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A STUDY ON PREVALENCE OF CAROTID ARTERY STENOSIS IN PATIENTS OF STROKE USING DOPPLER ULTRASOUND IN A TERTIARY CARE HOSPITAL IN NORTH KERALA

Nandu K.R, Jinu C.K, K.M Navas, V. Rajendren, C.K Vasu, Anoop K. and Farsana T.K.
Department Of Radiodiagnosis, Kmct Medical College, Mukkam, Calicut, Kerala, India.

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Abstract

Introduction: A stroke, also known as a cerebrovascular accident, is the sudden onset of a neurological deficit caused by a focal vascular cause. It is one of the leading causes of morbidity and mortality worldwide. Most cases of cerebrovascular disorders are caused by lesions of the extracranial carotid arteries, particularly the internal carotid artery near the bifurcation. To prevent or reduce morbidity and mortality from stroke, it is critical to provide early diagnosis and treatment. The primary reason for extracranial Doppler examination is stroke prevention. Colour Doppler sonography is a sensitive method for detecting atherosclerotic plaque and provides information on the extent and severity of the plaque as well as the resulting narrowing of the arterial lumen.

Aim And Objectives: To evaluate the role of carotid Doppler ultrasonography in patients presenting with acute ischemic stroke and to determine the association between carotid artery stenosis and risk factors such as diabetes mellitus, hypertension, hyperlipidemia, smoking and age.

Materials And Methods: The present study was conducted on 100 patients. MRI scan was done to diagnose acute ischemic stroke in patients who presented to emergency medicine with symptoms of acute ischemic stroke. Retrospectively CIMT and plaque characterization were done by gray scale ultrasound. Site and severity of stenosis were assessed on colour Doppler. All these findings were correlated with clinical presentation and risk factors. The collected data was statistically analyzed using SPSS 16.0 version software.

Results: A total of 100 patients were examined by color Doppler sonography and out of these 58 showed carotid artery disease. 26 patients had unilateral involvement while 32 patients had bilateral involvement of carotid vasculature. In our study 42% patients had normal ipsilateral ICA on color Doppler imaging. 5% patients total occlusion of ipsilateral ICA. 32% patients had <50% stenosis, 13% patients had 50-69% stenosis and 7% patients had >70% stenosis of ipsilateral side ICA.

Conclusion: Color Doppler examination is a non-invasive, cost-effective, safe, reproducible, and time-saving method of identifying the root cause of cerebrovascular insufficiency in the extracranial carotid artery system and will aid in determining the best management option.

Corresponding Author:-* **Nandu K. R., *Department Of Radiodiagnosis, Kmct Medical College, Mukkam, Calicut, Kerala, India.*

Introduction:-

Stroke or cerebrovascular accident is an emergency medical condition which is characterized by acute compromise of cerebral perfusion. According to the World Health Organization (WHO), it is the second leading cause of mortality and the fourth leading cause of morbidity worldwide. Stroke is responsible for millions of deaths in developing countries and is a major cause of morbidity and mortality in Asian countries like India. It is therefore critical to provide early diagnosis and treatment for stroke to prevent or minimize morbidity and mortality. The incidence of cerebrovascular accidents increases with age, and the number of stroke cases is projected to increase as the elderly population grows.

Approximately 75% of all strokes are ischemic in origin. Four-fifths are caused by atherosclerosis, and one-fifth is due to thromboembolism from the heart. Cerebral ischemia is caused by a reduction in blood flow that lasts several seconds or minutes. When blood flow to the brain is interrupted for more than 5 minutes, infarction of the brain tissue occurs. Atherosclerotic disease of the extracranial carotid arteries is the most common source of emboli causing ischemic stroke[1].

Age, cigarette smoking, alcohol consumption, hyperlipidaemia, hypercholesteremia, hypertension, diabetes mellitus, obesity, type A personality, insufficient physical activity, and newer risk factors such as homocysteine and lipoprotein (a), among others, all contribute to the formation of plaque and the subsequent narrowing of the vessel lumen. Furthermore, in symptomatic carotid artery disease, the degree of stenosis is strongly linked to the risk of cerebral infarction[2-4]. Therefore, proper assessment of carotid artery disease using various imaging modalities is of utmost importance.

Cerebral angiography is the gold standard diagnostic tool for the evaluation of carotid arteries. However, angiography has several disadvantages, such as its invasive nature, high cost, thromboembolic processes caused by intra-arterial catheter manipulation, puncture site hematoma formation, and allergic events to contrast medium. Furthermore, a recent review of prospective studies found that the risk of neurologic complications with cerebral angiography was around 4%, with severe neurologic complications or death being around 1% (range 0-5.7%). Carotid duplex ultrasound (CDUS), on the other hand, is a non-invasive, safe, and low-cost technique for assessing the extracranial carotid arteries and can provide anatomical and functional information about vessel stenosis[5,6].

CDUS employs B-mode and Doppler ultrasound imaging to detect a focal rise in blood flow velocity indicative of high-grade carotid stenosis. CDUS is less precise in determining stenosis of less than 50%, and its accuracy is largely operator dependent. The complex assessment of critical carotid artery stenosis attributable to low intrastenotic velocities with frequency-based sonography was improved using the power Doppler[7]. Different methods have been described to estimate the degree of CAS with CDUS.

Besides estimating the degree of stenosis, the major advantage of ultrasonography is its ability to identify and characterise plaque, which helps in identifying plaques with a higher risk of embolisation.

For patients with high-grade stenosis of the symptomatic internal carotid artery, the European Carotid Surgery Trial (ECST) and the North American Symptomatic Carotid Endarterectomy Trial (NASCET) have shown that carotid endarterectomy is the best treatment option. In such patients, carotid endarterectomy reduces the risk of stroke or death by approximately 75%.

Several research studies have been done to investigate the role of Doppler ultrasound in assessing carotid artery stenosis. However, only a few studies have investigated the topic from a South Indian perspective. In the present study, all patients presenting with neurologic deficits underwent Magnetic resonance imaging (MRI), and the diagnosis of acute ischemic stroke was made. These patients were then evaluated retrospectively using carotid Doppler ultrasonography to determine the prevalence of carotid artery stenosis. The association between carotid

artery stenosis and various risk factors such as diabetes, hypertension, hyperlipidemia, smoking, and age was evaluated using a detailed clinical history, laboratory investigations, and patient examination.

Material And Methods:-

This is a cross sectional study conducted in KMCT Medical College Hospital, Kozhikode, Kerala, India ,over a period of three years from 2021-2022. The study was carried out on 100 patients who had undergone the MRI stroke protocol for clinical signs and symptoms of stroke .Approval from institutional ethical and research committees and informed consent from all participants were obtained before starting the study.

The present study is aimed at assessing the prevalence of carotid artery stenosis in stroke patients using Doppler ultrasound. The study group consists of all adult patients who present with clinical symptoms of stroke and are diagnosed with ischemic stroke in the anterior circulation of the brain (as confirmed by MRI of the brain). Patients who suffered a stroke due to intracerebral hemorrhage and those who suffered stroke due to head injury were excluded from the study.

Detailed demographic and clinical histories were taken from each patient. This includes age, sex, and risk factors including hypertension, diabetes mellitus, smoking, peripheral arterial disease, and hyperlipidemia (serum cholesterol, triglyceride levels).

Colour Doppler criteria for evaluation of carotid artery atherosclerotic disease as per SRU consensus[8].

Carotid Colour Doppler Examination Technique

GE Logiq F6 ultrasound machine was used for the examination. This real time ultrasound equipment is capable of B-mode imaging, pulsed-wave duplex scanning, colour Doppler flow imaging and power Doppler imaging. The B/L carotid arteries were carefully examined for wall changes. The examination started with a transverse scan of the carotid arteries from as low in the neck as possible to as high in the neck as possible behind the angle of the mandible. Using the gray scale ultrasound imaging, three measurements of intima media thickness (IMT) of common carotid artery by evaluating the far walls & the mean value was recorded. An IMT value of more than or equal to 0.9 mm was considered abnormal. When the plaque was seen, the location and characterization of the plaque were assessed.

Areas of abnormal flow were identified with color Doppler and then a spectral Doppler examination was undertaken to determine peak systolic velocity (PSV) and end diastolic velocity (EDV), with measurements taken from the bilateral common carotid artery and internal carotid artery. In general, grayscale and color/power Doppler images are better at demonstrating and quantifying low-grade stenosis, whereas Doppler spectral analysis is more accurate in assessing high-grade stenosis. Only grayscale assessments without colour or power Doppler ultrasound can be performed for plaque characterization. The degree of stenosis was assessed using three types of data: direct measurement of the diameter of the stenosis, measurement of the diameter of the residual lumen, and the original diameter of the vessel. Other methods for evaluating ICA stenosis were peak systolic velocity at the level of stenosis and the ICA/CCA PSV ratio.The data was checked and entered into the statistical package for social science (SPSS) software, version 27, for the analysis of the data.

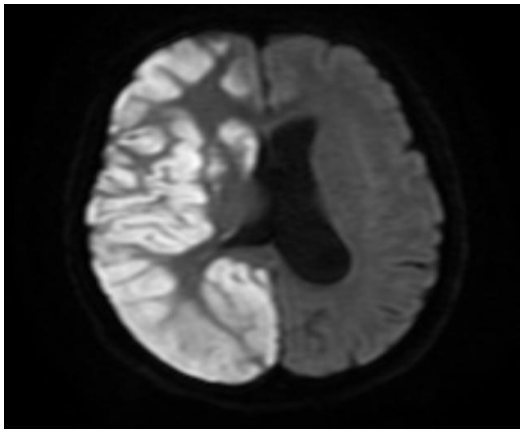

Figure 1:- Diffusion hyperintensity noted involving the right cerebral hemisphere with mass effect in the form of diffuse effacement of the extraventricular CSF spaces and the ipsilateral ventricular system – suggestive of acute malignant infarct.

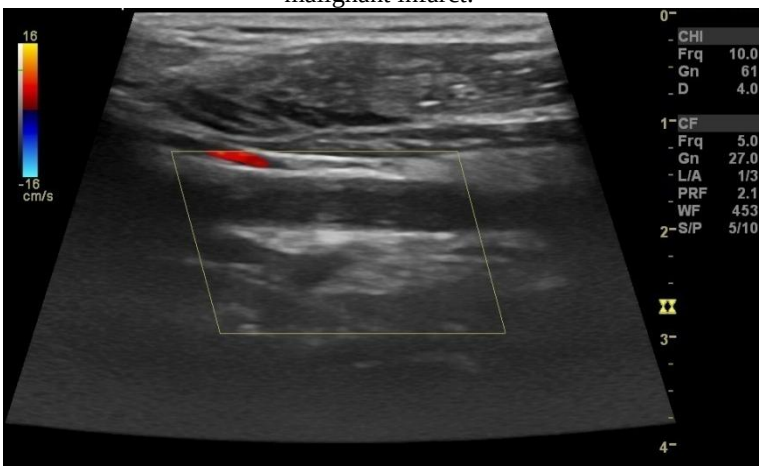

Figure 2:- On carotid Doppler evaluation, complete occlusion of the ipsilateral common and internal carotid artery was noted with no obvious color flow.

