# Value of carotid Doppler ultrasound and brain CT scan in ischemic stroke

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الخلاصة
تستخدم الامواج فوق الصوتية على حد سواء باستخدام السونار العادي او السونار المعروف بالدوبلر على نطاق واسع لفحص الشرايين السباتية وذللك لتقييم المخاطر للحوادث الدماغية الوعائية (السكتة الدماغية ) وقد اجريت هذه الدراسة لتقييم حالة الاوعية السباتية في المرضى الذين يعانون من السكتة الدماغية الحادة من خلال تقييم سماكة الجدار الداخلي للشريان السباتي الرئيسي ,قياس منطقة التضيق وتشخيص اللويحات داخل الشريانزما مجموعه 68 مريضا مع السكتة الدماغية (21 انثى .47 ذكر) تم فحص الشرايين السباتية لنفس جهة الدماغ المتاثرة.وجد ان 36 مريض ليس لديهم تضييق. 32 مريض (47.05 %) لديهم درجات مختلفة من التضييق على النحو التالي : 19 مريض (59.94%) لديهم تضيق خفيف.9 مريض (28.12%) لديهم تضييق معتدل .4 مريض(12.5%) لديهم تضيق حاد. واظهر ان 40 مريض (58.825) لديهم زيادة في سماكة الجدار الداخلي .28 مريض سماكة الجدار كانت طبيعية كما وجد ان 42 مريضا (61.76%) كان مدخنا. وترتبط زيادة سماكة الجدار االداخلي للشريان السباتي مع السكتة الدماغية ووجد ان الحجم الكبير لاحتشاء الدماغ هي الاكثر ارتباطا مع التضييق الشديد للشرايين السباتية ، وهناك علاقة كبيرة بين اللويحات وحجم احتشاء الدماغ

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**Abstract**

Sonographic evaluation of the carotid arteries, both gray scale and Doppler is widely used for risk assessment for cerebrovascular accidents .This study was conducted to assess the state of carotid vessels in patients with acute ischemic stroke by assessing intima-media thickness of common carotid , internal carotid stenosis with the size of ischemic area that diagnosed by using computed tomography . : A total of 68 patient with stroke (21 females , 47 males) were assesed, Gray scale & Doppler US of the ipsilateral carotid arteries performed , measurement of IMT of CCA , the presence of any plaque recorded , the diameter reduction measurement PSV & EDV of the CCA & ICA . 36 patient have no stenosis (52.94%), 32 remaining patient have different degree of stenosis (47.05%),as follow .19 patient have mild stenosis (H1)(59.37%), 9 patient have moderate stenosis (H2)(28.12%) , 4 patient have sever stenosis(H3)(12.5%).40 patient showed increased IMT (58.82%), 28 patient had normal IMT (41.17%).42 patients are smokers (61.76%),So increased intimal media thickness of common carotid artery is associated with stroke .Large size ischemic stroke are more associated with high degree of internal carotid artery stenosis ,There is a significant relation between atheromatous plaque and size of brain infarction

**Key words**. Stroke,, Carotid gray scale, Carotid Doppler, head CT scan .

## Introduction

Ischaemia due to of the extracranial carotid arteries flow limiting stenosis is common predisposing cause of stroke [1]. Pathological studies indicate that 80-85 % of strokes are due to cerebral infarctions. Atherosclerotic disease of the carotid arteries outside the cranial cavity has long been recognized as the most common source of emboli that travel to the brain causing stroke [2]. Therefore early detection of these athermanous changes in carotid artery will

help a great deal in reducing stroke related morbidity and mortality. [3].The main goal of carotid arteries imaging with color Doppler is to quantify the degree of stenosis caused by atherosclerosis in patient with stroke.[4]

