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Evaluation of Carotid Artery Stenosis by High Resolution Ultrasonography with Colour Doppler Study and Computed Tomography Angiography: Comparison with Digital Subtraction Angiography

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Abstract
Objective- The main objective of the study was to diagnose carotid artery stenosis (CAS) by high resolution ultrasonography (HRUSG) and CT angiography (CTA) and to compare the findings with Digital subtraction angiography (DSA).
Introduction-CAS is one of the important causes of stroke so diagnosis and characterization of CAS is a crucial step in management of stroke. Many modalities have come up for diagnosis of CAS, of which DSA is considered gold standard. In this study, we aim to evaluate the reliability of USG and CTA (non-invasive technique) for detection of CAS and compare with gold standard DSA which is an invasive technique.
Materials and methods- An institution based correlation study was performed on 33 patients presenting with stroke and TIA in the department of Neuromedicine who were sent to the department of Radiodiagnosis for evaluation of CAS by HRUSG and CTA and then DSA was done in those patients who were found to have >50% stenosis of carotid artery.
Result- Both HRUSG and CTA showed good correlation with DSA in detecting CAS.
Conclusion- CTA can be used as an alternative of DSA when combined with HRUSG in early cases and DSA should be reserved for patients when non-invasive imaging techniques have yielded discordant results or patient is planned for therapeutic intervention.

Keywords: *Carotid artery stenosis(CAS), High resolution ultrasonography(HRUSG), Computed tomographic angiography(CTA), Digital subtraction angiography(DSA), NASCET criteria, Transient ischaemic attack(TIA),Sroke*

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I. Introduction

Stroke is the third cause of disability in the world and third leading cause of mortality. Approximately 80 to 85% of strokes are due to ischemic causes. One of the main cause of ischaemic stroke is carotid artery stenosis due to atherosclerotic changes. As the atherosclerosis progresses the atherosclerotic plaques rupture resulting in the formation of thrombus and arterial occlusion or dislodged materials from the plaques blocking the smaller branches of the carotid artery. Approximately 20 to 30% of all strokes are caused by extracranial carotid artery stenosis (CAS), while intracranial CAS accounts for 5 to 10% of strokes. Transient ischemic attacks (TIA) are a brief period of symptoms similar to stroke due to temporary blockage of blood supply to a section of the brain and often lasts less than 24 hours. Carotid artery disease is responsible for nearly 50% of all TIAs. Risk of developing stroke after TIAs is as high as 20% within the 1st month [2]. If untreated, TIAs result in development of stroke within 2 years. Risk of stroke events remains high for 10 to 15 years after TIAs.

CAS manifests into clinical syndromes, that is, asymptomatic, TIAs, and ischemic stroke. CAS is considered symptomatic when ipsilateral retinal or cerebral ischemia occurs and asymptomatic when these symptoms are absent. Around 5 to 10% of the general population over 65 years of age has an asymptomatic CAS of 50% or greater. Risk of stroke increases with increasing CAS. There is less than 1% stroke per year for a CAS less than 80% but increases to 4.8% per year for a CAS greater than 90%. A stenosis of the carotid artery greater than 50% is considered significant carotid artery disease. Differentiation between asymptomatic and symptomatic CAS is important for treatment of CAS. In general, medical treatment is provided for asymptomatic patients while invasive treatment is considered for symptomatic patients with CAS greater than 50% and for asymptomatic patients with CAS greater than 60%. For invasive or medical treatments, the risk factors for CAS have to be considered.

So diagnosis and characterization of carotid artery stenosis is a very important aspect to manage stroke.

The severity of stenosis is one of the most important criteria that may influence the choice of treatment. However, it is possible that even a low-grade stenosis in the carotid arteries can lead to the development of cerebrovascular events. Hence, it may be important to look beyond the degree of stenosis and determine wall and plaque morphology. Besides the severity of stenosis, other factors like plaque ulceration, composition and neovascularization are independent predictors of stroke.

Four diagnostic modalities are used to image carotid artery: digital subtraction angiography (DSA), duplex ultrasound (DUS), computed tomography angiography (CTA), and magnetic resonance angiography (MRA). Invasive DSA is still considered the gold standard of the carotid artery diagnostic imaging and therapeutic stenting procedure. The choice of methods depends on the clinical indications and the availability of methods in individual centers. However, the general approach to patient with suspected carotid artery stenosis is to first perform DUS and then other noninvasive methods such as CTA, MRA, or transcranial Doppler US.

Therefore, the aim of our study was to evaluate the reliability of US and CTA in the detection and quantification of carotid stenosis, when compared with the current gold standard of DSA.

II. Aims And Objectives

a)GENERAL-to diagnose carotid artery stenosis by HRUSG, CT Angiography and comparison with Digital Subtraction Angiography.

b) SPECIFIC- 1) to detect, localize, &characterize carotid artery stenosis and calculate the area of stenosis by HRUSG, CT Angiography and compare the findings with DSA.

2) To assess the effectiveness and cost-effectiveness of HRUSG and CT Angiography in patients with a transient ischemic attack (TIA) or stroke who are suspected of having carotid artery stenosis (CAS).

ATHEROSCLEROTIC PLAQUE

Atherosclerosis is characterized by the presence of intimal lesions called atheromas (or atheromatous or atherosclerotic plaques). Atheromatous plaques are raised lesions composed of soft grumous lipid cores (mainly cholesterol and cholesterol esters, with necrotic debris) covered by fibrous caps (Figure.1).

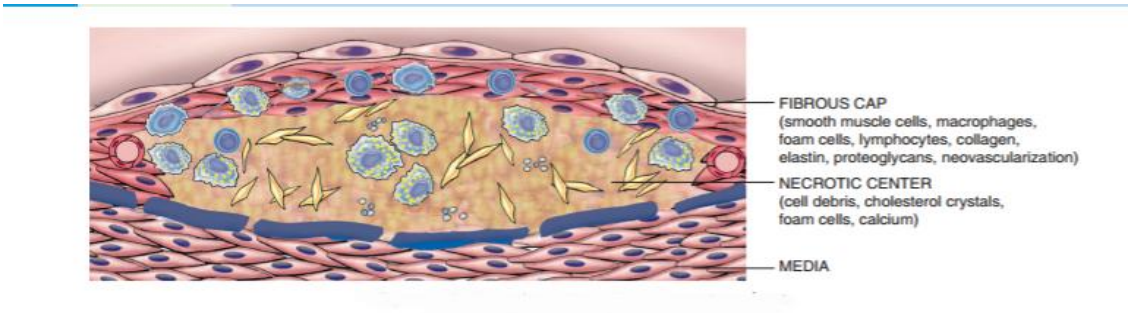


Figure1--Basic structure of an atheromatous plaque

Atherosclerotic plaques are susceptible to several clinically important changes:

• Rupture, ulceration, or erosion of the luminal surface of atheromatous plaques exposes highly thrombogenic substances and induces thrombus formation. Thrombi may partially or completely occlude the lumen, leading to tissue ischemia (Fig. 2). If the patient survives, thrombi become organized and incorporated into the growing plaque. .

• Hemorrhage into a plaque. Rupture of the overlying fibrous cap or of the thin-walled vessels in the areas of neovascularization can cause intra-plaque hemorrhage; the resulting hematoma may cause rapid plaque expansion or plaque rupture. Ruptured plaque can discharge debris into the blood, producing microembolicomposed of plaque contents.