Results:-

A total of 100 patients were examined by color Doppler sonography and out of these, 58 showed carotid artery disease. 26 patients had unilateral involvement while 32 patients had bilateral involvement of the carotid vasculature. A detailed workup of these 100 patients was done; their clinical history and laboratory data were recorded. The results are tabulated and percentages calculated with representation in the form of pie diagrams and graphs for easy understanding.

Age distribution.

There were 60 men and 40 women among the 100 patients studied. The highest number of patients with carotid artery disease in our study was found to be in the age group of 60 to 70 years, which constituted 40% of the total number of patients with stroke. Minimum number of patients were seen in <40 age group (5%).

Table 1:- Age Distribution.

AGE GROUP	NUMBER OF PATIENTS
<40	5
41-50	8
51-60	22
61-70	40
70-80	20
>80	5

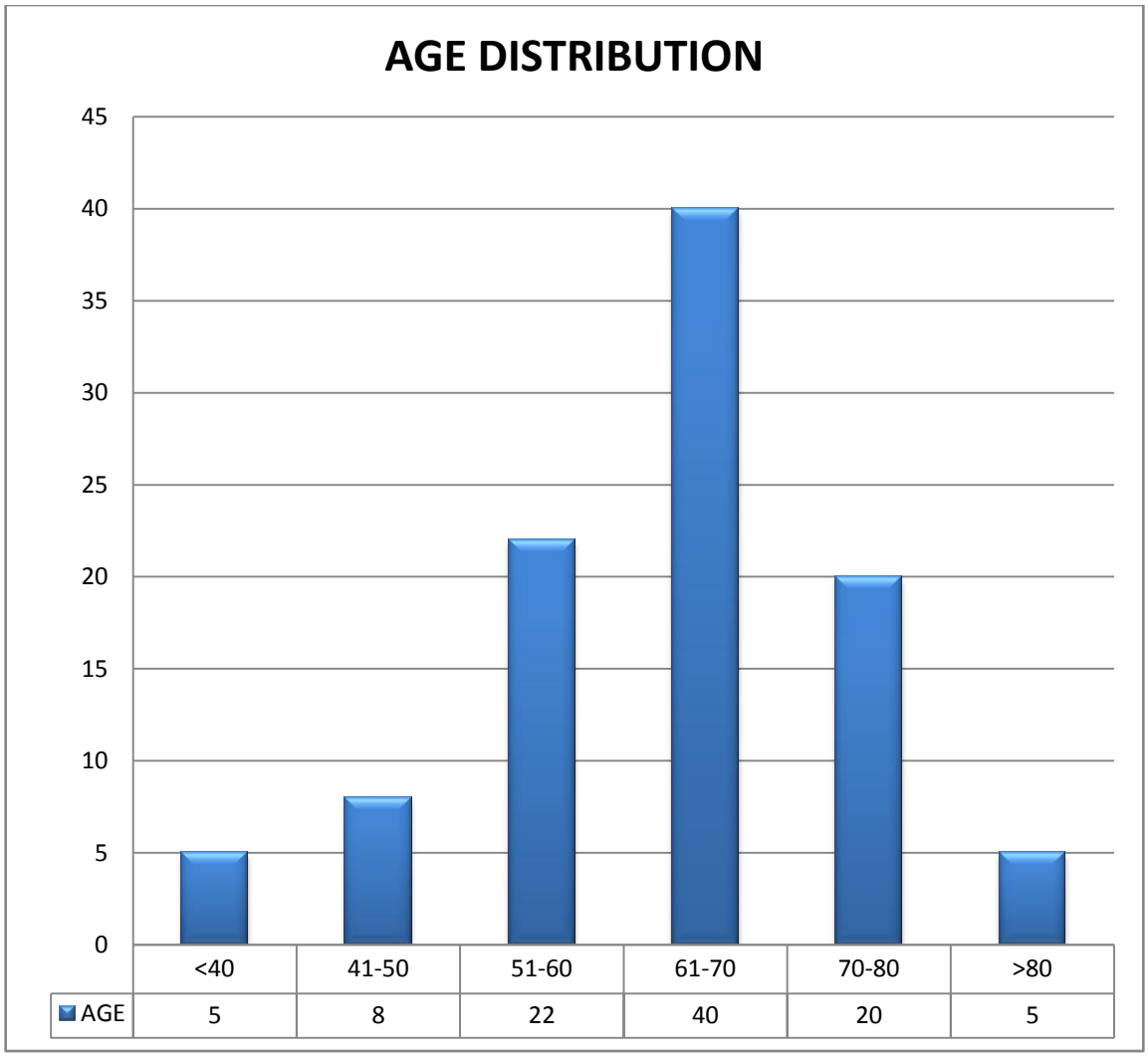

Figure 3:- Age Distribution.

Gender Distribution.

Table 2 and pie diagram (in figure no: 4) shows there is a slight male preponderance.

GENDER	NUMBER	PERCENTAGE
FEMALE	40	40.0
MALE	60	60.0
TOTAL	100	100.0

Table 2:- Distribution Based On Gender.

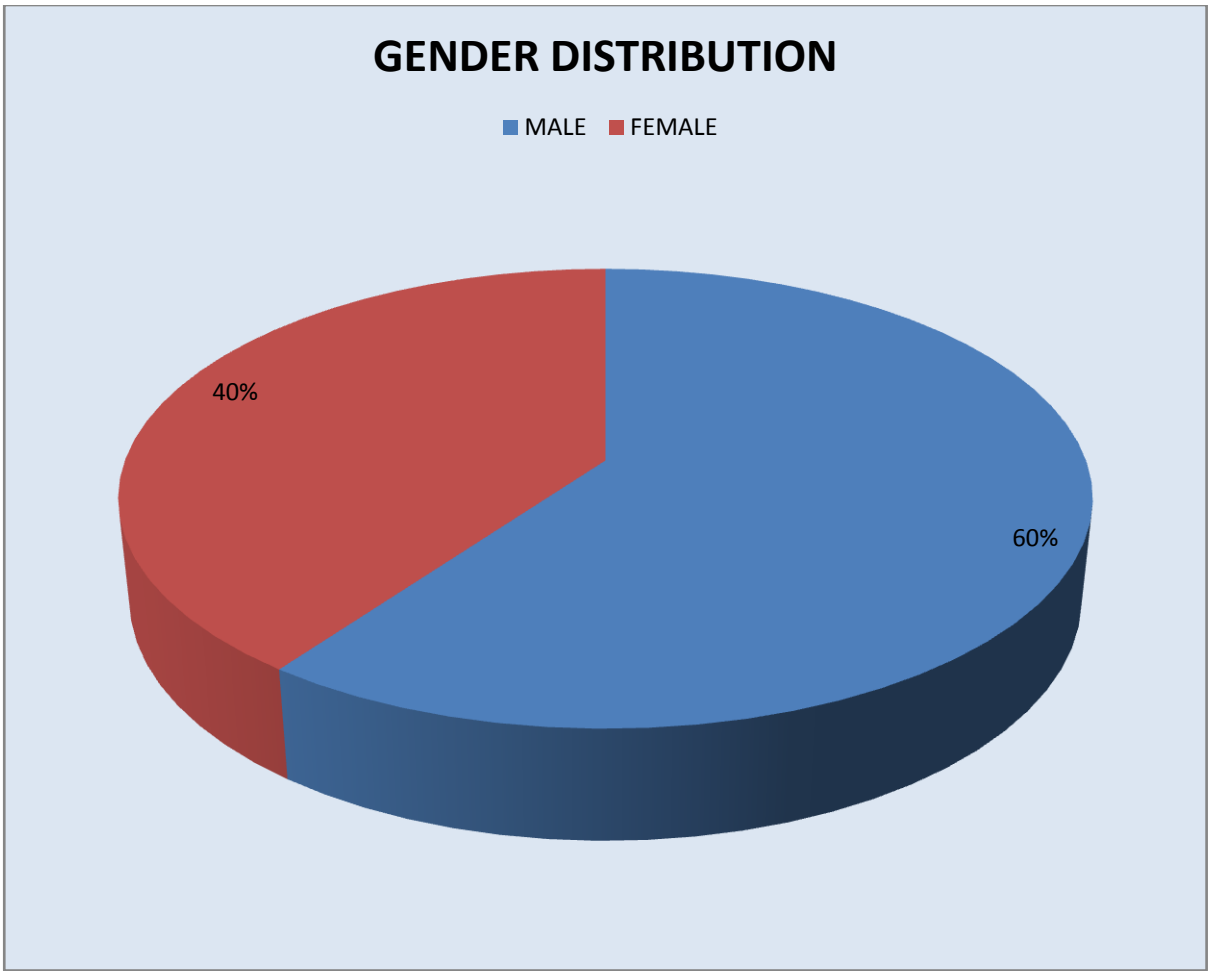

Figure 4:- Gender Distribution.

Side Of Carotid Artery Involvment

In our study, 58 percent patients with ischemic stroke demonstrated involvement of the carotid artery. Right sided involvement was seen in 14 patients, left-sided involvement in 12 patients and bilateral involvement was seen in 32 patients.

Table 3:- Side Of Carotid Involvement.