Doppler imaging is a useful non-invasive procedure which is able to find carotid artery stenosis in patient with stroke or TIA [5]. By sing B mode imaging , the presence of early stages of atherosclerosis can be detected , including intima-media thickness IMT .[6] . Besides this it helps to detects plaques, characterize them into those associated with high risk or low risk for cerebrovascular accidents [7 ]. Colour Doppler shows flow in normal carotid arteries is pulsatile with forward flow throughout the cardiac cycle

Spectral Doppler helps us to evaluate the waveform in carotid vessels.[8] . Peak systolic velocities seen in the carotid arteries typically less than 110 cm/s in the normal ICA.Significant changes in the velocity within and just beyond a stenosis will be detected once the vessel is narrowed by a 50% reduction in diameter .The information obtained from all three modalities should be used to estimate the degree of narrowing [9]

Stenosis degree in the ICA was classified into 5 categories (table 1) based on 2 primary parameters, ICA PSV and plaque size, and 2 secondary parameters, ICA/CCA PSV ratio and ICA EDV ,convened in San Francisco by multidisciplinary panel of experts under the auspices of the Society of Radiologists inUltrasound (SRU) (10)

**Table (1) show the criteria for grading carotid stenosis**

| Degree of stenosis | ICA PSV cm/sec | Plaque Estimate | ICA/CCA PSV ratio | ICA EDV cm/sec. |
|---|---|---|---|---|
| Normal | Less 125 | none | <2.0 | <40 |
| < 50 | 125 | <50 | <2.0 | <40 |
| 50-69 | 125-230 | >50 | 2.0-4.0 | 40-100 |
| >70 less than total occlusion | >230 | >50 | >4.0 | >100 |
| Near occlusion | High ,low or undetectable | Just visible | Variable | Variable |
| Total occlusion | | No detectable lumen | Not applicable | Not applicable |

CT scanning has been the modality of choice for imaging patients with acute stroke[11 - 13] may show Hypo attenuating brain tissue ,obstruction of lentiform nucleus or blurred basal ganglia ,Insular ribbon sign and dense middle cerebral sign .

**Aim of study**

- To assess the state of the extracranial carotid vessels in patients with acute ischemic stroke
- To study the relation of intima-media thickness of common carotid & the degree of internal carotid stenosis with the size of ischemic area

**Patient and method**

This is a prospective study, conducted from October 2013 to August 2014 in Department of Radiology at Al- Imamein kademein medical city . A total of 68 (21 females , 47 males) Patients with diagnosis of acute ischemic stroke , then brain CT examination was done within the first 7days after presentation ,the findings were recorded including the size, site & density of the lesions . Demographic & Clinical Information recorded including history of hypertension, diabetes mellitus, cardiac

diseases & smoking , lipid profile was assessed for each patient.

In Doppler unit ,ultrasonic machine **(Philips HD 11-EX )** utilizing high frequency linear transducer 7.5 MHz , sonographic examination of the ipsilateral internal, external and common carotid arteries of patient was done .The examination started with a transverse scan of carotid artery 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 CCA by assessing the far walls & the mean value was recorded , a value of more than 1 mm was considered abnormal

When plaque was seen, characterization of this plaque was done (figure 5 ) the plaques were classified according to Thiele et al [14 ] .[table 2 ].

**Table (2 ) show the diameter stenosis grading , morphology & surface classification of carotid plaque .**

| Homodynamic ( % stenosis diameter) | morphplogical | By surface |
|---|---|---|
| H H1,mild (<50%)<br>H2,moderate (50%-69%)<br>H3,sever (70%-95%)<br>H4,critical (95%-99%)<br>H5,occluding (100%) | P1, homogenous<br>P2, heterogeneous | S1,smooth<br>S2,irregular(defect <2mm)<br>S3.ulcerated(defect >2 mm |

**With doppler** Areas of abnormal flow are identified with color Doppler, then spectral Doppler examination was undertaken , peak systolic velocity (PSV) and end diastolic velocity (EDV) and measurements are taken from CCA, ICA ..Degree of stenosis was assessed by two types of data: Direct measurement of the diameter of stenosis , measure the diameter of the residual lumen & the original diameter of the vessel..The data is checked and entered into statistical package for social science (SPSS), we used the version 17 in the analysis of our data. To determine the association between different variable, Chi square was used the determined these association where P value < 0.05% is considered as statistical significant.