• Aneurysm formation. Atherosclerosis-induced pressure or ischemic atrophy of the underlying media, with loss of elastic tissue, causes structural weakening that can lead to aneurysmal dilation and rupture.

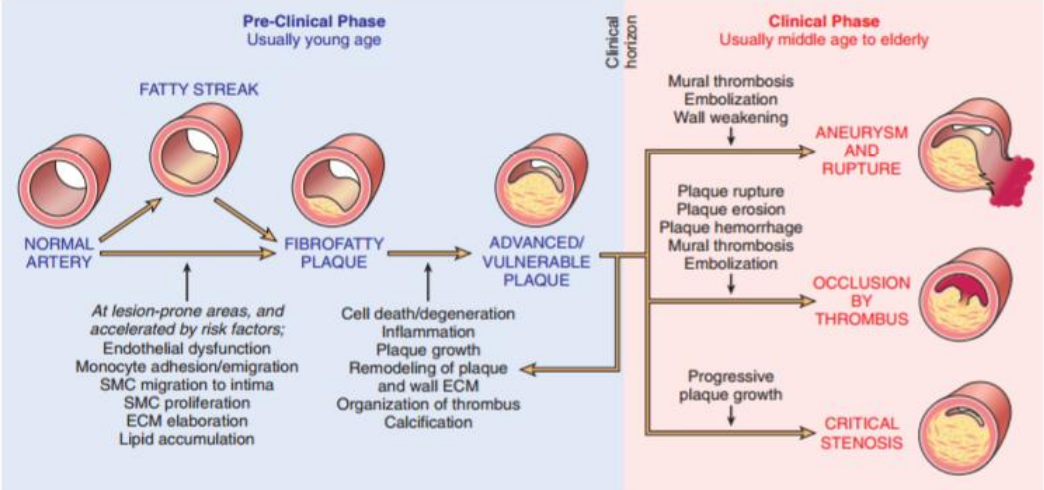


Figure2-Summary of the natural history, morphologic features, main pathogenic events, and clinical complications of atherosclerosis.

CAROTID ARTERY STENOSIS

The goals of carotid imaging are early detection, clinical staging, surgical road mapping, and postoperative therapeutic surveillance. The detection of a clinically significant carotid stenosis represents an important first step in the prevention of cerebral infarction. Four diagnostic modalities are used to image the carotid artery: digital subtraction angiography (DSA), duplex ultrasound (DUS), computed tomography angiography (CTA), and magnetic resonance angiography (MRA). Noninvasive methods have undergone significant development in the recent years, especially computed tomography and magnetic resonance. Despite this development, invasive DSA is still considered the gold standard.

DIGITAL SUBTRACTION ANGIOGRAPHY

Currently, conventional DSA is not the first-line method for assessment of carotid stenosis; however, it is still considered the gold standard and is an indivisible part of the carotid stenting procedure. The carotid artery is visualized in several projections, two at least, but three or more are recommended. DSA allows evaluation of the severity and morphology of stenosis, when an irregular margin suggests plaque ulceration and an intraluminal defect suggests thrombus. DSA of intracranial arteries allows visualization of collateral flow (Fig. 3).

Several methods can be used to measure the severity of carotid stenosis based on angiographic images. Currently, three methods predominate worldwide (►Fig.4). The North American Symptomatic Carotid Endarterectomy Trial (NASCET) method compares stenosis to the distal normal poststenotic internal carotid artery (ICA) diameter. The European Carotid Surgery Trial (ECST) method compares stenosis to estimate the normal diameter of the carotid bulb. The common carotid (CC) method measures the residual lumen diameter at the most stenotic portion of the vessel and compares this to the lumen diameter in the proximal CC artery. Different measurement techniques lead to different estimations of the degree of stenosis. The relations between measurements are approximately linear. The ECST and CC methods indicate that twice as many stenosis are severe, as did the NASCET method, and classified less than one-third of the number of stenosis as mild.

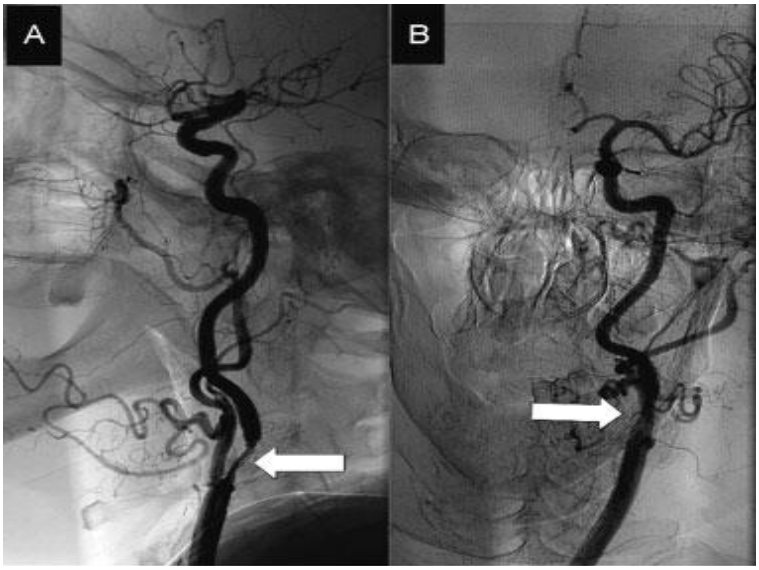


Fig.3 Digital subtraction angiography of the carotid artery with stenosis more than 70% (arrow) in (A) lateral and (B) anteroposterior view. Stenosis is clearly visible in lateral view but obscured by external Carotid artery in anteroposterior view.

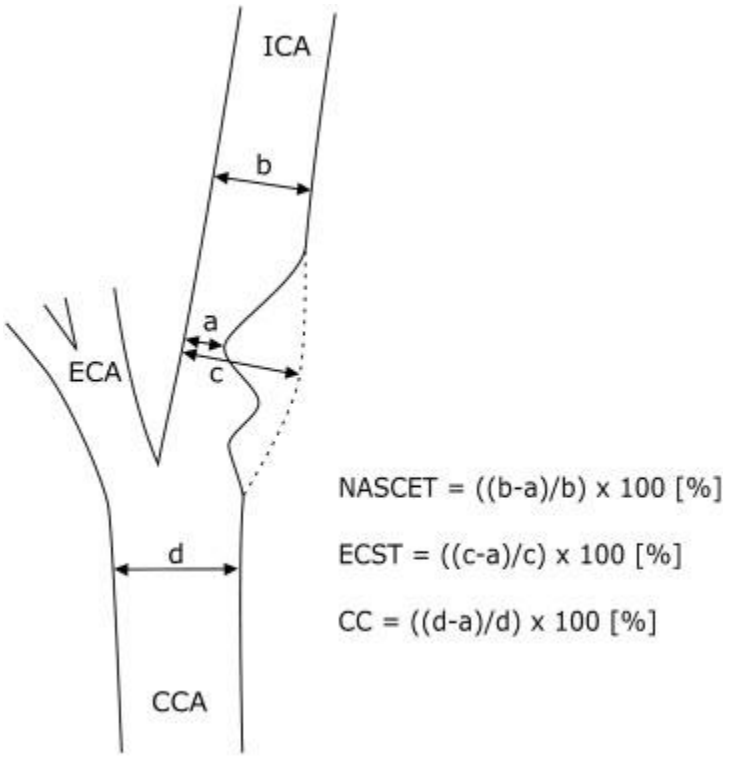


Fig. 4 Methods of the measurement of the carotid artery stenosis severity: The North American Symptomatic Carotid EndarterectomyTrial (NASCET), European Carotid Surgery Trial (ESCT), and common carotid (CC) method. CCA, common carotid artery; ECA, external carotid artery; ICA, internal carotid artery.

