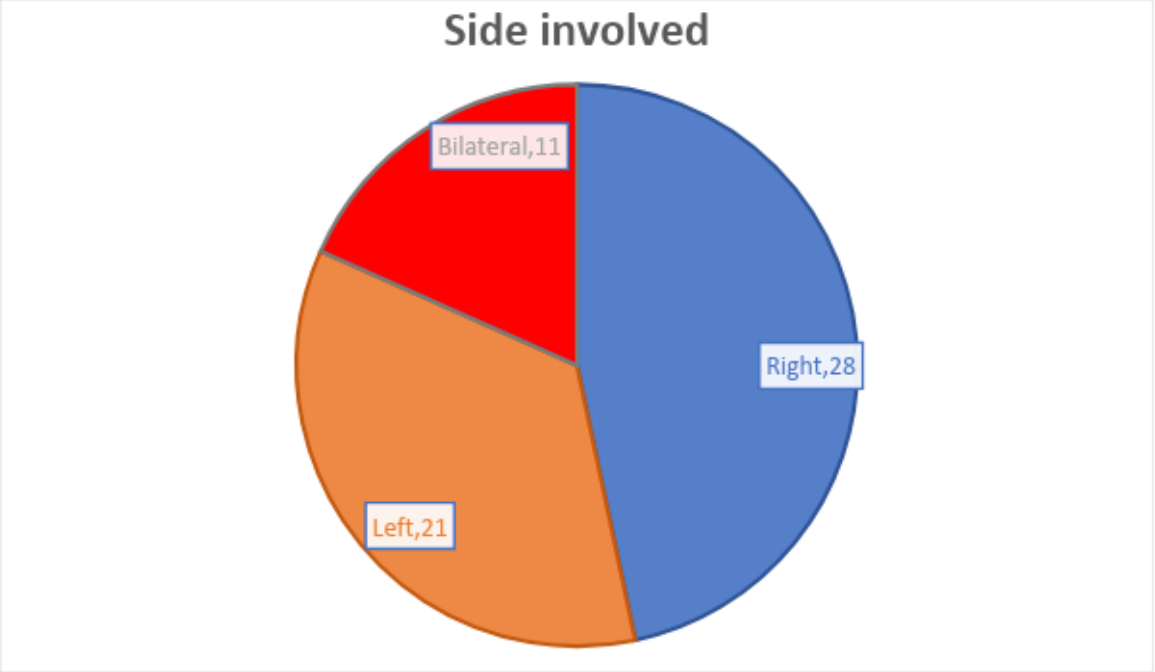
Table 11: IHD in cases and controls

IHD	Stroke present or cases	No stroke patients or controls	Total Patients
Yes	19 (63.3%)	11(27.2%)	30
No	41 (59.6%)	29	72

IHD is found to be more common in cases (63.3%) compared to controls (27.2%), indicating that lipid levels play a vital role in the development of stroke.

Side involved:
Out of 60 stroke patients, 28 patients had problem in the right sided vessel.

Graph 10: Side involved in stroke patients



Vessel involved: In most of the patients, right CCA is involved followed by right ICA. Both vessels are involved in 11 patients-22 vessels.

Table 12: Vessel involved in stroke patients

Vessel involved	No of patients	% of stroke patients
Left CCA	14	23.33%
Left ICA	3	5%
Bilateral	11	18.33%
Right CCA	20	33.33%
Right ICA	8	13.33%
Right carotid bulb	2	3.33%
Left carotid bulb	2	3.33%

IV. Discussion

This study was done to assess the extracranial carotid arterial system in the population who presented with stroke.

The main role of color doppler sonography is the detection of occlusive lesions in the extracranial course of the common carotid and internal carotid arteries.

Treatment of stroke depends on reaching the most accurate possible diagnosis possible through clinical and laboratory evaluation, as per G.K.CALL.

A randomized asymptomatic carotid surgery trial (ACAS) [6]showed distinct advantage for surgical intervention for a patient with at least 60% stenosis.

AGE AND SEX DISTRIBUTION:

In our study, the highest incidence of carotid artery disease was found in the age group of 30 to 60 years. Out of 60 patients, 34 patients were males, and 26 were females. The male and female ratio came to be 1.3:1. This is in contrast to the study done by Paivansolo.M, Leininens, and Turunen[7] J et al. in 1996 who quoted the male and female ratio as 2:1 and also highest incidence of carotid artery disease were among patients between 30 to 60 years.

NON ATHEROSCLEROTIC CAROTID DISEASE:
Non atherosclerotic affections are found to be less common than atherosclerotic plaques. In our study we came across 24 subjects with non atherosclerotic disorders.
Cervical trauma can produce carotid dissections and aneurysms.

W.J. Zweibel[8] stated the identification of fluttering intima causing severe flow disturbance or a thick tissue duplicating the carotid lumen as criteria for identification of dissection.

Caroll.B stated that differentiation of true aneurysm from post-traumatic pseudoaneurysm is possible by identifying to and fro movement in neck and cavity of aneurysm.

S.K.Gupta described circumscribed narrowing of common carotid arteries with sparing of the internal carotid artery and regions of saccular dilation in the disease course as signs of Takayasu's arteritis. We in our study came across 12 patients with clinical suspicion of Takayasu's arteritis showing concentric narrowing of common carotids with sparing of internal carotid arteries diagnosed as Takayasu's arteritis.
About 30-60% of strokes are caused by atherosclerotic disease involving the extracranial carotid arteries, usually within two cms of carotid bifurcation. Angiography is the gold standard procedure, but it is invasive and expensive. It also poses significant risk to the patients.