**Results**

Sixty eight patient. (21 female, 47 male), their ages ranged from 32-75 years, the mean age was57.2 years,of these 26 patients were in age group (50-59) which represented (38.2% ) with male predominance in all age groups .

**Risk factor:**

- 30 out of 68 patients (44.11 %) had hypertension (HPT)
- 21 out of 68 patients (30.88 %) had diabetes (D.M.)
- 42 out of 68 patients (61.76 %) were smokers.
- 19 out of 68 patients (27.94 %) had cardiac disease
- 15 out of 68 patients (22 %) had abnormal lipid profile

**CT scan of ischemic stroke regarding the size of infracted area**

- Small infarction (<1.5cm) seen in 24 from 68 (35 %) patients
- Medium infarction (1.5-3cm) seen in 12 from 68 (17.6 %) patients
- Large infarction (> 3cm) seen in 32 from 68 (47.05 %) patients

**Intimal media thickness (IMT)**

- 40 from 68 (58.82%) patients had increase IMT above 1mm.

- ❖ 28 from 68 (41.17) patient had normal IMT.

**Athermanous plaque** studied in patient with stenosis of ipsilateral ICA with more than one plaque may be found in the same patient, 41 plaques identified in (32 patients with plaques)

**Surface of the plaque**

- 17 out of 41 (41.46%) plagues are smooth (S1).
- 14 out of 41 (34.14%) plagues are irregular (S2) (defect less 2mm )
- 10 out of 41 (24.39%) plagues are ulcerated (S3) (defect more 2mm)

**Morphology of the plaque**

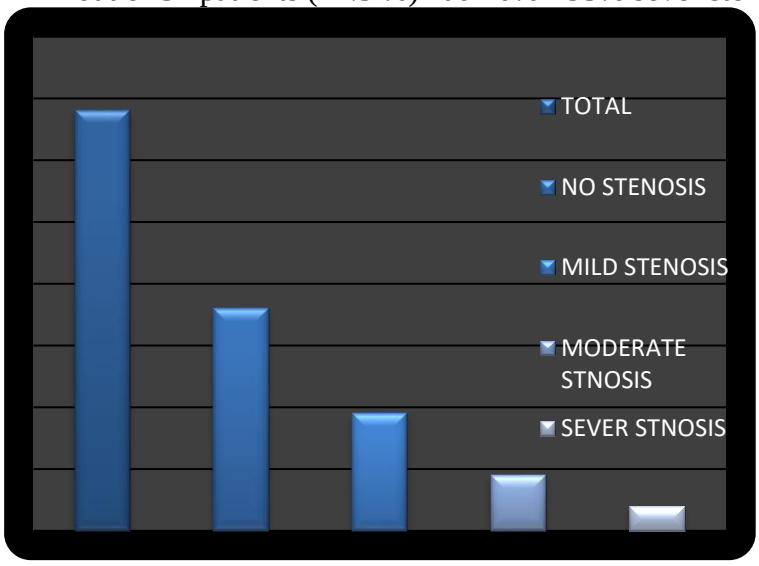
- 28 out of 41 (67.58 %) plaque are homogenous (P1).
- 13 out of 41 (31.70 %) plaque are heterogeneous (P2).

**Stenosis of internal carotid artery by Doppler was as follow (Fig 1 )**

- 36 out of 68 patients (52.94 %) had no evidence of stenosis
- 32 out of 68 patients (47.05 %) had evidence of internal carotid artery stenosis

**The degree of stenosis of ICA was as follow (Fig 1)**

- 19 out of 32 patient (59.37 %) had <50% mild stenosis (H1).
- 9 out of 32 patient (25 %) had 50%-69% moderate stenosis (H2) .
- 4 out of 32 patients (12.5 %) had 70% - 95% sever stenosis (H3).