Advantages

DSA have both diagnostic and therapeutic role in case of carotid artery stenting or angioplasty.

Disadvantages

DSA is an invasive method. The most feared complication is embolization with consequent stroke; however, the incidence of permanent stroke is less than 1%. The quality of the angiogram depends on selective catheterization of the carotid artery with at least two views.

Duplex Ultrasound

Grayscale and Doppler ultrasound are used for assessment of extracranial segments of carotid arteries. The combination of these two ultrasound methods is called DUS. Grayscale US allows evaluation of morphology with assessment ofvessel wall atherosclerotic changes. Calcified (hyperechoic) and noncalcified (hypoechoic) parts of atherosclerotic plaques can be differentiated .Hypoechoic plaques are an independent risk factor for stroke. Grayscale US also allows measurement of intima-media complex thickness, which helps detect preclinical atherosclerosis and assess risk stratification. Doppler US is based on the Doppler effect that allows measuring of flow based on the reflection of mechanical waves. Pulse and color Doppler US are both used. Color Doppler US visualizes flow in color-coded information about direction and velocity interposed on grayscale images, and high-grade stenosis can be more easily detected with color Doppler than with pulse Doppler US. However, pulse Doppler US allows direct measurement of flow velocity (Fig. 18). Peak systolic velocity (PSV) is used for quantifying stenosis, but other parameters including end-diastolic velocity, carotid index, and spectral analysis of waveforms are also used for evaluation of stenosis. Standard criteria for stenosis assessment based on the study by Grant et al are in shown in Table 2.

Identification of carotid arteries:

A key element of the examination is to correctly distinguish the internal from the external carotid artery. The ICA should be the larger of the two branches since it takes 70% to 80% of the net blood flow from the CCA. It is also typically located superficial to the ECA from a posterolateral imaging approach. All of the findings listed in the (Table 1).

Table 1

Features	External Carotid Artery	Internal Carotid Artery
Size	Usually smaller of the two	Usually larger of the two
Branches	Always	Very rarely (case reports)
Orientation	Proceeds anteriorly toward the face	Proceeds deep and slightly posteriorly toward the mastoid
Doppler characteristics	High resistance	Low resistance
Response to temporal tap	Well-perceived oscillations	Poorly perceived to absent oscillations

Advantages

Carotid DUS is a noninvasive, safe, and inexpensive technique. DUS allows direct visualization of morphology and flow measurement.

Disadvantages

1)The accuracy of DUS depends on the experience and expertise of the sonographer.2)Patient habitus, atypical anatomical situation, or the tortuous course of carotid arteries might cause difficulties in detection and flow measurement. 3)The absence of flow in the internal carotid artery may be because of the occlusion, but hairline residual lumens can be missed on DUS. 4)Only the cervical portion of the internal carotid artery can be evaluated; Contrast-enhanced ultrasound seems to be a promising method for further evaluation of carotid stenosis morphology, plaque structure, and also possibly neovascularization of plaque. But this method is not widely used and has to be standardized and proven in prospective studies [96]

Table 2 Gray-scale and Doppler US criteria for diagnosis of ICA stenosis

Degree of stenosis (%)	Primary parameters		Additional parameters	
	ICA PSV (cm/sec)	Diameter reduction (%)	ICA/CCA PSV ratio	ICA EDV (cm/sec)
Normal	<125	None	<2.0	<40
<50	<125	<50	<2.0	<40
50–69	125–230	≥50	2.0–4.0	40–100
≥70 but less than near occlusion	>230	≥50	>4.0	>100
Near occlusion	High, low or undetectable	Visible	Variable	Variable
Total occlusion	Undetectable	Visible, no detectable lumen	Not applicable	Not applicable

Abbreviations: CCA, common carotid artery; EDV, end-diastolic velocity; ICA, internal carotid artery; PSV, peak systolic velocity; US, ultrasound.
Note: Adapted from Grant et al.[93]

Computed Tomography Angiography

CTA with intravenously administered iodine contrast medium shows the whole course of the carotid artery from the aortic arch to intracranial segments and allows assessment of the severity of stenosis at all levels. Evaluation is done in multiple view and different types of reconstructions with the possibility of plaque composition evaluation (Fig. 5). Stenosis measurement can be done based on luminal area, but usually diameter measurement using NASCET or ESCT criteria is used in clinical practice. CT technology development with increasing the number of detector rows from 4 to 320 has influenced accuracy.

Advantages

Wide availability of CT with the possibility of performing brain CT and CTA of carotid arteries anytime of the day. Acquisition of CT images is also faster than other methods and examination is relatively operator independent.

Disadvantages

Main disadvantages are the use of iodine contrast medium intravenously and radiation. Therefore, impaired renal function is a relative contraindication for its use.

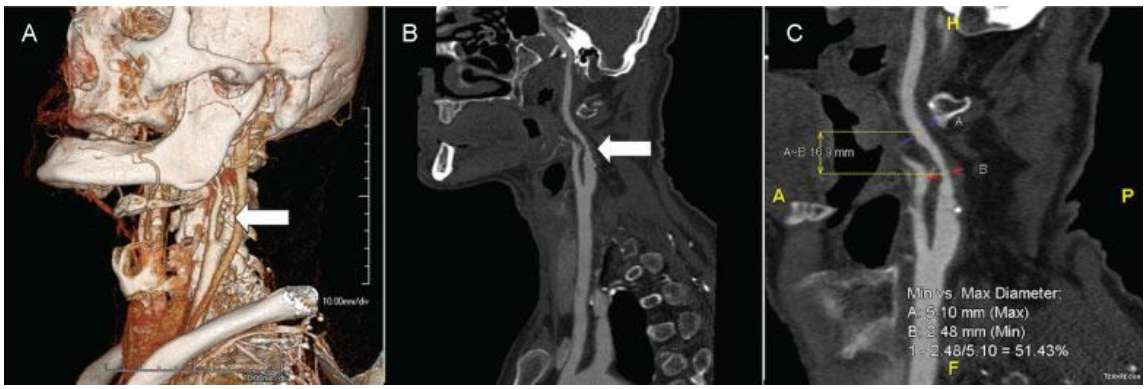


Fig. 5 Computed tomography angiography with mixed plaque in the internal carotid artery and stenosis (arrows). (A) Volume rendering
technique, (B) curved multiplanar reconstruction, and (C) curved multiplanar reconstruction with stenosis measurement using North American Symptomatic Carotid Endarterectomy Trial method.