SIDE OF INVOLVEMENT	NO OF PATIENTS
RIGHT	14
LEFT	12
BILATERAL	32
TOTAL	58

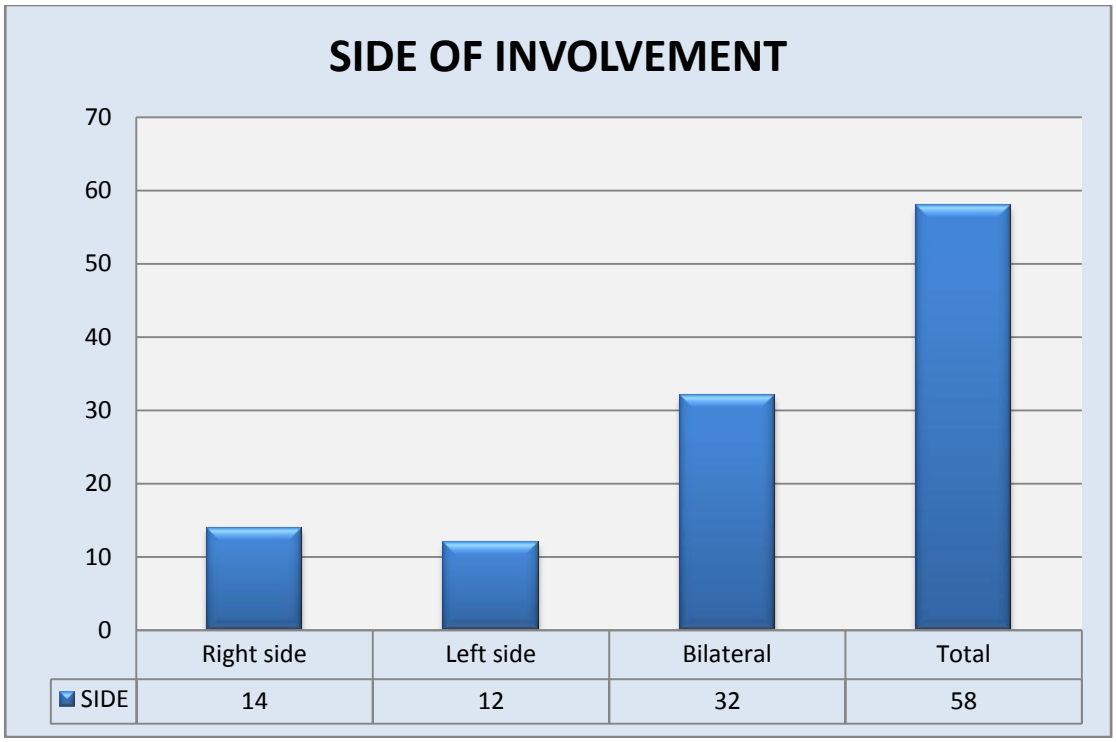

Figure 5:- Side Of Carotid Involvement.

In our study, 58 percent patients with ischemic stroke demonstrated involvement of the carotid artery. Right sided involvement was seen in 14 patients, left-sided involvement in 12 patients and bilateral involvement was seen in 32 patients.

MCA territory was most commonly involved in anterior circulation stroke.

Table 4:- MRI Scan Findings In Stroke Patients.

VASCULAR TERRITORY	NO. OF PATIENTS
Right MCA	28
Right ACA	11
Right MCA/ACA	7
Left MCA	37
Left ACA	8
Left MCA/ACA	5
BILATERAL	4
Total	100

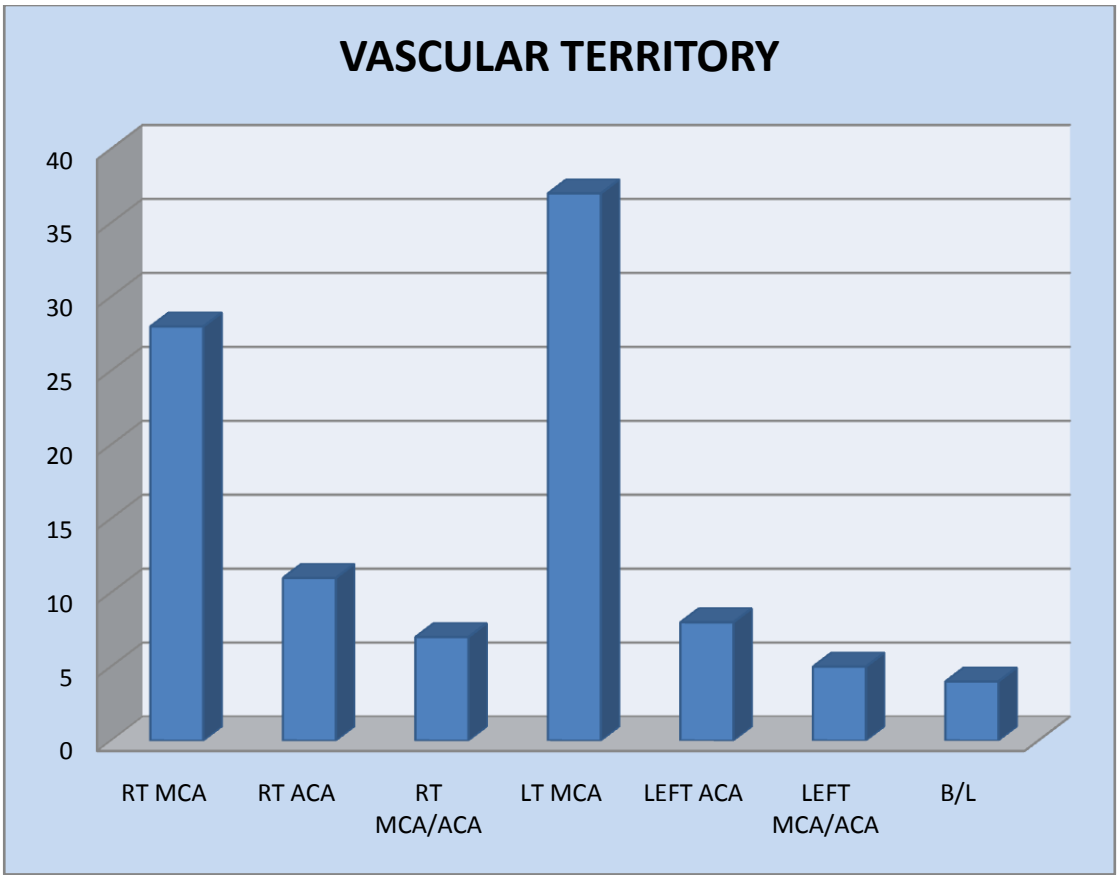

Figure 6:- MRI Scan Findings In Stroke Patients.

Sites Of Plaque Involvement

26 out of the 100 patients studied had unilateral disease, 32 had bilateral disease. Therefore a total of 90 vessels were showing disease. Maximum number of plaques was noted in the carotid bulb.

Table 5:- Sites Of Plaque Involvement.

PLAQUE LOCATION	NUMBER OF PLAQUES	PERCENTAGE
CCA	24	24.9
Carotid Bulb	37	38.1
CCA Bifurcation	14	14.4
ICA	22	22.6
Total	97	100

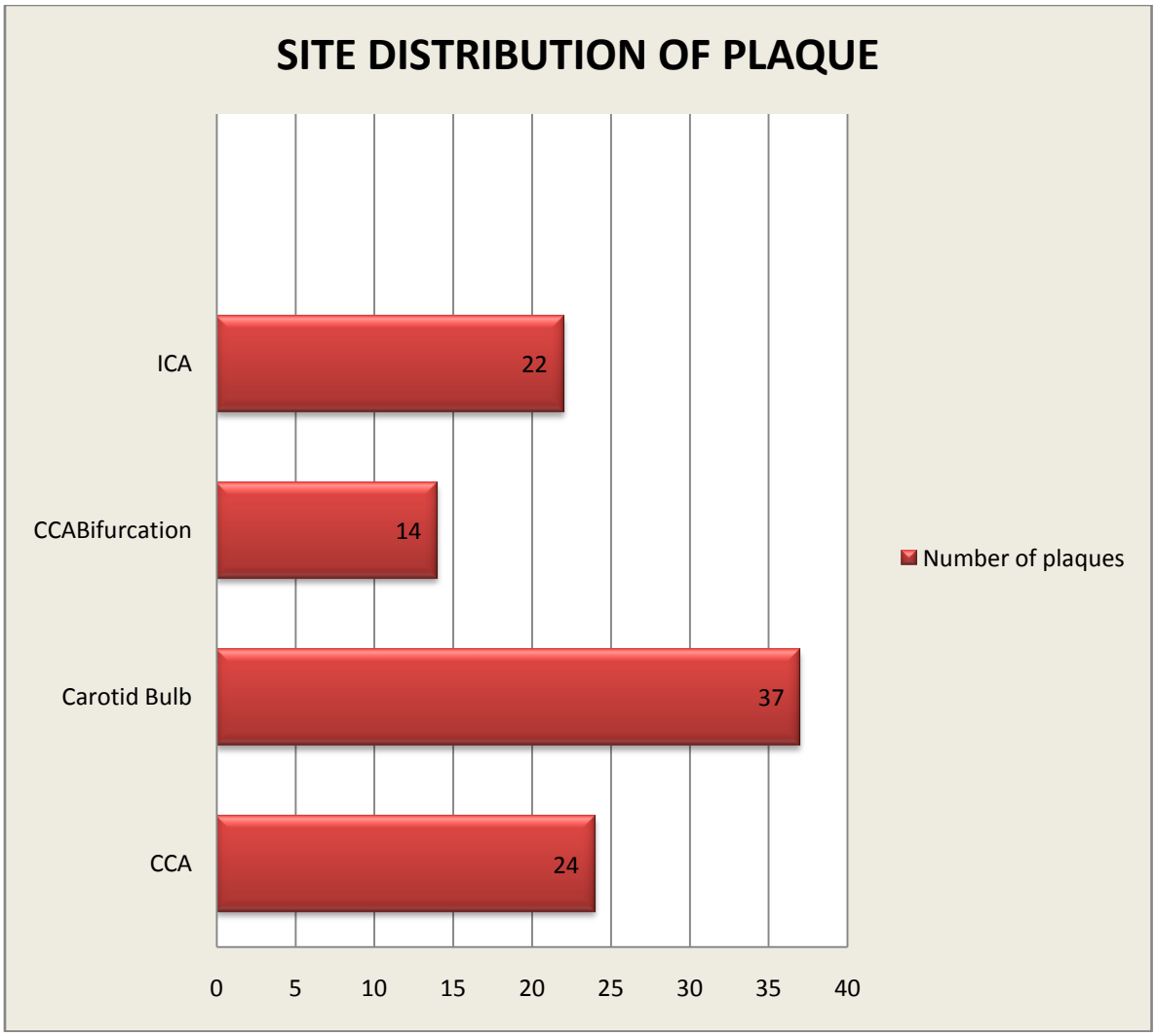

Figure 7:- Sites Of Plaque Involvement.