**(Fig. 1) distribution of patient with ischemic stroke according to the presence & degree of carotid stenosis**

**. <u>Stenosis of ICA</u>.**

**<u>No stenosis</u>**

With no stenosis This group is represented by 36 patient (25 male, 11 female) which constitute 52.94% of all the cases ,Regarding the size of infarction, 55.55 % cases had small size infarction with significant association at ($P < 0.05$). (fig. 2)

The most associated risk factors were as follows (fig 3):

Smoking (52.77 %), cardiac disease (41.66 %), hypertension (33.33 %), D.M (33.33%), and hyperlipdemia (25.00%) .

**<u>Mild Stenosis H1 (<50%).</u>**

This group consisted of 19 patient (13 male, 6 female) which constitute (27.94 %) of all the cases ,The majority of cases (73.68 %) had large size infarction with significant association at ($P < 0.05$).(fig 2)

The most associated risk factors were as follows (figure 3):

Smoking (57.89 %), hypertension (52.63 %), hyperlipidemia (31.57%), D.M. (26.31%) and cardiac disease (21.05%).

**<u>Moderate Stenosis H2 (50% - 69%)</u>**

This group consisted of 9 patient (6 male, 3 female) which constitute (13.23 %) of all the cases ,There are (66.66 %) cases

of large size infarction seen with significant association at (P < 0.05) (figure 2).

The most associated risk factors were as follows (fig 3): Smoking and hypertension represented (66.66 %), diabetic mellitus (44.44 %) , hyperlipidemia (33.33%) and cardiac disease (11.11%).

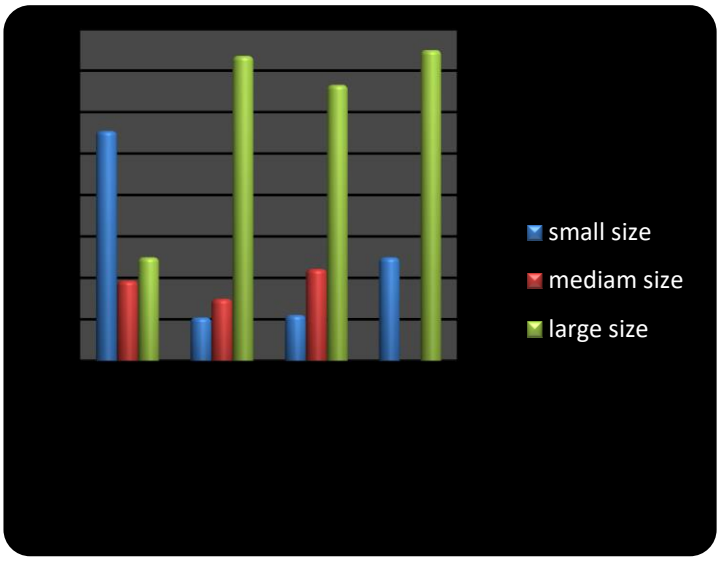
**Sever Stenosis (70% - 95%).**

The group were 4 patient which consist (5.88 %) of all the cases In this group, (75 %) cases had large size infarction seen with significant association at (P value less 0.05) (figure 2)

The most associated risk factors were as follows (fig 8): Smoking and hypertension represented (100 %), diabetes and hyperlipidemia (50%), cardiac disease (25%).

No patients have critical (stenosis 95% - 99%) or occluded (100% stenosis) were seen during the study time.