III. Materials And Methods

a) STUDY DESIGN – Institution based, Comparative Cross sectional Study
b) PLACE OF STUDY- DEPT. OF RADIODIAGNOSIS, BIN, KOLKAT and Dept. of NEUROMEDICINE, BIN, KOLKATA
c) STUDY SETTING- CT ANGIOGRAPHY and DSA section at Dept. of RADIDIAGNOSIS ,BIN,KOLKATA
d)STUDY TOOLS:
A. BROADBAND LINEAR ARRAY WITH SELECTIVE FREQUENCY Electronic Transducer of PHILIPS HD-7 Colour Doppler USG Machine having Electronic focusing facility.
B. 16 SLICE CT MACHINE
C. BI-PLANAR (FD20/20) DSA

e) STUDY TECHNIQUE: Patients presenting at Neuromedicine ER/OPD at BIN, Kolkata or at ER of SSKM HOSPITAL with signs and symptoms of cerebrovascular accident and transient ischaemic attack were examined clinically and those, being made provisional diagnosis of the same by Neurophysician based on history, clinical examination and investigations like CT Scan Brain, were referred for further investigations .Screening of carotid arteries done with PHILIPS HD-7 Color Doppler USG Machine and patients having carotid artery stenosis were selected for further investigation of the study. After informed consent patients were enrolled considering the inclusion and exclusion criteria and had undergone 16 SLICE CTA WITH 3-D RECONSTRUCTION. Anticipating surgical intervention, invasive procedure DSA with 3D RECONSTRUCTION, the gold standard investigation, was done in patients having carotid artery stenosis more than 50% .Results of HRUSG, CTA and DSA are compared for each patient after completion of the study.
f)PERIOD OF STUDY- January 2017 to august 2018
g)STUDY POPULATION : patient attending the OPD / IPD at the Dept. of NEUROMEDICINE ,BIN, KOLKATA
h) sample size –not less than 30
i) Control-not required
j) INCLUSION CRITERIA : 1) patients with symptoms of CVA and TIA
2) Patients willing to participates in the study through a written informed consent for DSA and CT angiography
k)EXCLUSION CRITERIA- 1) Patients with a history of renal disease or allergic reaction to contrast material
2) Age less than 12 years
3) PT-INR Value more than 1.5
4) Platelet count less than 50000/cmm
5) Elevated urea and creatinine level
l) Study variables –age, sex, risk factors of CVA, % of stenosis in HRUSG, DSA and CT angiography

m) Data collection and interpretation –
statistical calculation to be performed on a PC using statistical package for the social sciences (SPSS) software. Demographic data such as age, sex, address, height, weight, religion, socio-economics status were collected.
n) Laboratory investigation:
Complete blood count including platelet count, PT-INR value, urea, creatinine, lipid profile electrolyte, HBsAg, Anti-HCV, HIV 1 & 2.
o) Outcome definition and parameters:
the proposed outcome of the study is to presence of stenosis, site & side of stenosis and compare percentage of stenosis of HRUSG, CT ANGIOGRAPHY & DSA.
P) Statistical analysis plan:
data collected and entered in Microsoft excel and analyzed by appropriate statistical method. Data analysis was done using statistical packaged for social sciences (SPSS)

IV. Result & Analysis

We have studied 33 patients of carotid artery stenosis who presented with stroke and TIA, and got admitted in the department of neuromedicine, BIN, IPGME&R. HRUSG and CTA were done in all patients, however DSA was done only in those patients having carotid artery stenosis more than 50% of luminal diameter. All the patients were compared with both HRUSG and CTA, and statistical significance was assessed using paired t-test. For the patients with more than 50% carotid artery stenosis, area of stenosis was calculated using NASCET Criteria for HRUSG, CTA, and DSA separately, and result has been compared with Pearson correlation coefficient.

Out of 33 patients, 21 (63.63%) patients were male and 12 (36.36%) patients were female (FIG-6& table no 3).

Fig. no 6: shows distribution of sex

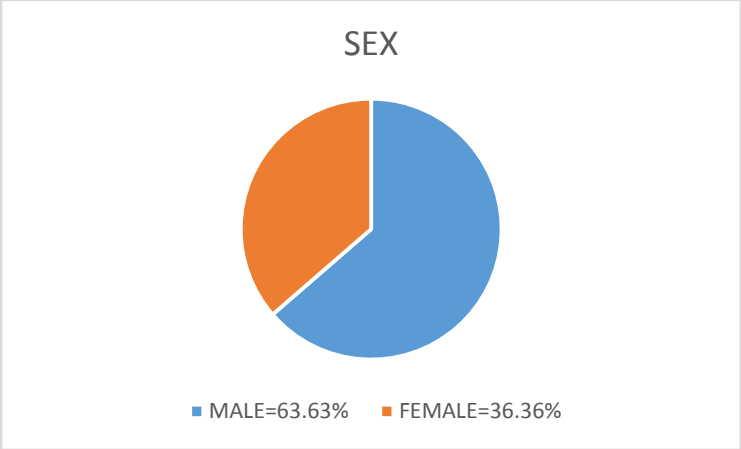


Table no 3: shows sex distribution in our study

SEX	NO OF PATIENTS
MALE	21
FEMALE	12
TOTAL	33

Table no – 4: shows prevalence of carotid artery stenosis in different age groups and severity of area of stenosis in these groups. There is increased area of stenosis with increased age.

AGE, YEARS	PREVELANCE, %	MEAN PERCENTAGE, %
< 49	21.21	41.9
50 – 59	24.24	47.4
60 – 69	30.30	58.3
70 – 79	21.21	64.4
>80	3.03	84.6

All the female patients of our study are presented in post- menopausal age group and mean age of the female patients are 67 years, more than the male patients, mean age 57.42 years (table no 6). Severity of carotid artery stenosis is more in female patients than male patients, may be due to more age of presentation (table no 5).

Table no 5: shows area of carotid artery stenosis in male and female patients

AREA OF STENOSIS	MALE PATIENTS	FEMALE PATIENTS
MEAN ± SD, %	45.9 ± 18.8	68.9 ±15.6
MEDIAN, %	44.5	70.6
RANGE, %	71.4	52

Table no 6 : shows mean age of presentation in male and female patients

AGE(YEARS)	MALE PATIENTS	FEMALE PATIENTS
MEAN ± SD	57.4 ± 10.7	67.0 ± 6.9
MEDIAN	58	67
RANGE	36	26

Fig. no 7: shows prevalence of carotid artery stenosis in different age groups

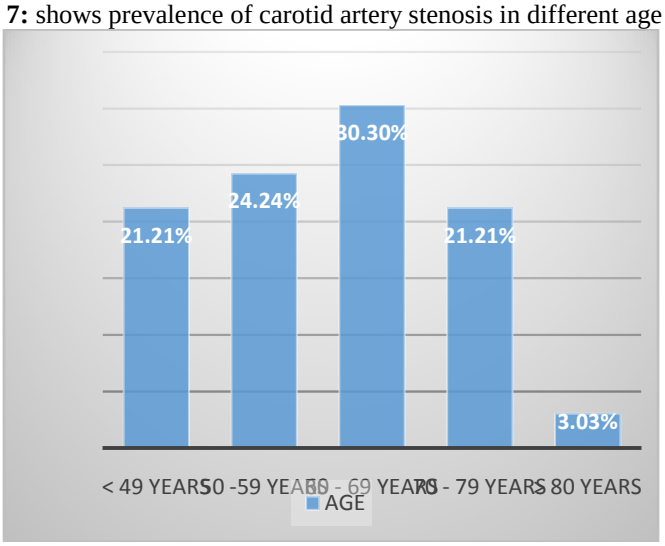
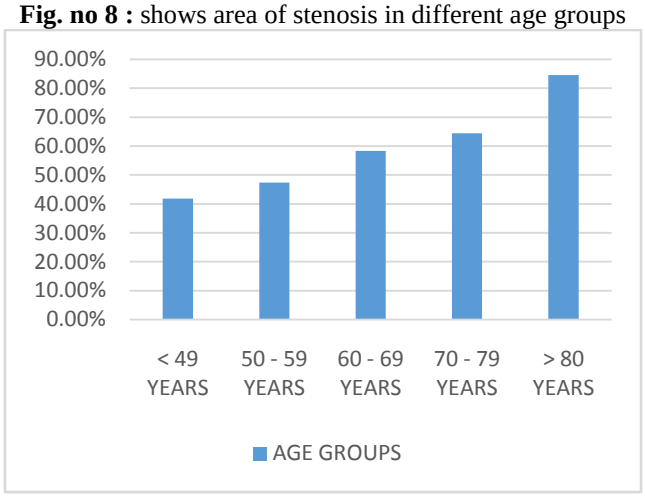
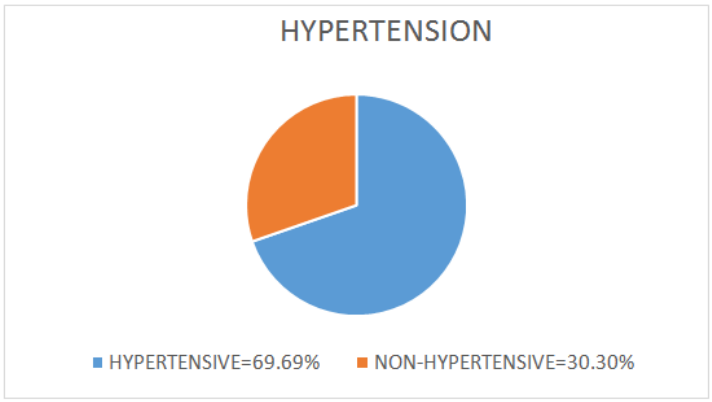