Plaque Characterization

Table 6:- Plaque Characterization.x

PLAQUE MORPHOLOGY	NO. OF PLAQUES	PERCENTAGE
Hypoechoic	15	16
Echogenic calcified	37	38
Echogenic	45	46
Total	97	100

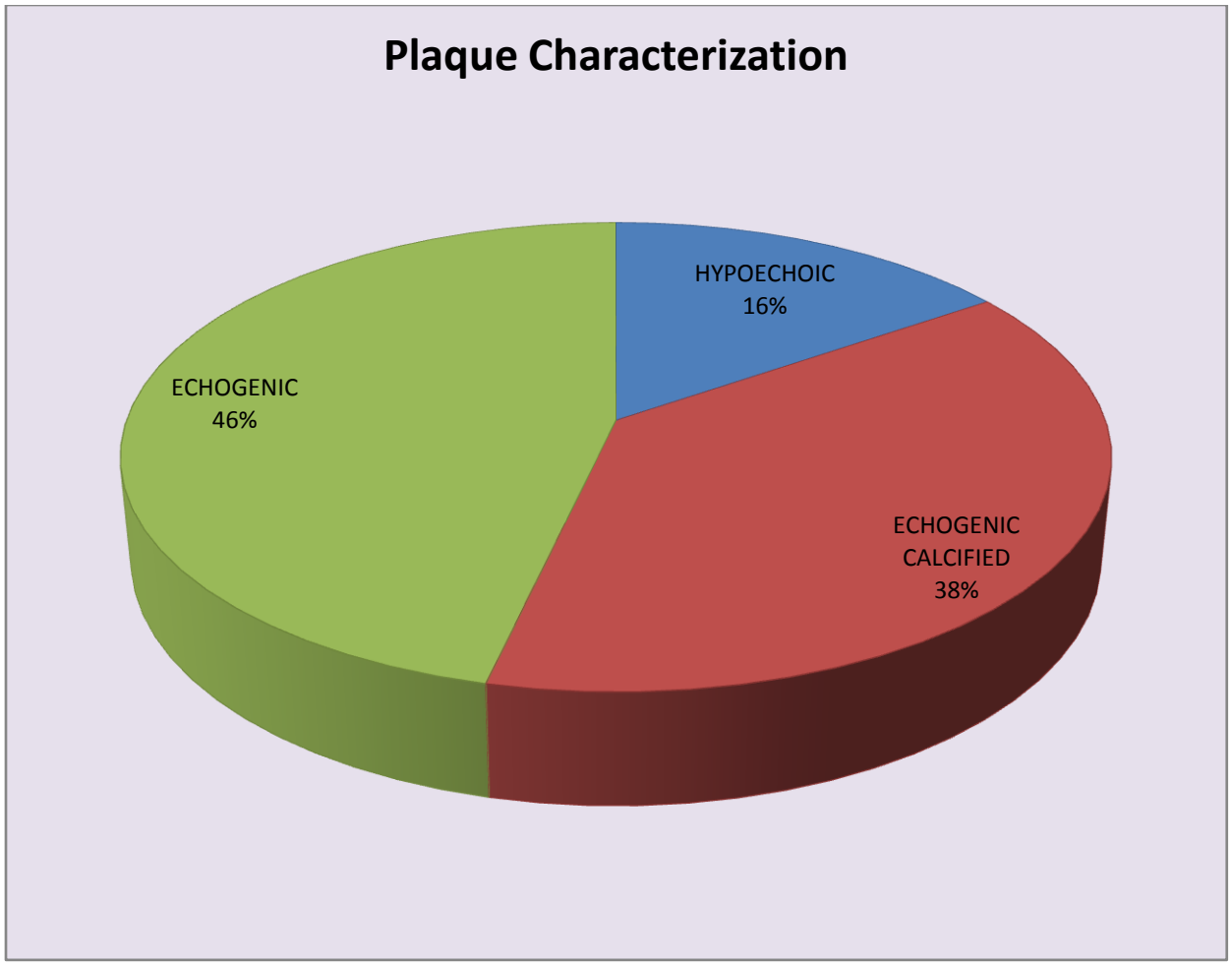

Figure 8:- Plaque Morphology.

Out of 97 carotid plaques studied, 15 were homogenously hypoechoic, 45 hyperechoic and 37 calcified. Homogenously hypoechoic plaques were associated with larger sized infarcts.

Intimal Media Thickness (IMT)

Bilateral common carotid arteries in the 100 patients in study group were evaluated. In our study Mean CA IMT in males was found to be 0.0942cm and mean CA IMT in females was 0.0825cm.

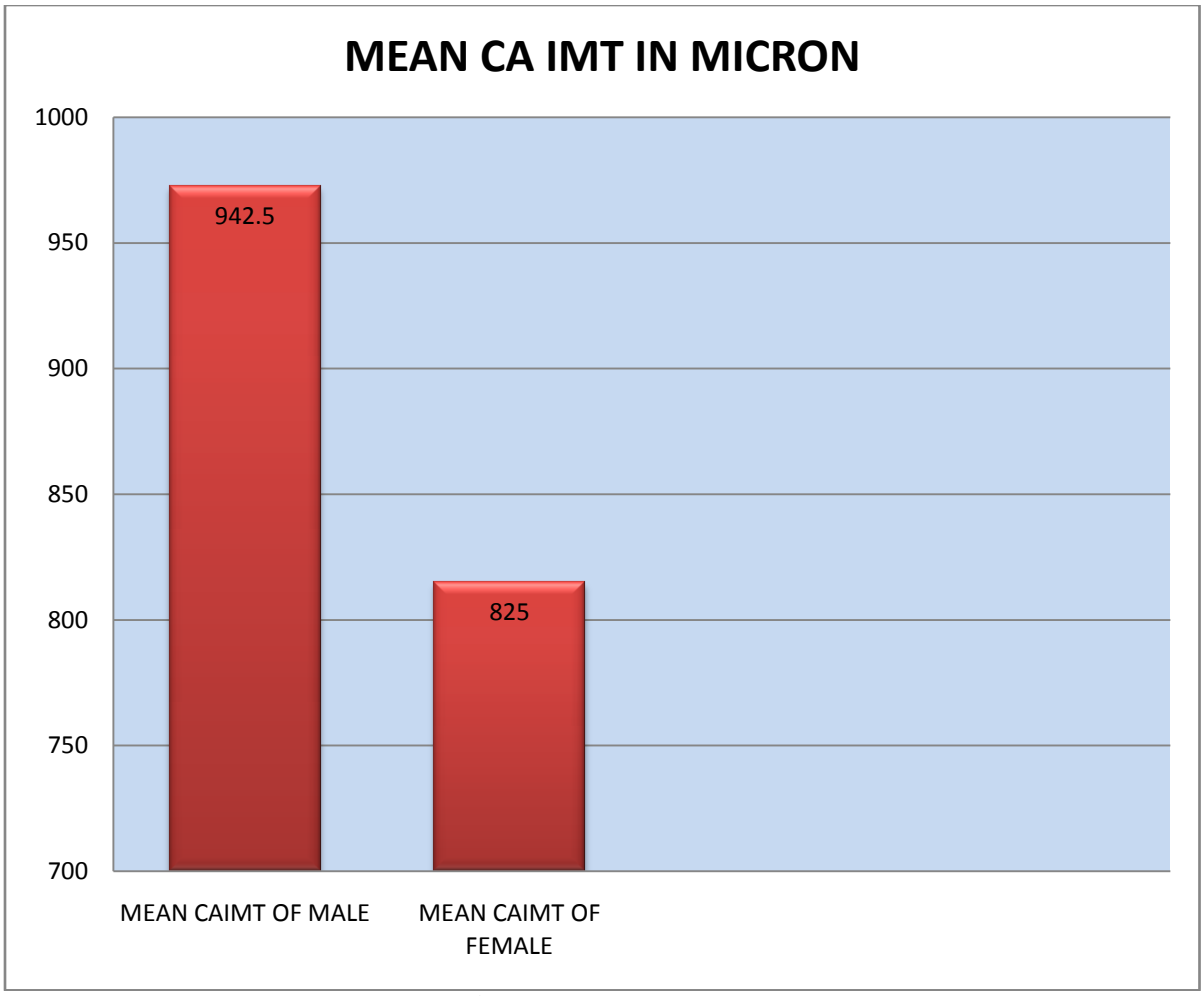

Figure 9:- Mean Ca Imt.

Table 7:- Intima Media Thickness.

IMT	Male	Female	Total
Less than 0.9	61	64	125
More than or equal to 0.9	59	16	75
Total	120	80	200

Out of 200 arteries evaluated, were 75 vessels had an IMT value of more than or equal to one.

Table 8:- Gender And CA IMT.

IMT(in mm)	MALE	FEMALE	TOTAL
<0.9	61	64	125
≥0.9	59	16	75

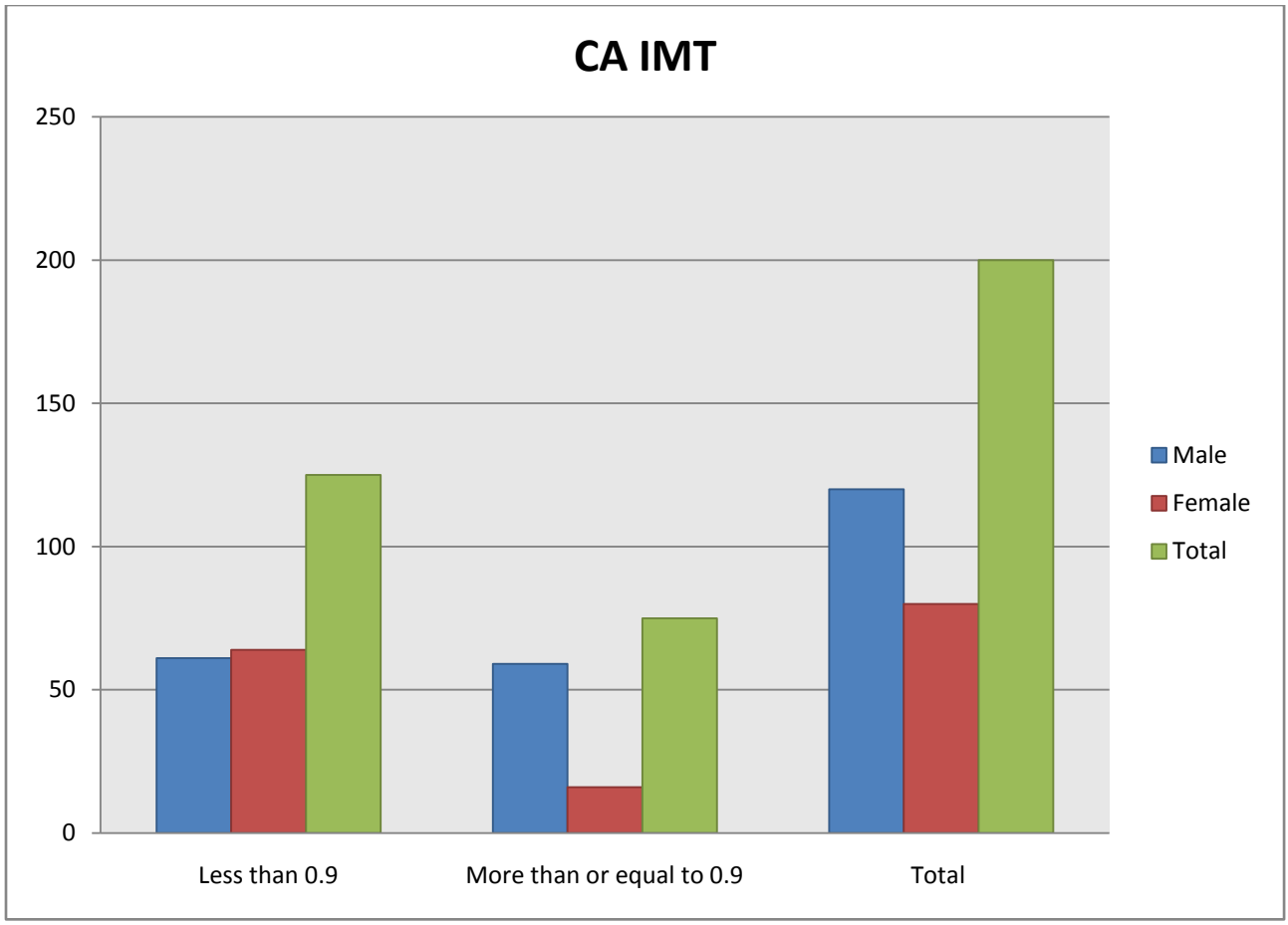

Figure 10:- Gender And Ca Imt.