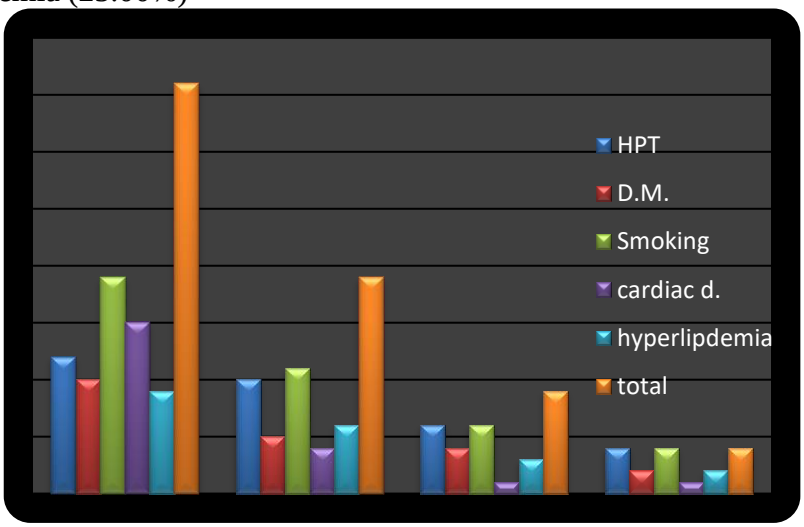
Regarding the size of infarction, 55.55 % cases had small size infarction with significant association at (P < 0.05). (Fig. 2)




**(Fig.2) relation between the stenosis and size of infarction**

**The most associated risk factors were as follows (fig 8):**

Smoking (52.77 %), cardiac disease (41.66 %), hypertension (33.33 %), D.M (33.33%), and hyperlipdemia (25.00%)




**(Fig .3) relation between risk factor and stenosis of ICA**

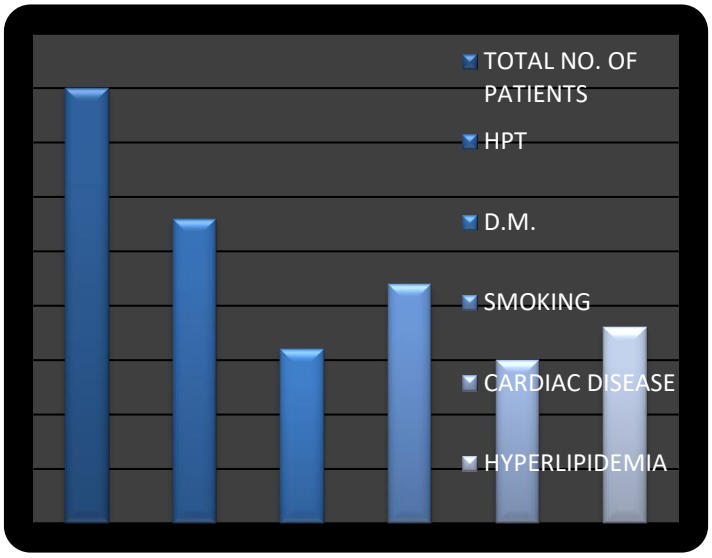
**Analysis of intimal thickness**

There is 40 patients out of 68 who had increased in IMT which they represented (58.82 %), while there is 28 patients have normal IMT, they represented (41.17 %).