Fig. no 8 : shows area of stenosis in different age groups



Good correlation has been seen between patients having hypertension and carotid artery stenosis. In our study, out of 33 patients 23 (69.69%) patients were hypertensive and 10(30.30%) patients were normotensive(Fig. no 9).

Figure no9: prevalence of hypertension in carotid artery stenosis



Diabetes and ischemic stroke are common diseases that frequently occurring together. It is well known that diabetes mellitus may contribute to systemic and intracranial atherosclerotic disease and this increased risk has been linked to pathological changes seen in the cerebral vessels of patients with diabetes. There were 20 patients who were known diabetic and 13 patients were non-diabetic(figure no 10)

Figure no 10: shows prevalence of Diabetes in our study

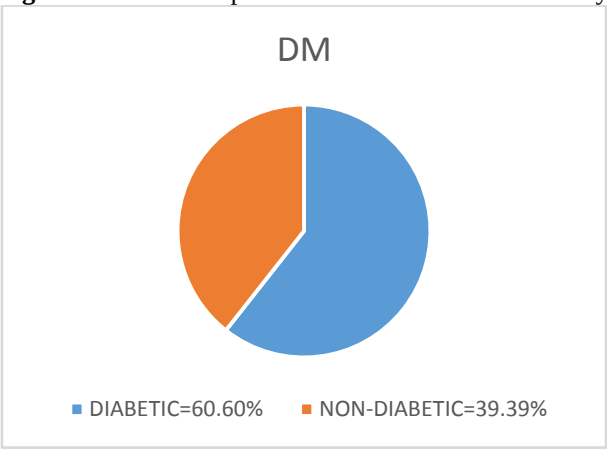


Figure no 11 : shows prevalence of hypertension and diabetes in our study

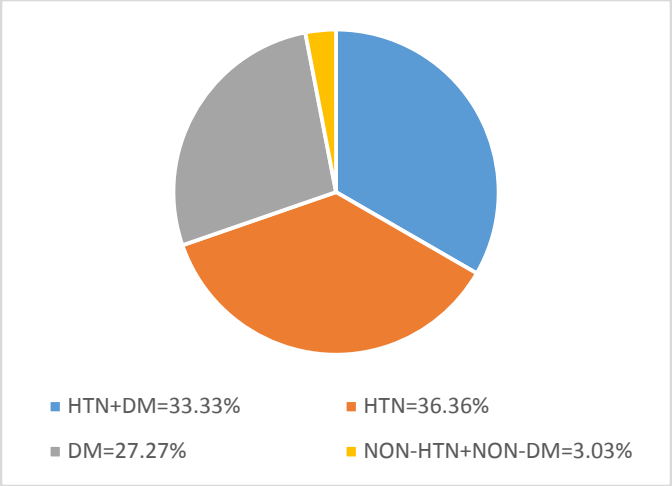


Figure no.11 depicts the relationship amongst diabetes, hypertension and carotid artery stenosis. In our study it is found that 11 patients have both diabetes and hypertension, 12 patients have only hypertension, 9 patients have only diabetes and 1 patient had no history of diabetes or hypertension.

Dyslipidemia is one of the major risk factors for cardiovascular and cerebrovascular disease. We got 21(63.63%) patients who had dyslipidemia and 12 patients have normal lipid profile(figure no 12).

Figure no 12: shows prevalence of dyslipidemia in our study

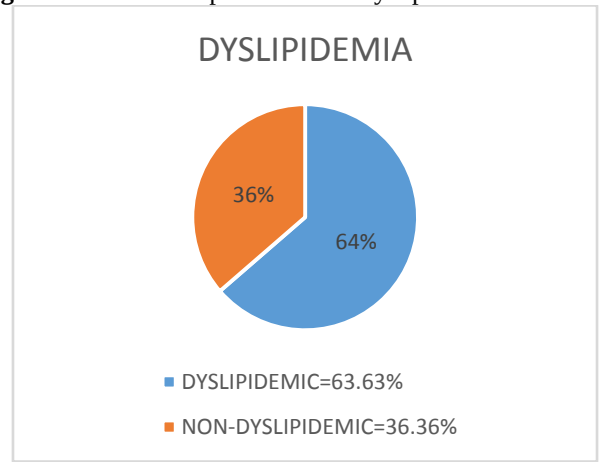
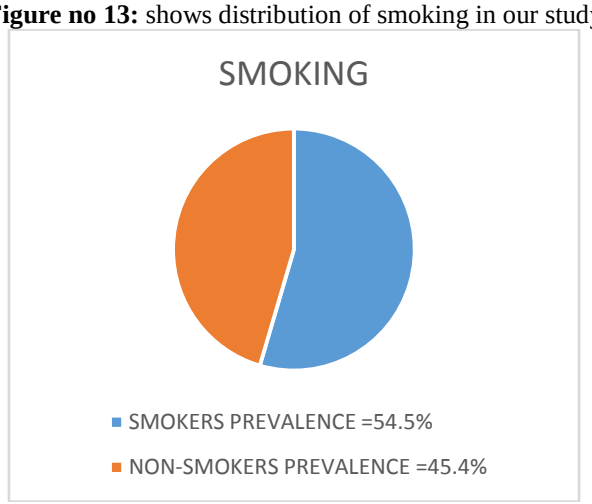
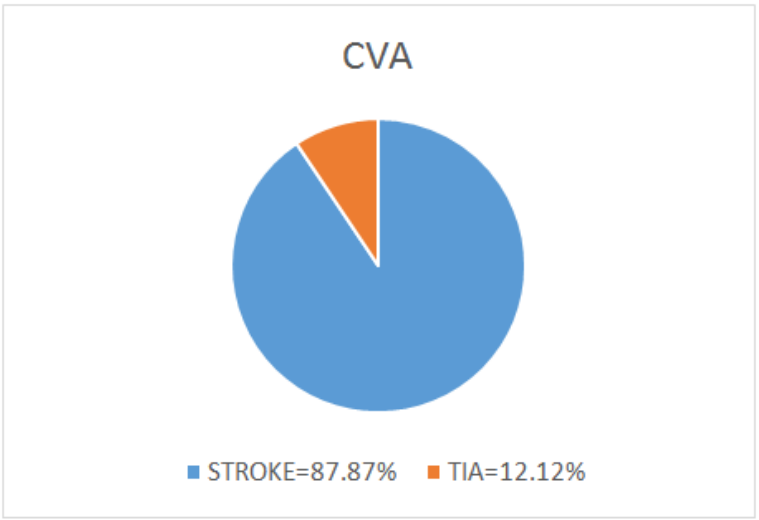


Figure no 13: shows distribution of smoking in our study



We have seen that 20 patients were smokers and 13 patients were non-smokers which indicates that there is a relationship between smoking and carotid artery stenosis (figure no 13).
In our study, 29 patients presented with ischemic stroke and 4 patients presented with TIA (Figure no 14).