Sonography is an imaging procedure that can assess plaque composition. Sonographically detected plaque features may be helpful in the selection of medical and surgical therapy.

Palomaki[9] H et al. found that the incidence of stroke increases after 60 years of age10. The highest number of stroke patients in our study were found in the age group of 51- 60 years which was 31.3%.

Iemolo F[10], in his study, showed that females had less incidence of stroke. In his study, only 2.5% of stroke victims were females16. In this study, 63% of females had a stroke. Of 41 female patients, 26 are having a stroke in the current study.

Risk factors and stroke:

Carlene[11] et al. studied 188000 patients with hypertension, out of which 6800 had stroke events. In this study, out of the 102 patients, 54 patients had hypertension.
Diabetes mellitus is another risk factor for stroke.

Lindberg[12] Perth and Roine Risto had observed that two-thirds of all ischemic stroke types on admission had diabetes mellitus8.
In our study, out of 60 patients with stroke, 26 had diabetes mellitus.

Schulz[13] U. G. et al. studied family history of stroke and found that 23% of stroke patients had positive family history.
In our study, we didn't analyze the family history of stroke.

PSV:
Peak systolic velocity ratio found to be the best parameter for assessing stenosis as proved by Zwiebel William J in his studies.

NASCET[14] trial demonstrated that endarterectomy provides more benefit than the medical treatment in patients with 60% or 70% internal carotid artery stenosis. The endarterectomy trials established 60-70% diameter reduction as clinically significant levels of ICA stenosis.

Arbeille defined a peak systolic velocity(PSV) ratio of more than 1.8 as an indicator of stenosis of more than 60% and a ratio of 3.7 as an indicator of more than 80% diameter stenosis.
In our study, a ratio of more than 3 denotes – stenosis of more than 70%. The most typical cause for obstruction in our study was found to be atheromatous plaque. Schulte[15]Altedorneburg G et al found steno occlusive carotid lesion in 64% of the patients studied.

Side of the plaque:

In our study, 36(60%) out of 60 patients had plaque in the carotid system. 28 patients had plaque on the right side, 21 patients had plaque on the left side, and eleven patients had both vessels involved.
Zwiebel found that the carotid bifurcation was commonly involved by the atherosclerotic plaque followed by the origin of carotid arteries.

Vessel involved:
In our study common carotid artery was found to be the commonest site affected by the plaque. Carotid bulb was involved on the right side in 2 patients and on the left side in 2 patients.

Type of plaque:
Aburahma[16] Ali F, Wulu John T & Crotty Brad. found that soft and nonhomogeneous plaques are more related to symptoms.56. In our study uniformly hypoechoic plaque was found to be more common compared to other types.
Histological association was done in our study as surgery was not done for these patients. These patients were managed conservatively.

V.Conclusion

The present study evaluated carotid vessels in 102 patients withattributable neurological and vascular symptoms attending to the
departments of radiodiagnosis and neurology of NRI Medical College.
Of 102 patients examined, 60 patients showed carotid disease, and 42patients showed normal extracranial carotid vasculature.
The incidence of stroke was found to be more in patients with more age.The mean age of patients with stroke or cases is more than that ofpatients without stroke, as evident by the p-value.
The most common cause of carotid disease in our study isatherosclerotic plaques.
The highest incidence of carotid disease is in the age group of 50 to 60years. There are no patients aged below 20 years in our study.
Stroke is seen in 26 female patients out of 41 female patients. It is seenin 34 male patients among 61 male patients.
Stenosis of more than 40% is found in 20 patients. Stenosis of morethan 60% is seen in 14 patients.
Three patients had stenosis more than 70% in their vessels. There iscomplete occlusion in 3 patients.
Eleven patients showed bilateral vessel involvement.

In most the patients, the right side is commonly involved. In the current study, common carotid arteries are more commonly
involved than internal carotid arteries and carotid bulbs.
Regarding the morphology of plaque, type 1 is more common in GWclassification for plaques.
Among the risk factors smoking, hypertension, diabetes and IHD, all arefound to increase the risk of stroke.Takayasu's arteritis is more of a common carotid disease second toatherosclerosis in our study.
Chemodacterma and post traumatic aneurysms are found to be rare inthis study.
EDV greater than 70 cm/sec is noted in 3 patients.PDV ratio of more than three is seen only in 3 patients in the current
study.
We conclude that agreement of velocity parameters is essential forstenosis estimation and also, velocity parameters are of little use in subquantifying stenosis below 40%.
Colour Doppler sonography is a significant advancement in carotiddiagnosis. It is a non-invasive, cheaper, and faster modality forevaluating the extracranial course of carotid vessels.It is helpful in assessing the prognosis of transient ischemic attacks and
thrombo-embolic stroke patients and deciding the immediate(medical/surgical) line of subsequent management.
Duplex sonography with high-resolution imaging and doppler analysisproved to be a popular, non-invasive, reliable and inexpensive means ofdetecting and assessing extracranial carotid disease.
The study is self-sponsored
There are no conflicts of interest.
The research is self-funded.

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