**Table (3) shows degree of stenosis in relation to abnormal & normal IMT**

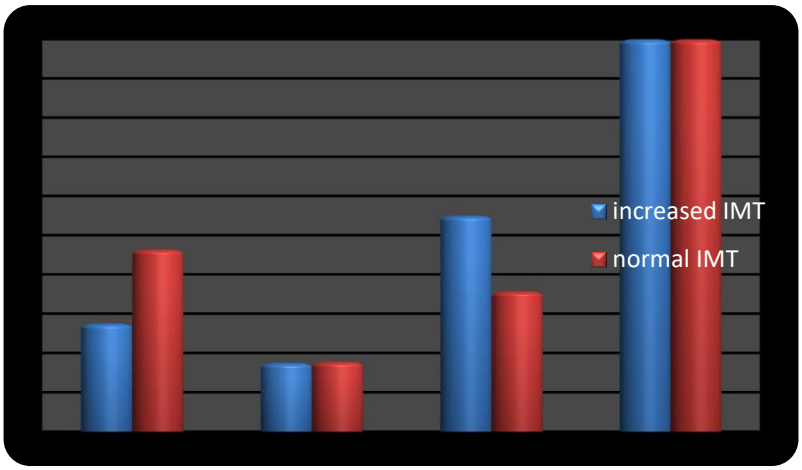
| (%) stenosis diameters | Abnormal IMT patient | Normal IMT patient |
|---|---|---|
| **No stenosis** | 16 (40%) | 20 (71.4%) |
| **H1 mild stenosis** | 14 (35%) | 5 (17.8%) |
| **H2 moderate stenosis** | 7 (17.5%) | 2 (7.14%) |
| **H3 sever stenosis** | 3 (7.5%) | 1 (3.57%) |
| **Total** | 40 (100%) | 28 (100%) |

The most common associated risk factor (fig 4)




**(Fig .4 ) shows relation of risk factors to increased IMT.**

There is no significant association between the increased abnormal IMT and the size of infracted area of ischemic stroke at (P value < 0.05. (fig 5 ).




**(Fig.5) normal and abnormal IMT relation to infarction size.**

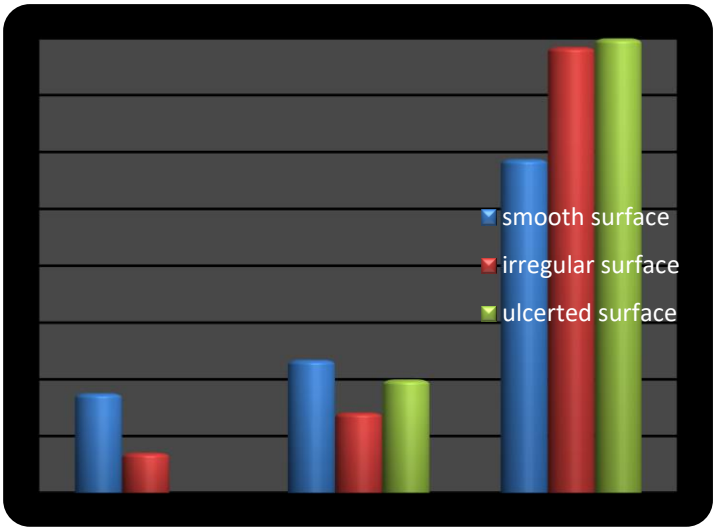
**Plaque characteristics**

The numbers of plaques exceed the number of patients that have the stenosis, which due to some patient shows more than one plaque during the exam, each plaque characterized and included in study

1- Surface of plaque results was as follow

- 17 plaques out of 41 (41.46 %) show smooth surface (S1).
- 14 plaques out of 41 (34.14 %) show irregular surface (S2).
- 10 plaques out of 41 (24.39 %) show ulcerated surface (S3).

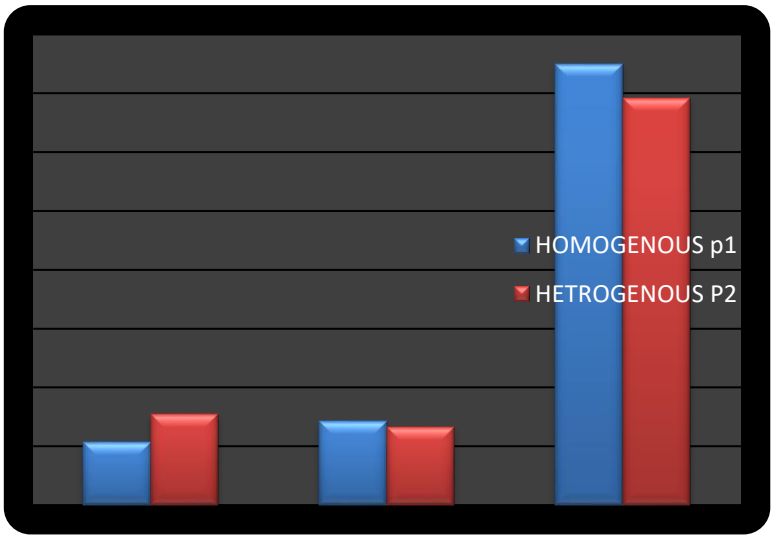
There is significant association between large size infarction and ulcerated and irregular plaque surface at P < 0.05) as shown in fig (6)