Figure no-14 shows distribution of TIA and stroke in our study



With utilization of CTA, mild carotid stenosis (< 50%) were found in 14 patients (42.42%) and moderate and severe ones (50% - 99%) in 19 (57.57%) subjects. Data of lumen diameter measurements obtained from ultrasonography and CTA areshown in Table 7 (for internal carotid artery) and Table8 (for common carotid artery). The paired sample t-test showed no significant differences between the two methods.

Table no 7 : Mean Values of Internal Carotid artery Lumen Diameter in Patients ICA stenosis.

Internal Carotid Lumen Diameter	CTA	HRUSG
MEAN ± STANDARD DEVIATION , MM	2.30 ± 1.09	2.145 ± 1.08
MEDIAN, MM	2.28	2.15
95% CONFIDENCE INTERVAL, MM	1.85 TO 2.75	1.70 TO 2.58
RANGE, MM	4.47	4.49

Table no 8: shows Mean Values of Common Carotid Lumen Diameter in Patients.

COMMON CAROTID LUMEN DIAMETER	**CTA**	**HRUSG**
MEAN ± STANDARD DEVIATION , MM	3.24 ± 1.16	3.06 ± 1.12
MEDIAN, MM	3.04	3.06
RANGE, MM	3.74	3.71

The results for moderate to severe carotid stenosis obtained from 3 different techniques (DSA, CTA, and DUS) are shown in Table 9. Finally, the correlations of CTA and Doppler ultrasonography results with DSA results in stenosis > 50% were calculated and shown in Table 10. The Pearson correlations coefficient of 0.947 and 0.0.962 (P < 0.001) were highly significant.

Table no 9 : The Results for Moderate to Severe Carotid Stenosis Obtained From 3 Different Techniques (DSA, CTA, and USG)

	USG	CTA	DSA
MEAN ± STANDARD DEVIATION, %	66.72 ± 12.55	68.05 ± 14.007	70 ± 91
95% CONFIDENCE INTERVAL, %	66.72 ± 5.64 ; 61.1 TO 72.4	68.05 ± 6.3; 61.8 TO 74.4	70.91 ± 5.75 ; 65.2 TO 76.7
MEDIAN, %	62.8	66.3	70.4

Table no 10: Pearson correlation of CT Angiography and Ultrasonography with Digital Subtraction Angiography Results for Moderate to Severe carotid artery Stenosis (> 50%).

	PEARSON CORRELATION COEFFICIENT
CORRELATION OF USG/ DSA	0.947
CORRELATION SIGNIFICANCE P	< 0.0001
CORRELATION OF CTA / DSA	0.9625
CORRELATION SIGNIFICANCE P	< 0.0001

V. Discussion

In this, institution based cross sectional study, done in BangurInstitution of Neuroscience, IPGME&R, we have included 33 patient of carotid artery stenosis. Patients who presented with TIA or Stroke in OPD of Neuromedicine or ER of SSKM hospital were screened with HRUSG and positive patients were planned for CTA and DSA (only stenosis > 50%). Luminal diameter of stenosed carotid artery of all the selected patients were calculated by HRUSG, CTA and DSA (stenosis > 50 %) separately. Percentage of luminal narrowing was calculated using NASCET criteria.

The single largest risk factor of stroke is age, however, males are more likely to suffer a stroke as compared to females. Males are more likely to suffer a pediatric stroke and this trend continues through adolescence. Interestingly, young adults females are more likely than males to experience stroke. This is likely due to the pro-thrombotic actions of oral contraception. After age thirty, however, male predominance returns. Following menopause, however, the protection in females is lost. When women suffer a stroke they are significantly more likely to have what is classified as a "severe" stroke more likely to result in death. The women who survive are also more likely to experience more severe outcomes with less of a chance of complete recovery. Women are more likely to experience long-term handicaps, a reduced quality of life and are more likely to experience depression . Overall there are significant sex differences in the incidence, severity and recovery from stroke. In our study, Out of 33 patients, 21 (63.63%) patients are male and 12 (36.36%) patients were female. Female are presented with more severe stenosis than male and female are presented with more advance age.

The risk increases with age, the incidence doubling with each decade after the age of 45 years and over 70% of all strokes occur above the age of 65. In our study, mean age of presentation is 60.90 years with most of the patients presented in 60 years to 69 years groups.

All the female patients of our study are presented in post- menopausal age group and mean age of the female patients are 67 years, more than the male patients, mean age 57.42 years. Severity of carotid artery stenosis is more in female patients than male patients, may be due to more age of presentation.

Aoyaliu et al suggest that carotid stenosis prevailed among patients with hypertension prevalence rate of 78% in the group above 60 years old and of 86.3% in the group above 70 years old. This rate was higher than that in developed western countries. Saba et al. finds that seventy-one patients with significant stenosis; patients with hypertension were 55, (43 with stenosis and 12 without stenosis). Good correlation has been seen between patients having hypertension and carotid artery stenosis. In our study, out of 33 patients 23(69.69%) patients were hypertensive and 10(30.30%) patients were normotensive.

Bosebski M et al. described that diabetes mellitus has been recognized as one of the main determinants for the presence and progression of asymptomatic and symptomatic carotid artery disease. P. Lacroix et al. finds that good correlation between diabetes and asymptomatic carotid artery stenosis. In our study, there were 20 patients who were known diabetic and 13 patients were non-diabetic.

G. S. Tell et al. reports positive relation between smoking and carotid artery disease to a population-based sample of older adults using several different indicators of atherosclerotic disease.

RuijunJi et al. systematically investigated the relationship between cigarette smoking and the occurrence of CAS They found that cigarette smoking was significantly associated with the occurrence of CAS.

We have seen that 20 patients were smokers and 13 patients were non-smokers which indicates that there is a relationship between smoking and carotid artery stenosis.

Ischemic stroke secondary to thromboembolic event from extracranial carotid artery disease remains an important cause of morbidity and mortality. Previous landmark trials have shown correlation of degree of carotid stenosis and future cerebrovascular events. Accurate evaluation of the degree of carotid stenosis is essential for guiding clinical treatment.

Noninvasive vascular imaging techniques have gradually replaced DSA for the diagnosis of carotid artery stenosis. Due to its high spatial resolution and fast imaging, CTA has been widely used in the examination of the carotid artery. Accurate identification and measurement of carotid artery stenosis in CTA is possible. However, in cases with severe calcification on the vessel wall, the demonstration of the lumen may be compromised; this compromise affects accurate evaluation of the degree of carotid stenosis.

