Carotid Doppler Study in Patients with Cerebral Infarction

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Summary:

Background: Duplex ultrasound is inexpensive, non-invasive and can provide functional and anatomical information about vessel stenosis and plaque morphology. Color duplex flow ultrasonography has thus become the most widely used noninvasive method of assessing extra cranial cerebrovascular occlusive disease.

Objectives: To find the relation of the severity of carotid artery stenosis, intima media thickness, and atheromatous plaque morphology with the size of cerebral infarction.

Patients and Methods: A prospective study, conducted from September 2010 to May 2011, in Department of Radiology in Baghdad Teaching Hospital. A total of 62 Patients with clinical & radiological (brain CT) diagnosis of acute stroke, (42 males & 20 females) had been referred from Medical & Neurological units to the Radiology Department / Ultrasound Unit for carotid arteries examination.

Results: Thirty out of 62(48.4%) patients had evidence of ipsilateral carotid stenosis distributed as: 18 out of 30 patients (60%) had < 50% stenosis, 8 patients (26.7%) had 50-69% stenosis, and 4 patients (13.3%) had > 70% stenosis. Also in our study we found that homogenous hypoechoic and ulcerated plaques were more frequent in patients with large size infarcts.

Conclusion: From this study we concluded that the size of cerebral infarction is related to degree of ipsilateral carotid artery stenosis, especially when the plaque is soft with irregular or ulcerated surface, and that increased intima media thickness of common carotid artery is strongly associated with stroke and its risk factors.

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Introduction:

Stroke is an injury of central nervous system that is characteristically abrupt in onset and is due to a vascular insult. The term is reflective to damage to the brain secondary to ischemia or hemorrhage (1). Pathological studies indicate that 80-85 % of strokes are due to cerebral infarctions and 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). High-degree internal carotid artery stenosis is the most well-known risk factor for the development of cerebrovascular events (3). Duplex ultrasound is inexpensive, non-invasive and can provide functional and anatomical information about vessel stenosis and plaque morphology (4,5). The sensitivity and specificity of carotid duplex US range from 90% to 95% for measurement of carotid diameter reduction, and duplex US may be more sensitive for detection of minimal atherosclerotic plaque (6,7). The main goal of carotid arteries imaging with color Doppler is to quantify the degree of stenosis caused by atherosclerosis in patient with stroke. Additional findings such as intima-media thickness (IMT) of the common carotid artery (CCA) & plaque morphology may help in assessing the carotid artery as the source of the cerebrovascular symptoms (8). Criteria for grading stenosis were according the stratification developed by the consensus panel of the Society of Radiologists in Ultrasound in 2003.

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Patients and Methods:

This is a prospective study, conducted from September 2010 to May 2011, in Department of Radiology in Baghdad Teaching Hospital. A total of 62 Patients with clinical & radiological diagnosis of acute stroke, (42 males & 20 females) referred from Medical & Neurological units to the Radiology Department /Ultrasound Unit for carotid arteries examination. In all cases, the brain CT examination was done within the first 5 days after presentation (i.e. in acute phase). At first, patient information and his/her past medical history were recorded. Then the brain CT films were reviewed & findings were classified according to the subtypes of stroke including: Lesion is ischemic or hemorrhagic, size, site, number of lesions, and chronicity. Then complete Sonographic examination of the extracranial carotid arteries of the patients was performed. All patients were examined by ultrasound device Philips HD 11-XE using 7.5 MHz linear probe. 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. Doppler is then activated & the vessels are examined in the longitudinal plane again from the lower neck upwards. Areas of abnormal flow are identified with color Doppler, an initial assessment of their significance is made & the need to undertake a spectral examination can be considered. Just importantly, areas of normal flow are seen so that the normal segment of the vessel can be identified rapidly & excluded from investigation. After delineation of CCA, ICA, bulb & ECA, vessel wall

is assessed & IMT of CCA is measured (value of >1mm is abnormal). All focal plaques are considered abnormal. Once plaque is seen, its morphology is evaluated, including: extent, location, texture whether homogenous or heterogeneous, hyperechoic (calcified) or hypoechoic & surface whether smooth, irregular, or ulcerated. Once the bifurcation & its branches have been identified & when no areas of significant disease are present, peak systolic velocity (PSV) and end diastolic velocity (EDV) and measurements are taken from CCA, ICA & ECA. These are obtained using spectral Doppler from upper CCA 2-3 cm below bifurcation; ICA from 1-2 cm above the bulb, or as high as possible in order to allow the normal bulbar turbulence to settle; & from proximal ECA. Degree of stenosis was assessed by two types of data direct measurement using calipers on machine by assessing arterial diameter reduction ratio or by analysis of the Doppler spectra which includes: analysis of waveform components (peak systolic & end diastolic flow, flow direction & reversed flow) & shape (high resistance e.g. ECA, low resistance e.g. ICA) & ICA/CCA Systolic ratio.