Percentage Of Stenosis:
Bilateral internal carotid arteries in the 100 patients in study group were evaluated for assessing the presence and degree of stenosis.

Table 9:- Degree Of Ica Stenosis.

% OF STENOSIS	NUMBER OF PATIENTS
NORMAL	42
<50	33
50-69	13
>70	7
OCCLUSION	5

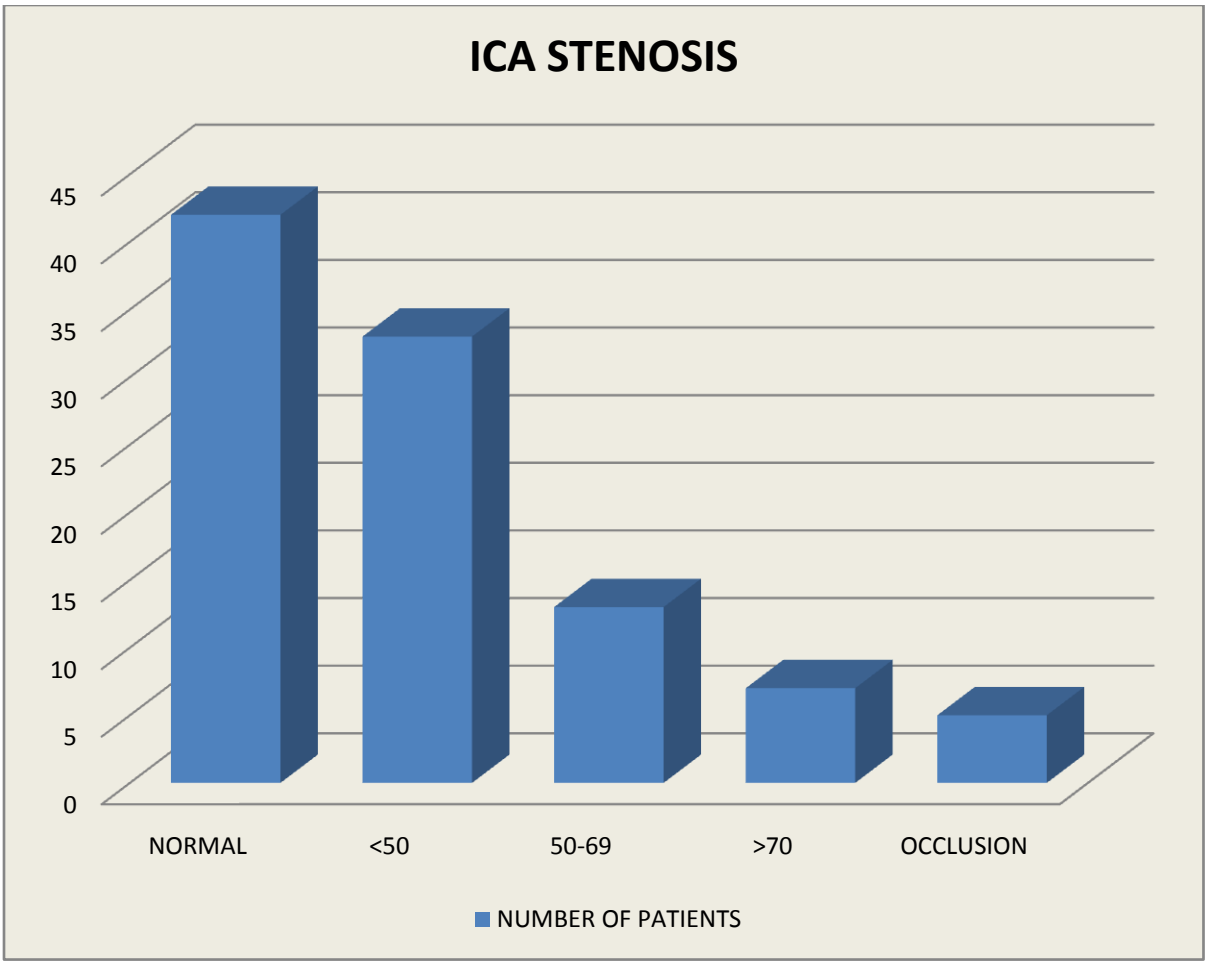

Figure 11:- Degree Of Ica Stenosis.

ICA Peak Systolic Velocity In Patients With Stenosis

Bilateral internal carotid arteries in the 100 patients in study group were evaluated. Peak systolic velocities of internal arteries were evaluated at the level of stenosis, in pre and post stenotic segments.

Table 10:- Peak Systolic Velocity.

PSV IN CM/S	NO OF PATIENTS
<125 cm/sec	33
125-230 cm/sec	13
>230	7
occlusion	5
TOTAL	58

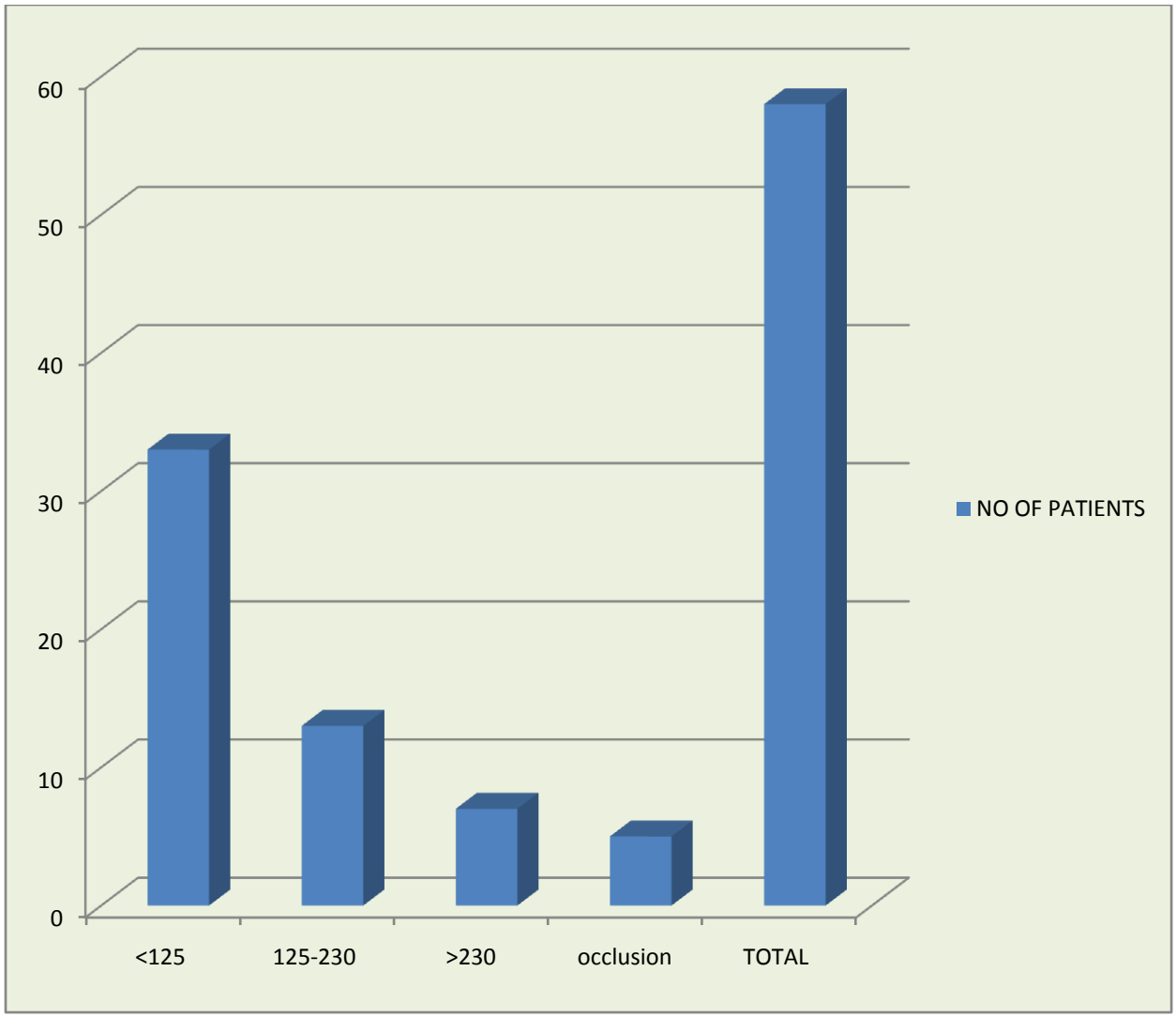

Figure 12:- ICA Peak Systolic Velocity.

Risk Factors:
Association of various risk factors like smoking, hypertension, diabetes mellitus and hypercholesterolemia with stroke and carotid artery involvement were assessed.

Table 12:- Risk Factors.