**(Fig. 6) shows the relation between the infarction size and plaque surface**

Texture of plaque and results was as shown below. Homogenous hypo echoic 28 plaque out of 41 (68.29 %).Heterogeneous 13 plaque out of 41 (31.70 %)

There is significant association between the homogenous plague and large size infarction in ischemic stroke patient (28 patient = 75 % at P value <0.05) fig (7)




**(Fig.7) shows the relation between the morphology of plaque and infarction size.**

## Discussion

A stroke, is the loss of brain function due to a disturbance in the blood supply to the brain. Atherosclerotic disease of carotid arteries outside the cranial cavity has long been recognized as the most common source of emboli to the brain causing stroke. [2]

Smoking and hypertension are the most common risk factors that associated with sever degree of stenosis H3 which is similar to finding reported by Alexander el al [15] . We found that there was a significant association between large size infarcts with presence of carotid stenosis , the majority of patients with ICA stenosis show large size infarction while most of the those patients with no stenosis had small size infarction ,these findings are in part in agreement with study of Lodder et al [16].

Increased common carotid artery intimal thickness is seen in considerable number of stroke patients (40 case which represented 58.82 % from all patients ),more in patient with internal carotid artery stenosis (24 cases which is represented 60% from the cases show increased IMT), which is corresponding with finding of Touboul et al [17] and Bots et al [18].

There is significant association of the known risk factors of stroke with increased IMT in our study for hypertension we have 28 case which represented (70% from all cases with increased IMT ) and smoking we have 22 cases which is represented (55% from all cases with increased IMT ) which is corresponding to the finding of Essa et al [5] and Geroulakos Get al[19].

Homogenous plaques are more frequent in patients with large size infarction (21 cases which is represented 75% of all cases show homogenous plaque. Which is slight higher than Aubaid et al (20) how record (67%) , that Support the suggestion that the more friable, lipid containing soft plaques is more likely to result in plaque disruption and produce symptoms more than that of firmer more fibrous and coherent plaques [4].

There is significant association between the large size infarction and ulcerated plaque, due to that these plaque of ulcerated surface give rise to large emboli which is produced large infarct area.

Sever stenosis H3 (70%-95%) associated with large size infarction (3 cases which represented 75% of all cases show that stenosis), which is slightly higher than Aubaid et al [20] that record (66%) .Carotid Atheromatous plaques with high lipid content are at an increased risk of giving rise to massive cerebral infarction. [21 ].

The presence of ulcerated plague in internal carotid artery is risk factor for ischemic stroke; Nakamura et al demonstrated a significant association between stroke and presence of echo lucent ulcerated plaque [22].

## Recommendation

Doppler study for carotid artery stenonsis is recommended for those old persons who have risk factor for cerebrovascular accident as hypertension ,smoking ,hypercholesteremia ,diabetes and known cardiovascular disease.

## Conclusion

- Smoking, hypertension and male gender is the most associated risk factor.
- Increased intimal media thickness of common carotid artery is associated with stroke and regarded as risk factor.
- Large size ischemic strokes are more associated with high degree of internal carotid artery stenosis .
- Small size ischemic strokes are more associated with normal carotid artery study.
- There is a significant relation between Atheromatous plaque characteristics of ipsilateral carotid artery and size of brain infarction especially when the plaque is homogenous with irregular or ulcerated surface .

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