Results:

A total of 62 patients aged 35-78 years with stroke diagnosed by Brain CT examination underwent a color Doppler examination of their bilateral carotid arteries and findings were recorded and the results were as following. The mean age of the patients was 55.8 $\pm$ 11.8 years. There were 42 males (67.7%) and 20 females (32.3%). The main age group included in the study was between 50-59 years. Risk factors were as follow: 28 patients were hypertensive (45.1%), 20 patients were diabetic (32.3%), 36 patients were smokers (58%), 19 patients had a cardiac disease (30.6%) and 20 patients had a previous history of stroke (32.3%). Carotid Doppler findings were 32 out of 62 (51.6%) patients had no stenosis in carotid Doppler ultrasound, 30 out of 62 (48.4%) patients had some evidence of ipsilateral carotid stenosis distributed as shown in figure (1). All patients had ischemic infarction on Brain CT**;** Large infarction (> 3 cm) in 30 out of 62 patients (48.4%), Medium infarction (1.5-3 cm) in 10 patients (16.1%), and Small infarction (< 1.5 cm) in 22 patients (35.5%)**.** Patients with no stenosis were 32 (22 males and 10 females) in number constituting (51.6%) of all cases. Main age group involved was between 50-59 yeas (11 patients, 34.3%). Small sized infarct was the most frequent (18 cases, 56%) with significant association (P value < 0.05). Patients with mild Stenosis (<50%) were 18 (12 males and 6 females) constituting (29%) of all cases. The commonest age group was between 50-59 years (7 patients, 38.8%). Large sized infarct was the commonest (13 cases, 72.2%) with significant association (P value < 0.03). Patients with moderate Stenosis (50-69%) were 8 (5 males and 3 females) constituting (12.9%) of all cases. The main age group was between 50-59 and 60-69 years (3 patients in each group, 37.5%). Large sized infarct was the commonest (6 cases, 75%) with significant association (P value < 0.05). Patients with severe Stenosis (≥70%) were 4 patients (3 males and 1 female) constituting (6.5%) of all cases. The main age group were between 60-69 and 70-79 years (2 patients in each group, 50%). Large sized infarct was the commonest (3 cases, 75%) with significant association (P value < 0.01). Table (1) Thirty six out of 62 patients (58.1%) had bilateral increased IMT (> l mm) distributed as shown in figure (2). There was a significant association (P value < 0.02) between abnormal IMT and size of brain infarction, and most of cases had large brain infarcts (14 cases, 38.9%). Regarding plaque morphology: Of the 30 patients who have ipsilateral carotid stenosis, the plaque texture was as follow, homogeneous hypoechoic in 11 patients (36.7%), homogeneous hyperechoic in 9 patients (30%), and heterogeneous in 10 patients (33.3%) as shown in table (2). In our study we found a significant association (P value < 0.03) between homogenous hypoechoic plaque and large sized cerebral infarction (9 cases, 81.8%). Regarding plaque surface, the results were smooth in 12 patients (40%), irregular in 10 patients (33.3%), and ulcerated in 8 patients (26.7%) as shown in table (3). There was a significant association (P value < 0.05) between large sized infarction and ulcerated surfaced plaque (7 cases, 87.5%).

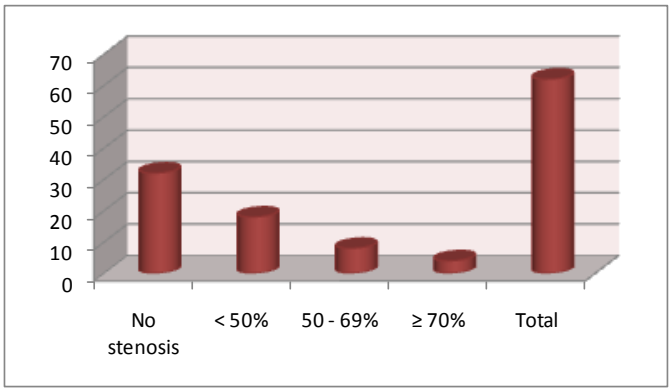

Figure (1): Shows ipsilateral carotid stenosis in patients with stroke

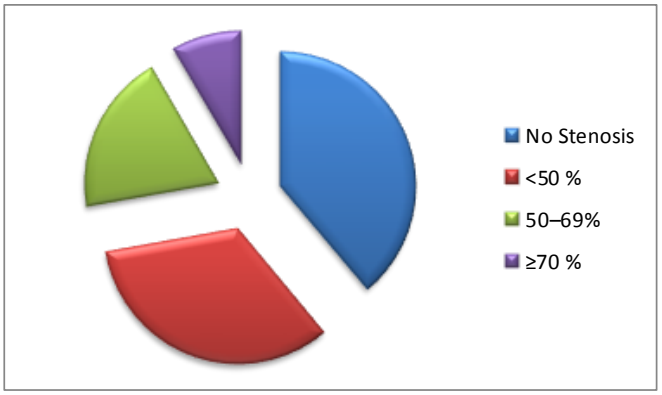

Figure (2): Shows on to ipsilateral carotid

Table (1): Shows degree of ipsilateral carotid stenosis in relation to infarct size in patients with stroke

ipsilateral stenosis degree	Infarction size			Total
	Small	Medium	Large	
No Stenosis	18 (56%)	6 (19%)	8 (25%)	32 (51.6%)
<50% Stenosis	3 (17%)	2 (11%)	13 (72%)	18 (29%)
50–69% Stenosis	1 (12.5%)	1 (12.5%)	6 (75%)	8 (13%)
≥70 % Stenosis	0	1 (25%)	3 (75%)	4 (6.4%)
Total	22 (35.5%)	10 (16%)	30 (48.5%)	62 (100%)