RISK FACTORS	NUMBER OF PATIENTS
HYPERTENSION	57
DM	43
DYSLIPIDEMIA	34
SMOKING	26

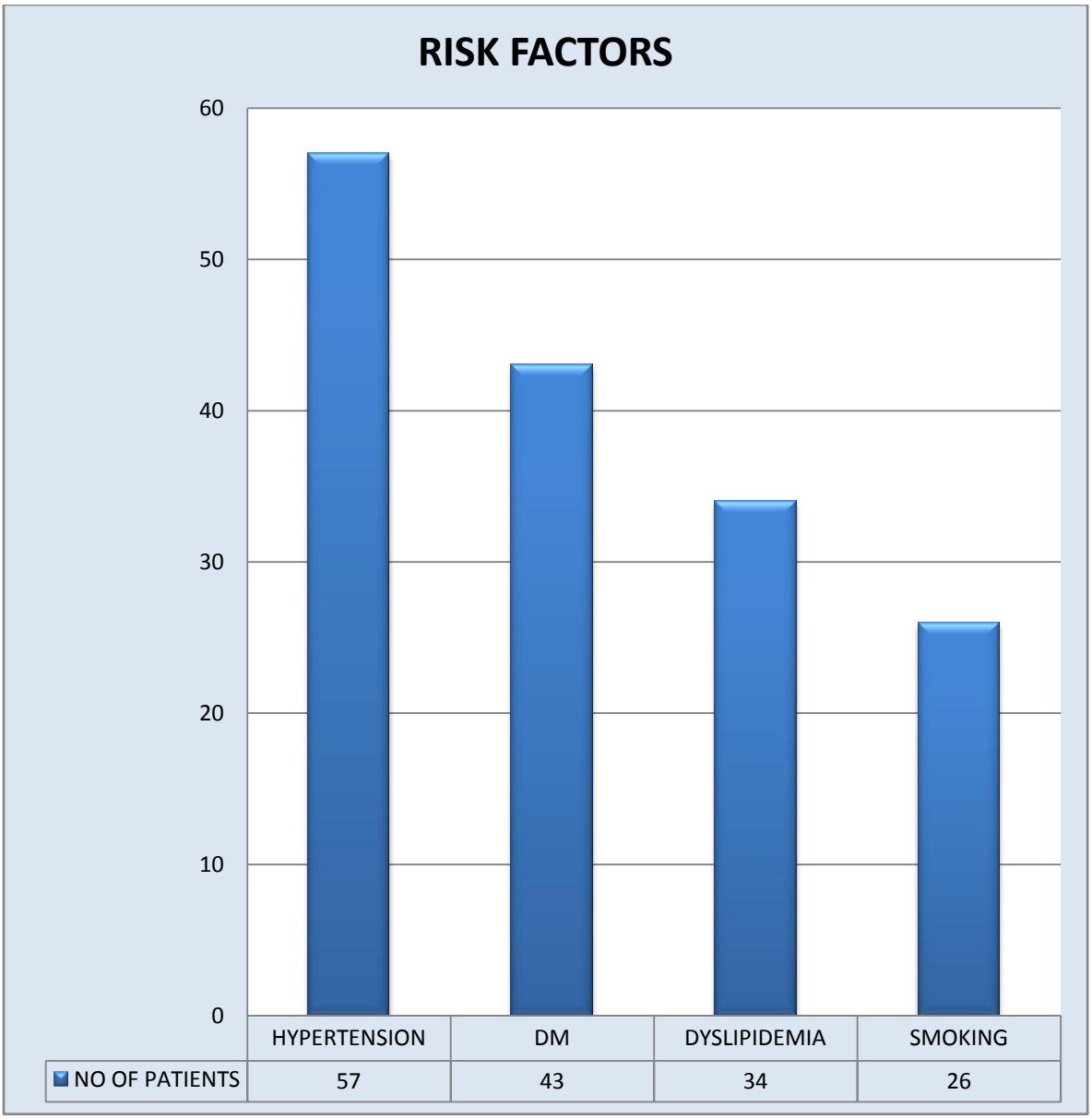

Figure 14:- Risk Factors In Stroke.

Relation Between Gender And Risk Factors

Table 13:- Gender And Risk Factors.

RISK FACTORS	MALE	FEMALE	TOTAL
HYPERTENSION	33	24	57
DIABETES	23	20	43
DYSLIPIDEMIA	25	9	34
SMOKING	26	0	26

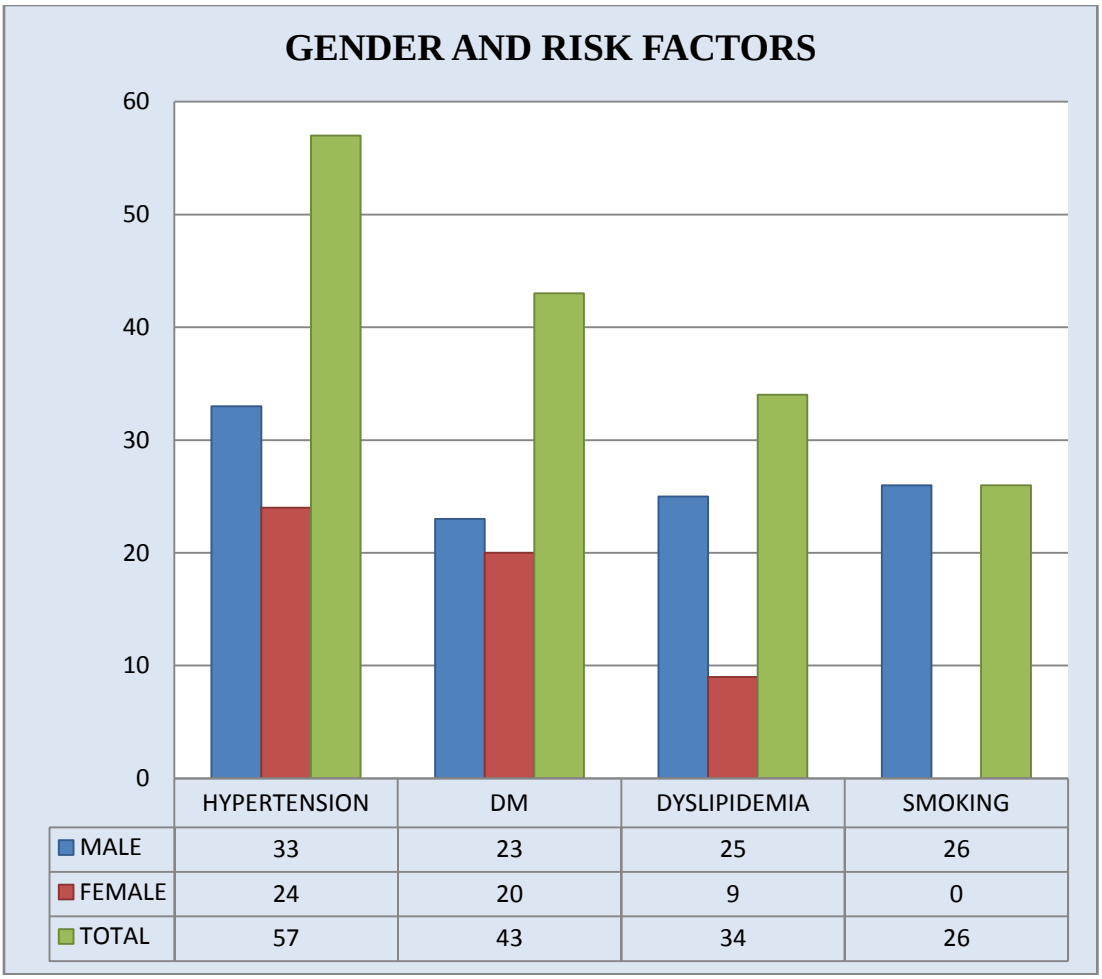

Figure 15:- Gender And Risk Factors.

Risk Factors And Carotid Stenosis

In our study of 100 patients, 57 were hypertensive, out of which 21 (36%) had significant carotid stenosis. Among the 43 patients who had diabetes mellitus, 11 (25%) had significant stenosis. 26 patients were chronic smokers, of whom 8 (30%) had significant stenosis. Out of 34 individuals with abnormal lipid profiles, 10 (29%) showed significant stenosis.

Table 14:- Risk Factors And Carotid Stenosis.

Risk factors	**Total patients having specified risk factors**	**Patients having >50% stenosis**
HYPERTENSION	57	21
DM	43	11
DYSLIPIDEMIA	34	10
SMOKING	26	8

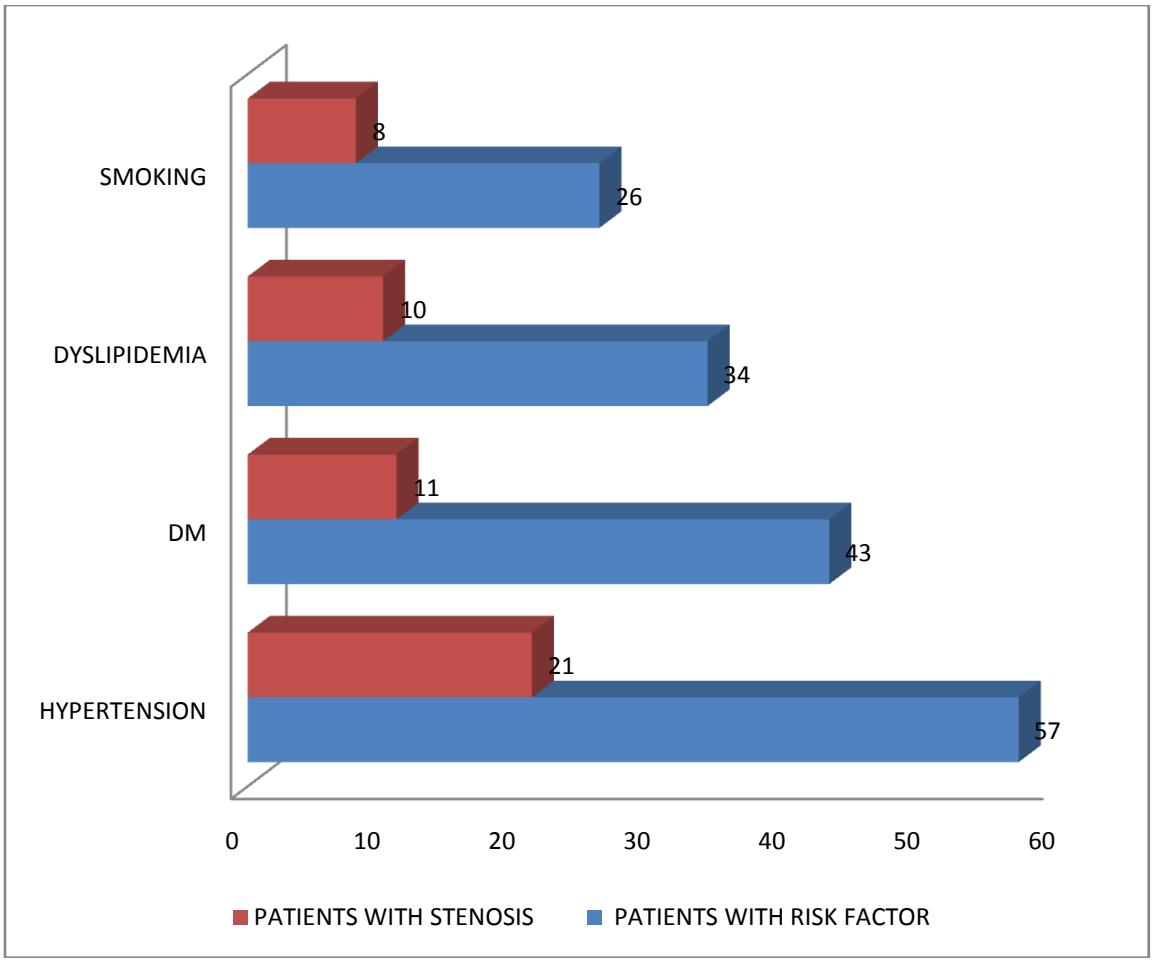

Figure 16:- Risk Factors And Carotid Stenosis.