In the study conducted by S G Patel et al showed that DUS, CTA, and MRA all have similar accuracy in the diagnosis of symptomatic carotid stenosis. No technique on its own is accurate enough to replace DSA. In the study by Amin Banaei et al. showed that significant correlations were found between CTA/DSA and DUS/DSA.

In our study, we got mild carotid stenosis (< 50%) in 14 patients (42.42%) and moderate and severe ones (50% - 99%) in 19 (57.57%) subjects using CTA parameter. Data of lumen diameter were measured obtaining from ultrasonography and CTA. The measured value were calculated using paired sample t-test and showed no significant differences between the two methods.

Finally, the correlations of CTA and Doppler ultrasonography results with DSA results in stenosis > 50% were calculated. The Pearson correlations coefficient of 0.947 and 0.962 ($P < 0.001$) were highly significant and showed no significant difference between them.

LIMITATIONS

1)This study was done in a limited time period and included limited number of patients.
2)For proper evaluation large number of patients and longtime of period is needed.
3)In our study, characteristics of plaque morphology were not included. We have only studied the luminal diameter carotid artery.

VI. Conclusion

In our study, we found good correlation when compared between HRUSG and CTA, HRUSG and DSA, CTA and DSA separately.

So, HRUSG can be used in screening of the carotid artery stenosis as it is very cheap and easily available. CTA have good correlation with DSA and can be used for accurate assessment of HRUSG findings or can be used as an alternative of DSA when combined with HRUSG in early cases. DSA is gold standard test for carotid artery stenosis and should be used in cases of severe stenosis.

To improve the accuracy of the diagnosis, the use of two-imaging modalities before revascularization is suggested. The general approach to patients with suspected carotid stenosis is to first perform USG, which is cheap, readily available. Patients with stenosis < 50% may be followed with serial examinations to determine whether disease progression has occurred. Patients with stenosis > 50% should be evaluated with CTA or other non-invasive test. Conventional angiography is usually reserved for patients when noninvasive imaging studies have yielded discordant results or in the case of poor quality of the noninvasive imaging or patient is planned for therapeutic intervention.

Bibliography

[1]. Feigin V L, Lawes C M, Bennett D A, Anderson C S. Stroke epidemiology: a review of populationbased studies of incidence, prevalence, and case-fatality in the late 20th century. Lancet Neurol. 2003; 2(1):43–53. [PubMed]
[2]. Go AS, Mozaffarian D, Roger VL, et al. American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics — 2014 update: a report from the American Heart Association. Circulation 2014;129:e28–e292. [PMC free article] [PubMed]
[3]. Tapuwa D. Musuka, MBChB, Stephen B. Wilton, MD, MouhieddinTraboulsi, MD, and Michael D. Hill, MD. Diagnosis and management of acute ischemic stroke: speed is critical. CMAJ. 2015 Sep 8; 187(12): 887–893.
[4]. Kailash Prasad, MBBS (Hons.), MD, PhD, DSc, FRCPC, FACC, FIACS, FICA. Pathophysiology and Medical Treatment of Carotid Artery Stenosis. Int J Angiol. 2015 Sep; 24(3): 158–172.
[5]. The Intercollegiate Working Party for Stroke. London: Royal College of Physicians; 2004. National Clinical Guidelines for Stroke. 2nd ed.
[6]. Sacco R L. Clinical practice. Extracranial carotid stenosis. N Engl J Med. 2001; 345(15):1113–1118. [PubMed]