Table (2): Shows plaque texture in relation to the size of infarction in stroke patient with carotid stenosis

Atheroma texture	Infarction size			Total
	Small	Medium	Large	
Homogeneous hypoechoic	1 (9.1%)	1 (9.1%)	9 (81.8%)	11 (36.7%)
Homogeneous hyperechoic	2 (22.2%)	2 (22.2%)	5 (55.6%)	9 (30%)
Heterogeneous	2 (20%)	1 (10%)	7 (70%)	10 (33.3%)
Total	5 (16.7%)	4 (13.3%)	21 (70%)	30 (100%)

Table (3): Shows plaque surface in relation to the size of infarction in stroke patient with carotid stenosis

Atheroma surface	Infarction size			Total
	Small	Medium	Large	
Smooth	2 (16.7%)	3 (25%)	7 (58.7%)	12 (40%)
Irregular	1 (10%)	1 (10%)	8 (80%)	10 (33.3%)
Ulcerated	0	1 (12.5%)	7 (87.5%)	8 (26.7%)
Total	3 (10%)	5 (16.7%)	22 (73.3%)	30 (100%)

Discussion:

Commonest age group (21 patients, 33.87%) involved in our study were between 50-59 years old age (mean 55.8 $\pm$ SD 11.8 years) with males exceeding females in all age groups and these finding are similar to that seen by Alexander et al (9). Smoking and hypertension were more frequent in patients with higher degrees of stenosis (50-69% and ≥ 70%) than in milder degree (< 50% stenosis) which was similar to what was reported by Alexander et al study (9). Of all 62 patients, 32 (51.5%) had no stenosis of ipsilateral ICA and 30 (48.4%) had different degrees of stenosis; this was comparable to the findings of Zhu et al (10). Of the 30 patients with stenosis, 18 (60%) had <50% stenosis which was approximately similar to previous studies by Adetiloye et al (11), and Carroll et al (12). The prevalence of patients with 50-69% stenosis was 8 (26.7%) which was approximately similar to that reported by Alexander et al (9) (24.3%). While the prevalence of ≥ 70% stenosis was 4 patients (13.3%) & was slightly lower than that reported by Brown et al (6) (20%). Regarding the size of brain infarction, we found that there was a significant association between large size infarcts with presence of carotid stenosis and this was in agreement with study of Lodder et al (13), who suggested that hemodynamic impairment may contribute to infarct size in territorial infarcts of non-cardiac origin. Regarding the atheromatous plaque morphology, homogenous hypoechoic plaques were more frequent in patients with large size infarcts with statistically significant association support the suggestion that the more friable, lipid containing soft plaques are more likely to result in plaque disruption and produce symptoms more than that of firmer more fibrous and coherent plaques (14) and this was in agreement with results of previous studies by Carra (15) and Tegos (16). The large size infarcts were significantly associated with only ulcerated plaques; we thought that ulcerated plaques give rise to large emboli that produce infarcts larger than that produced from irregular plaques because of smaller surface defect. This observation confirms the Handa et al (17) suggestion about the important role of plaque surface in pathogenesis of cortical infarcts, as he found that patients with ulcerated plaques have 7 folds increased risk for stroke. This significant association of plaque characteristics with infarction supports the suggestion that cerebrovascular diseases not only result from flow limiting effect of stenosis, but also from embolism, especially in non-hemodynamic stenoses (17). Interestingly, we found that increased IMT in both CCA was present in significant number of our stroke patients (36, 58.1%) but more frequent in patients with ICA stenosis (22, 61.1%) than in those with no stenosis (14, 38.9%) which was comparable to other studies by Touboul et al (18), Bots et al (19), who reported that there was a significantly higher incidence of stroke in patients who had increased IMT, suggesting a type of relationship with brain infarction related to atherosclerosis irrespective to the presence of stenosis, because increased IMT is thought to be a measurable index of the presence of atherosclerosis (20,21) and associated with increased risk of coronary vascular diseases (22). Furthermore, as it is thought that the IMT of the CCA is associated with risk factors for stroke (23), the statistically significant association of the known risk factors of stroke with increased IMT in our study is supported by other studies (22).

Conclusion:

We concluded that most of cases with normal carotid Doppler study are seen to have a small size infarction. While those with 50% or more carotid stenosis, most of them have large size infarcts. Also there is a significant relation between atheromatous plaque characteristics in ipsilateral carotid artery and size of brain infarction especially when the plaque is soft with irregular or ulcerated surface. And increased IMT of CCA is strongly associated with stroke and its risk factors.

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