Discussion:-

Cerebrovascular disease is one of the leading causes of death in developed countries. Atherosclerotic disease affecting the extracranial carotid arteries, typically within 2 cm of carotid bifurcation, is responsible for 30 to 60% of strokes. The benefits of carotid endarterectomy in patients with high-grade (>70%) carotid artery stenosis have already been proven in numerous large randomized studies[9] .

The identification of these patients with high risk of developing cerebrovascular accidents warrants for a precise, safe and relatively cost effective diagnostic tool to assess the degree of carotid artery stenosis. Angiography is still remaining the gold standard for preoperative evaluation of carotid stenosis, however it involves significant risk[10,11,12] to the patients and the incidence of intervention-related stroke ranges from 0.5% to 1.0%.

Ultrasonography is a unique vascular imaging procedure that can evaluate plaque composition. Characterization of plaque morphology has prognostic value and may be beneficial in the selection of medical and surgical therapy. It is often difficult to distinguish between complete and near-complete occlusions of the internal carotid artery (ICA). This analysis, on the other hand, is critical due to the significant implications for therapy and clinical outcome. Symptomatic patients are at high risk of embolic stroke as long as the ICA lumen is patent. The probability of an embolic stroke and the benefit of surgery are stratified according to the degree of stenosis.

The present study was done to evaluate the extracranial carotid arterial system in the population who presented in our hospital with ischemic stroke. Out of the 100 patients who was diagnosed with ischemic stroke, 46 patients had right sided stroke, 50 patients had left sided stroke. Bilateral involvement was seen in 4 patients.

An accurate distinction between complete occlusion of the internal carotid artery (ICA) from near-complete occlusion is often difficult. This analysis, however, is crucial because of the significant implications in therapeutic management and clinical outcome. Patent ICA lumen in symptomatic patients is at high risk for embolic stroke to develop. The risk of embolic stroke and the benefit of surgery stratify according to the degree of stenosis.

Mean Age Distribution:
Old age is a well-known and significant risk factor for the development of carotid artery stenosis. According to an Indian study conducted by Sethi[13] et al, the mean age of patients with carotid disease was 60.03 years, compared to 48.83 years in patients without carotid disease.

Palomaki[14] H et al. investigated the risk factors for cervical atherosclerosis in patients with ischemic stroke and transient ischemic attack and concluded that the risk of stroke rises after the age of 60.

In our study of 100 patients with a mean age of 63.48 (range 33-90 years) 40% were in the age group 61-70 years, followed by 51-60 years age group (22%). Minimum number of patients were seen in <40 age group (5%).

Sex Distribution:
Iemolo[15] F et al. in his study showed that only 2.5% of stroke victims were females. In this study 60% of the patients (60/100) were males and only 40% were females (40/100).

Table 15:- Sex distribution comparison in our study and other studies.

	GRYoung et al	MR Patel et al	Borisch et al	Our study
Male	49/70 (70%)	58/88 (65.9%)	32/39 (82.1%)	**60/100 (60%)**
Female	21/70 (30%)	30/88 (34.1%)	7/39 (17.9%)	**40/100 (40%)**
Mean Age (yrs.)	62	70	67.4	**63.48**

In a study conducted by Borisch[16] et al, out of 39 patients, 32(82.1%) were men; 7(17.9%) were women and with a mean age of 67.4. GR Young[17] et al. studied 70 patients; the distribution of male patients was 70% while females were 30%. MR Patel[18] et al. studied 88 patients, out of which 65.9% were male and 34.1% were female.

Site Of Plaque
Out of 100 patients, 58% had plaque in the carotid arterial system. We evaluated 97 plaques distributed in the carotid arterial system of these 58 patients. 14 patients had plaque on the right side, 12 patients had plaque on left and 32 patients had bilateral involvement.

Atherosclerotic plaque is the most frequent cause for carotid arterial stenosis. Schulte Altedorneburg[19] G et al found occlusive carotid lesions in 64% of the patients studied which was confirmed with postmortem studies.

Plaques seen on carotid ultrasonography were classified in a number of ways in previous studies. We took into account the plaque's location, morphology, and characteristics in the current study. The presence of plaque characteristics such as echogenicity and calcification was evaluated. The majority of the plaques in this study were echogenic. In our study, carotid bulb was the most common location for plaque formation, which was consistent with the findings of Sethi SK[13] et al. and Petrovic S[20] et al.

The reason for the increased number of plaques is attributed to the sudden and rapid change in the velocity and direction of blood in the bulb region, causing an increase in stress on the arterial walls and thus a greater propensity for damage[21]. Out of 97 plaques studied, the most common location was carotid bulb (38.1%) followed by common carotid artery (24.9%).

Abu rahma Ali F, Wulu John T & Crotty Brad[22] have confirmed that soft plaques and non-homogeneous plaques are more positively correlated with symptoms than with any degree of stenosis and were the cause of adverse neurological events. In our study out of the all the carotid vessels evaluated, 97 plaques were encountered, out of

which 15 plaques (16%) were homogenously hypoechoic in morphology. 45 plaques were hyperechoic (46%) and 37 plaques were hyperechoic and calcified.

Carotid Artery Involvement

Rukhsana[23] et al in a study on carotid Doppler ultrasound on patients with ischemic stroke found that 56% of patients had involvement of the carotid arteries (right, left or both).In our study, 58 % patients with ischemic stroke demonstrated involvement of the carotid artery. Right sided involvement was seen in 14 patients, left sided involvement in 12 patients and bilateral involvement was seen in 32 patients.

Carotid Artery Intima Media Thickness (CA IMT):

CA IMT is related to adaptive hypertrophy of the media layer and not a true representation of an atherosclerotic lesion[24]. The normal intima-medial thickness[25] of common carotid artery as evaluated by B-mode ultrasound imaging was 0.74 ± 0.14 mm.

Increased CA IMT may be characterized by fatty streaks, composed of foamy macrophages that appear non-raised in the arterial lumen. In contrast, "pathologic intimal thickening" refers to increased CIMT, which is the initial sign of progressive atherosclerosis[26]. The current study used 0.08 cm as a cut-off value for increased CA IMT. In present study, mean CIMT in males 0.094±0.034 and in females 0.082±0.027 .This difference in CIMT was statistically significant[27,28] (p-value<0.05).

Table 16:- Comparison of CIMT of current study with previous studies.

Study	Mean CIMT males	Mean CIMT females
Vicenzini E et al.	Right (R) 0.98±0. 18 Left (L)1.02±0.21	R 0.90±0.18 L 0.92±0.19
Riccio SA et al.	Overall 0.88±0. 15	Overall 0.84±.20
Present study	Overall 0.094±0.034	Overall 0.082±0.027

Risk Factors

In his study, MR Patel et al. reported various risk factors for atherosclerotic disease as hypercholesterolemia (47%), hypertension (73%), diabetes mellitus (35%), and smoking (64%).In our study, out of 100 patients, 57 had hypertension, 43 had diabetes mellitus and 34 had hypercholesterolemia.

Iadecola[29] et al proved in their study that control of blood pressure leads to a significantly reduces risk of stroke. Lawes[30] et al. studied 188,000 hypertensive patients, 6800 of whom had strokes. In our study, of the 100 patients, 57 patients were hypertensive out of which 21 (36%) had carotid artery stenosis of over 50%.

There is a positive relationship between smoking and stroke risk. An earlier study estimated that smoking[31] was responsible for 22% of all strokes. Our study included 26 patients with a smoking history of more than ten years. Of them, 8 (30%) had significant stenosis.

Another risk factor for atherosclerosis is diabetes mellitus. A study conducted by Lindsberg and Roine[32] observed that two-thirds of all ischemic stroke types on admission had diabetes mellitus. In this study, 43 patients had diabetes mellitus, of which 11 (25%) had significant stenosis.

Multiple researches[33] indicate that higher total and low-density lipoprotein (LDL) cholesterol levels are linked to an increased risk of ischemic stroke. In our study, of the 100 patients, 34 had an abnormal lipid profile, of whom 10 (29%) had significant stenosis.

Cardiac diseases were ruled out in our patient since they interfere with the velocity profiles of the carotid system. A diminished cardiac output will reduce both systolic and diastolic velocities.

Assessment Of ICA Stenosis

In literature different authors assert that three major Doppler parameters. i.e. peak systolic velocity(PSV), end diastolic velocity(EDV) and peak systolic velocity ratio are the most accurate predictors of clinically significant ICA stenosis. Peak systolic velocities, which are not well defined because of physiological variability and obstructive lesions, were originally defined for predicting the degree of stenosis. Peak systolic velocity ratio has been shown by Zwiebel William J in his tests to be the best for measuring stenosis since a ratio account for patient to patient physiological variability as well as instrument variability.

Cheng SF[34] et al did a prospective observational study for one year from 2014 to 2015 in a total of 2707 patients out of whom 1444 were diagnosed with ischemic stroke/TIA. Carotid stenosis of at least 50 % was seen in 238 patients (prevalence 19.0 %). From this study they concluded that carotid artery stenosis is common, affecting one in five patients presenting with stroke or TIA. Kelash Kumar[35] et al (2016)observed in their study that frequency of significant carotid artery stenosis (≥ 50% stenosis) on Doppler ultrasound in recent ischemic stroke patients is 27.7%. Regarding the degree of stenosis, 15.2% cases had 50 to 69%, 10.3% had 70 to 95% and 2.2% had above 95% stenosis. Khangure SR[36] et al conducted a retrospective study between 2007 and 2015 concluded that near-occlusions frequently have high PSV across the stenosis.

ICA/CCA PSV ratio is a good predictor of arterial stenosis. ICA/CCA PSV ratio of >2 is an indicator of 50% or greater and a ratio of >4 is an indicator of more than 70% diameter stenosis. It has been found that the ratio is more accurate than PSV. Samrin Haq[37] et al conducted a hospital based prospective study in Rajindra Hospital Patiala, Punjab, India, in 50 patients who presented with acute ischemic stroke over a period of three years from 2010-2013 to assess the role of carotid Doppler ultrasonography in patients presenting with acute ischemic stroke. From this study, they concluded that on carotid Doppler, the ICA/CCA PSV ratio was a good predictor of stenosis and a ratio > 3 indicated significant stenosis (> 60%).