[7]. Alpert J N. Extracranial carotid artery. Current concepts of diagnosis and management. Tex Heart Inst J. 1991;18(2):93–97. [PMC free article] [PubMed]
[8]. Clark T G, Murphy M F, Rothwell P M. Long term risks of stroke, myocardial infarction, and vascular death in "low risk" patients with a non-recent transient ischaemic attack. J NeurolNeurosurg Psychiatry. 2003;74(5):577–580. [PMC free article] [PubMed]
[9]. The European Carotid Surgery Trialists Collaborative Group . Risk of stroke in the distribution of an asymptomatic carotid artery. Lancet. 1995;345(8944):209–212. [PubMed]
[10]. Mineva P P, Manchev I C, Hadjiev D I. Prevalence and outcome of asymptomatic carotid stenosis: a population-based ultrasonographic study. Eur J Neurol. 2002;9(4):383–388. [PubMed]
[11]. Goessens B M Visseren F L Algra A Banga J D van der Graaf Y; SMART Study Group. Screening for asymptomatic cardiovascular disease with noninvasive imaging in patients at high-risk and low-risk according to the European Guidelines on Cardiovascular Disease Prevention: the SMART study J VascSurg 2006433525–532. [PubMed]
[12]. de Weerd M, Greving J P, Hedblad B. et al. Prevalence of asymptomatic carotid artery stenosis in the general population: an individual participant data meta-analysis. Stroke. 2010;41(6):1294–1297. [PMC free article] [PubMed]
[13]. Barnett H J, Taylor D W, Eliasziw M. et al. Benefit of carotid endarterectomy in patients with symptomatic moderate or severe stenosis. North American Symptomatic Carotid Endarterectomy Trial Collaborators. N Engl J Med. 1998;339(20):1415–1425. [PubMed]
[14]. Executive Committee for the Asymptomatic Carotid Atherosclerosis Study .Endarterectomy for asymptomatic carotid artery stenosis. JAMA. 1995;273(18):1421–1428. [PubMed]
[15]. Fine-Edelstein J S, Wolf P A, O'Leary D H. et al. Precursors of extracranial carotid atherosclerosis in the Framingham Study. Neurology. 1994;44(6):1046–1050. [PubMed]
[16]. Reilly LM, et al: Carotid plaque histology using real-time ultrasonography. Clinical and therapeutic implications, Am J Surg 146:188–193, 1983
[17]. Bluth E, Carroll B: The extracranial cerebral vessels. In Rumack CM, Wilson SR, Charboneau JW, et al, editors: Diagnostic Ultrasound, ed 4, St. Louis, MO, 2011, Elsevier..
[18]. Bluth EI, et al: Carotid duplex sonography: a multicenter recommendation for standardized imaging and Doppler criteria, Radiographics 8:487–506, 1988.
[19]. Bluth EI: Evaluation and characterization of carotid plaque, Semin Ultrasound CT MR 18:57–65, 1997. 31. Merritt CR, Bluth EI: The future of carotid sonography, AJR Am J Roentgenol 158:37–39, 1992.
[20]. Merritt CR, Bluth EI: The future of carotid sonography, AJR Am J Roentgenol 158:37–39, 1992 26:585–594, 1997
[21]. Bluth EI, Kay D, Merritt CR, et al: Sonographic characterization of carotid plaque: detection of hemorrhage, AJR Am J Roentgenol 146:1061–1065, 1986.
[22]. Bluth EI: B-mode evaluation and characterization of carotid plaque. In Tegeler CH, Babikian VL, Gomez CR, editors: Neurosonology, St. Louis, MO, 1996, Mosby-Year Book, pp 62–67
[23]. Langsfeld M, Gray-Weale AC, Lusby RJ: The role of plaque morphology and diameter reduction in the development of new symptoms in asymptomatic carotid arteries, J VascSurg 9:548–557, 1989.
[24]. Geroulakos G, et al: Characterization of symptomatic and asymptomatic carotid plaques using high-resolution realtime ultrasonography, Br J Surg 80:1274–1277, 1993.
[25]. Pandya A, Gupta A. Improving imaging to optimize screening strategies for carotid artery stenosis. Clin Imaging. 2015 Jul 16. [Medline].
[26]. Screening for asymptomatic carotid artery stenosis: recommendation statement. Am Fam Physician. 2015 May 15. 91 (10):Online. [Medline]. [Full Text].
[27]. Screening for carotid artery stenosis: U.S. Preventive Services Task Force recommendation statement. Ann Intern Med. 2007 Dec 18. 147(12):854-9. [Medline].
[28]. Smetana GW, Schermerhorn M, Mukamal KJ. Should We Screen This Patient for Carotid Artery Stenosis?: Grand Rounds Discussion From Beth Israel Deaconess Medical Center. Ann Intern Med. 2017 Oct 3. 167 (7):484-492. [Medline].
[29]. Collaborators NASCET; 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(7):445–453
[30]. ECST Collaborative Group Randomised trial of endarterectomy for recently symptomatic carotid stenosis: final results of the MRC European Carotid Surgery Trial (ECST). Lancet 1998;351(9113): 1379–1387
[31]. Williams MA, Nicolaides AN. Predicting the normal dimensions of the internal and external carotid arteries from the diameter of the common carotid. Eur J VascSurg 1987;1(2):91–96
[32]. Rothwell PM, Gibson RJ, Slattery J, Sellar RJ, Warlow CP. Equivalence of measurements of carotid stenosis. A comparison of three methodson1001angiograms.EuropeanCarotidSurgeryTrialists' Collaborative Group. Stroke 1994;25(12):2435–2439
[33]. Helipoulos, J., Vadikolias, K., Piperidou, C., &Mitsias, P. (2009). Detection of carotid artery plaque ulceration using 3-dimensional
[34]. Rosamond W, Flegal K, Furie K, Go A, Greenlund K, Haase N, Hailpern SM, Ho M, Howard V, Kissela B, Kittner S, Lloyd-Jones D, McDermott M, Meigs J, Moy C, Nichol G, O'Donnell C, Roger V, Sorlie P, Steinberger J, Thom T, Wilson M, Hong Y. Heart disease and stroke statistics--2008 update: a report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Circulation. 2008;117:e25–146. [PubMed]
[35]. Turtzo LC, McCullough LD. Sex-specific responses to stroke. Future Neurol. 2010;5:47–59.[PMC free article] [PubMed]
[36]. Golomb MR, Fullerton HJ, Nowak-Gottl U, Deveber G. Male predominance in childhood ischemic stroke: findings from the international pediatric stroke study. Stroke. 2009;40:52–57. [PubMed]
[37]. Ogeng'o JA, Olabu BO. Cortical stroke in Kenya. Int J Stroke. 2010;5:517–518. [PubMed]
[38]. Putaala J, Metso AJ, Metso TM, Konkola N, Kraemer Y, Haapaniemi E, Kaste M, Tatlisumak T. Analysis of 1008 consecutive patients aged 15 to 49 with first-ever ischemic stroke: the Helsinki young stroke registry. Stroke. 2009;40:1195–1203. [PubMed]
[39]. Bousser MG. Estrogens, migraine, and stroke. Stroke. 2004;35:2652–2656. [PubMed]
[40]. Spengos K, Vemmos KN. Female predominance at very young ages and other similarities between Finnish and Greek young ischemic stroke patients. Stroke. 2009;40:e491. author reply e492. [PubMed]
[41]. Haberman S, Capildeo R, Rose FC. Sex differences in the incidence of cerebrovascular disease. J Epidemiol Community Health. 1981;35:45–50. [PMC free article] [PubMed]
[42]. Gall SL, Donnan G, Dewey HM, Macdonell R, Sturm J, Gilligan A, Srikanth V, Thrift AG. Sex differences in presentation, severity, and management of stroke in a population-based study. Neurology. 2010;74:975–981. [PubMed]
[43]. Gall SL, Tran PL, Martin K, Blizzard L, Srikanth V. Sex differences in long-term outcomes after stroke: functional outcomes, handicap, and quality of life. Stroke. 2012;43:1982–1987. [PubMed]
[44]. Appelros P, Stegmayr B, Terent A. A review on sex differences in stroke treatment and outcome. ActaNeurol Scand. 2010;121:359–369. [PubMed]

[45]. Margaret Kelly-Hayes, Ed.D., R.N.* Influence of Age and Health Behaviors on Stroke Risk: Lessons from Longitudinal Studies; J Am Geriatr Soc. 2010 Oct; 58(Suppl 2): S325–S328.
[46]. Johnsen SH, Mathiesen EB, Joakimsen O, Stensland E, Wilsgaard T, Løchen ML, Njølstad I, Arnesen E. Carotid atherosclerosis is a stronger predictor of myocardial infarction in women than in men a 6-year follow-up study of 6226 persons: the Tromsø study. Stroke. 2007;38:2873–2880. [PubMed]
[47]. Saba, L; Fox, AJ; Sanfilippo, R; Montisci, R; Mallarini, G; HYPERTENSION AND CAROTID ARTERY STENOSIS. A CORRELATIVE STUDY… Journal of Hypertension: June 2010 - Volume 28 - Issue - p e312
[48]. Bosevski M; Carotid artery disease in diabetic patients; 2014;35(3):149-61. [PubMed]
[49]. P Lacroixa, V Aboyansa, MH Criquib, F Bertina, T Bouhameda, F Archambeaudc and M Laskara; Type-2 diabetes and carotid stenosis: a proposal for a screening strategy in asymptomatic patients; Vascular Medicine 2006; 11: 93–99
[50]. G S Tell , J F Polak , B J Ward , S J Kittner , P J Savage , and J Robbins Relation of smoking with carotid artery wall thickness and stenosis in older adults. The Cardiovascular Health Study. The Cardiovascular Health Study (CHS) Collaborative Research Group.; 1994;90:2905–2908 [PubMed]
[51]. Ruijun Ji,1,2,3,4,5 Yuesong Pan,2,3 Hongyi Yan,2,3 Runhua Zhang,2,3 Gaifen Liu,1,2,3,4 Penglian Wang,1,2,3,4 Yilong Wang,1,2,3,4 Hao Li,2,3 Xingquan Zhao,1,2,3,4 Yongjun Wang; Current smoking is associated with extracranial carotid atherosclerotic stenosis but not with intracranial large artery disease; BMC Neurol. 2017; 17: 120. [PubMed]
[52]. Tsuruda JS, Saloner D, Anderson D. Noninvasive evaluation of cerebral ischemia. Trends for the 1990s. Circulation 1991; 83(SI):I-176-I-189.
[53]. Zwiebel WJ. Duplex sonography of the cerebral arteries: efficacy, limitations, and indications. AJR 1992; 158:29-36.
[54]. Hunink JGM, Polak JF, Barlan MM, O'Leary DH. Detection and quantification of carotid artery stenosis:efficacy of various dopplervelocity parameters. AJR 1992; 160:619-25.
[55]. Randoux B, Marro B, Koskas F, et al. Carotid artery stenosis: prospective comparison of CT, three-dimensional gadolinium-enhanced MR, and conventional angiography. Radiology 2001;220:179–85
[56]. Amin Banaei, 2017 March 31, The Comparison between Digital Subtraction Angiography, CT Angiography, and Doppler Ultrasonography in Evaluation and Assessment of Carotid Artery Stenosis.

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