Shaalan[38] WE et al reviewed the results of duplex ultrasound imaging in 1093 patients from 2004-2006. From this study, they came to the view that a significantly higher PSV (155cm/sec) was more accurate for detecting ≥ 50% bulb ICA stenosis compared to established velocity thresholds commonly applied in practice. Combined parameters of PSV ≥155 cm/s and ICA/CCA ratio of 2 have excellent predictive value for this stenosis category.

CE Withers[39] et al in their study they deduced that sensitivities and specificities were highest when peak ICA velocity was used as criteria in quantifying the degree of ICA stenosis.

In our study, 42% patients had normal ipsilateral ICA on color Doppler imaging. The percentages of ipsilateral carotid artery stenosis in the current study were: total occlusion (5%), less than 50% stenosis in 32%, 50–69% stenosis in 13% and more than 70% stenosis in 7% of patients. This was confirmed by using the assessment of diameter stenosis, ICA PSV and ICA/CCA PSV ratio criteria.

Conclusion:-

1. The study was done with an aim to assess the role of Doppler ultrasound in evaluating the prevalence of carotid artery stenosis in stroke patients .100 patients were included in the colour Doppler study examination and the conclusions arrived are:
2. The highest incidence of stroke was found in the age group of 61–70 years (40%), with male predominance.
3. The various risk factors included age, hypertension, diabetes mellitus, smoking and family history.
4. A strong association of hypertension in the pathogenesis of carotid artery atherosclerosis and stenosis was established, as out of 100 patients, 57% were hypertensive and 36 percent of them had moderate to severe stenosis.
5. Atherosclerotic plaques were seen in 58% patients, majority (46%) being echogenic in morphology. Echolucent plaques comprise nearly one-sixth (16%) of total plaques.
6. We conclude from our study that color Doppler examination is a non-invasive, cost-effective, safe, reproducible, and time-saving method of identifying the root cause of cerebrovascular insufficiency in the extracranial carotid artery system and will aid in determining the best management option.
7. The study demonstrated atherosclerosis as the most common cause of carotid artery disease leading to stroke.

8. The present study also highlights the importance of Doppler sonography in stroke patients through surveillance of various risk factors that can predispose to cerebral ischemia.

References:-

1. Eliasziw M, Kennedy J, Hill MD, Buchan AM, Barnett HJM. Early risk of stroke after a transient ischemic attack in patients with internal carotid artery disease. Can Med Assoc J. 2004; 170:1105-9.
2. Staikov IN, Arnold M, Mattle HP, Remonda L, Sturzenegger M, Baumgartner RW, Schroth G. Comparison of the ECST, CC, and NASCET grading methods and ultrasound for assessing carotid stenosis. European Carotid Surgery Trial. North American Symptomatic Carotid Endarterectomy Trial. J Neurol. 2000;247:681–686.
3. North American Symptomatic Carotid Endarterectomy Trial Collaborators. Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. N Engl J Med. 1991; 325:445–453.
4. European Carotid Surgery Trialists' Collaborative Group. MRC European Carotid Surgery Trial: interim results for symptomatic patients with severe (70–99%) or with mild (0–29%) carotid stenosis. Lancet. 1991; 337:1235– 1243.
5. Strandness DE, Eikelboom BC. Carotid artery stenosis—where do we go from here?. Eur J Ultrasound. 1998; 7: 17-26.
6. PolakJF, O'Leary DH, Kronmal RA, Wolfson SK, Bond MG, Tracy RP et al. Sonographic evaluation of carotid artery atherosclerosis in the elderly: relationship of disease severity to stroke and transient ischemic attack. J Radiology. 1993;188: 363-70.
7. Hood DB, Mattos MA, Mansour A, Ramsey DE, Hodgson KJ, Barkmeier LD, Sumner DS. Prospective evaluation of new duplex criteria to identify 70% internal carotid artery stenosis. J Vasc Surg. 1996;23:254–261.
8. Grant EG, Benson CB, Moneta GL, et al. Carotid artery stenosis: gray-scale and Doppler US diagnosis—Society of Radiologists in Ultrasound Consensus Conference. Ultrasound Q 2003;19(4): 190 –198.
9. Executive Committee for the Asymptomatic Carotid Atherosclerosis Study. Endarterectomy for asymptomatic carotid artery stenosis. JAMA 1995;273:1421–1428)
10. Heiserman JE, Dean BL, Hodak JA, et al. Neurologic complicationsofcerebralangiography.AmJNeuroradiol1995;16:1382–1383
11. Grzyska U, Freitag J, Zeumer H. Selective cerebral intraarterial DSA: complication rate and control of risk factors. Neuroradiol 1990;32:296–299
12. Waugh JR, Sacharias N. Arteriograhic complications in DSA era. Radiology 1992;182:243–246.
13. 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 J Radiol Imaging. 2005;5: 91-8.
14. Palomäki H, Kaste M, Raininko R, Salonen O, Juvela S, Sarna S. Risk factors for cervical atherosclerosis in patients with transient ischemic attack or minor ischemic stroke. Stroke. 1993 Jul;24(7):970-5.).
15. Iemolo F, Martiniuk A, Steinman DA, Spence JD. Sex differences in carotid plaque and stenosis. Stroke. 2004;35:477–81.
16. Borisch, Ingitha, et al. "Preoperative evaluation of carotid artery stenosis: comparison of contrast-enhanced MR angiography and duplex sonography with digital subtraction angiography." American journal of neuroradiology 24.6 (2003): 1117-1122.
17. Young GR, Humphrey PRD, Shaw MDM, Nixon TE, Smith ETS. Comparison of magnetic resonance angiography, duplex ultrasound, and digital subtraction angiography in assessment of extracranial internal carotid stenosis. J NeurolNeurosurg Psychiatry 1994; 57:1466–1478
18. Mahesh R. Patel, MD; Karen M. Kuntz, ScD; Roman A. Klufas, MD; Ducksoo Kim, MD; Jonathan Kramer, MD; Joseph F. Polak, MD; John J. Skillman, MD; Anthony D. Whittemore, MD; Robert R. Edelman, MD K. Craig Kent, MD Preoperative Assessment of the Carotid Bifurcation Stroke. 1995;26:1753-1758.
19. Schulte Altedorneburg G; Droste DW, FelszeghySzabolcs et al : "Detection of carotid artery stenosis by invivo duplex ultrasound": Stroke 2002; 33(10): 2402.
20. Petrovic S, Petrovic D, Rancic Z, Zivkovic M, Bojanovic A, Budjevac D. The significance of colour doppler sonography in selection of patients for carotid endarterectomy. Acta Fac Med Naiss. 2006;23(1):31-38.
21. Lenzi GL, Vicenzini E. The ruler is dead: an analysis of carotid plaque motion. Cerebrovasc Dis. 2007;23:121–25.
22. AbuRahma AF, Wulu Jr JT, Crotty B. Carotid plaque ultrasonic heterogeneity and severity of stenosis. Stroke. 2002 Jul 1;33(7):1772-5.

23. Rukhsana NH, Awan KH, Iqbal N. Frequency of carotid artery stenosis in ischemic stroke by using carotid doppler ultrasonography in a teaching hospital. Gomal J Medical Sciences. 2009; 7:82-5.
24. Touboul PJ, Hennerici MG, Meairs S, Adams H, Amarenco P, Desvarieux M, et al. Mannheim intima-media thickness consensus. Cerebrovasc Dis. 2004;18(4):346–49.
25. Mohan V, Ravikumar R, Shanthi Rani S, Deepa R. Intimal medial thickness of the carotid artery in South Indian diabetic and non-diabetic subjects: The Chennai Urban Population Study. Diabetologia. 2000;43:494–9.
26. Wannarong T, Parraga G, Buchanan D. Progression of carotid plaque volume predicts cardiovascular events. Stroke. 2013;44(7):1859–65.
27. Riccio SA, House AA, Spence JD, Fenster A, Parraga G. Carotid ultrasound phenotypes in vulnerable populations. Cardiovascular Ultrasound. 2006;4:44.
28. Vicenzini E, Ricciardi MC, Puccinelli F, Altieri M, Vanacore N, Piero TD, et al. Common carotid artery intima-media thickness determinants in a population study. J Ultrasound Med. 2007;26:427-32
29. Iadecola Costantino, Gorelick Philip B : " Hypertension, angiotension and stroke:Beyond blood pressure" : Stroke2003 Feb; 35(2): 348-350
30. Lawes CM, Bennett DA, Feigin VL, Rodgers A. Blood pressure and stroke: An overview of published reviews. Stroke 2004; 35:1024.
31. Mannami T, Iso H, Baba S, Sasaki S, Okada K, Konishi M, Tsugane S. Cigarette smoking and risk of stroke and its subtypes among middle-aged Japanese men and women: the JPHC Study Cohort I. Stroke. 2004 Jun 1;35(6):1248-53.
32. Lindsberg PJ, Roine RO. Hyperglycemia in acute stroke. Stroke 2004;35:363‑ 4.
33. Wade S. Smith, S. Claiborne Johnston, J. Donald Easton; Carotid atherosclerosis. Harrison's Principles of Internal Medicine, 16th edition, McGraw Hill, 2004.
34. Cheng SF, Brown MM, Simister RJ, Richards T. Contemporary prevalence of carotid stenosis in patients presenting with ischemic stroke. Br J Surg. 2019;106(7):872-878.(17)
35. Kumar K, Kumar M, Shahzad G, Mashkoor S, Shaikh MH, Kumar B. Frequency of significant carotid artery stenosis on doppler ultrasound in patients with recent ischemic stroke. Pak J Surg. 2019 Apr 25;35(3):197-200.
36. Khangure SR, Benhabib H, Machnowska M, et al. Carotid near-occlusion frequently has high peak systolic velocity on Doppler ultrasound. Neuroradiology. 2018; 60(1):17-25. doi:10.1007/s00234-017-1938-4.
37. Haq S, Mathur M, Singh J, Kaur N, Sibia RS, Badhan R. Colour Doppler Evaluation of Extracranial Carotid Artery in Patients Presenting with Acute Ischemic Stroke and Correlation with Various Risk Factors. J Clin Diagn Res. 2017;11(3):TC01-TC05. doi:10.7860/JCDR/2017/25493.9541.
38. Shaalan WE, Wahlgren CM, Desai T, Piano G, Skelly C, Bassiouny HS. Reappraisal of velocity criteria for carotid bulb/internal carotid artery stenosis utilizing high-resolution B-mode ultrasound validated with computed tomography angiography. J Vasc Surg. 2008;48(1):104-113. doi:10.1016/j.jvs.2008.02.068.
39. Withers CE, Gosink BB, Keightley AM, et al. Duplex carotid sonography. Peak systolic velocity in quantifying internal carotid artery stenosis. J Ultrasound Med. 1990;9(6):345-349. doi:10.7863/jum.1990.9.6.345.