Role of Multislice CT in Assessment of Carotid Stenosis

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Abstract: Objective: the objective of this study is to evaluate the role of multislice CT in evaluation of carotid stenosis. Method: forty five patients who had neurological symptoms suggestive of neurovascular disease and who had 60% stenosis on Doppler study were evaluated by multislice CT and DSA and the results were compared for each of the ninety carotid arteries. Results: Conventional angiograms and CT angiograms were in agreement in 71 arteries (79 %). Disagreement was found in the remaining eighteen arteries were CT angiogram showed the stenosis to be one category less in 13 arteries (14.4%) and one category more sever in 6 arteries (6.66%). No disagreement was found by more than one category. Sensitivity and specifity for detecting sever stenosis or occlusion was 85% and 97 %.

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Introduction

Cerebrovascular Stroke is one of the leading causes of morbidity and mortality worldwide. Carotid artery stenosis is a frequent finding in the general population with a prevalence of 75% in men and 62% in women over 64 years as determined by ultrasonography. Atherosclerosis is by far the commonest cause of arterial stenosis and occlusion in clinical practice. Although atherosclerosis may affect the intracranial vessels themselves, 88% of patients with amaurosis fugax or hemispheric transient ischemic attacks have atherosclerotic disease at the carotid bifurcation(6)

Results of the North American Symptomatic Carotid Endoarterectomy Trial (NASCET); the European Carotid Surgery Trial (ECST); and the Asymptomatic Carotid Study (ECACAS) show the effectiveness of carotid endarterectomy for preventing stroke in patients with significant carotid stenosis. More recently, surgery has been suggested for high-grade asymptomatic severe stenosis. (6)

Conventional angiography was considered to be the standard method for evaluating stenosis of the internal carotid artery however, this technique is associated with a risk of thromboembolic event because of the use of an arterial catheter and because angiography outlines the luminal profile in limited angular projections and does not demonstrate the arterial wall or the plaque itself, it is unreliable in depicting ulceration. Furthermore, the results can cause under- or overestimation of the degree of stenosis. Moreover, the invasiveness of the technique adds risk, including stroke, making it impractical for the screening of asymptomatic patients or monitoring of disease progression. (3)

Recently, noninvasive techniques, such as computed tomographic (CT) angiography, have been developed. By using CT angiography, the cross-sectional luminal morphology can be accurately evaluated and the degree of stensis can be assessed .(5)

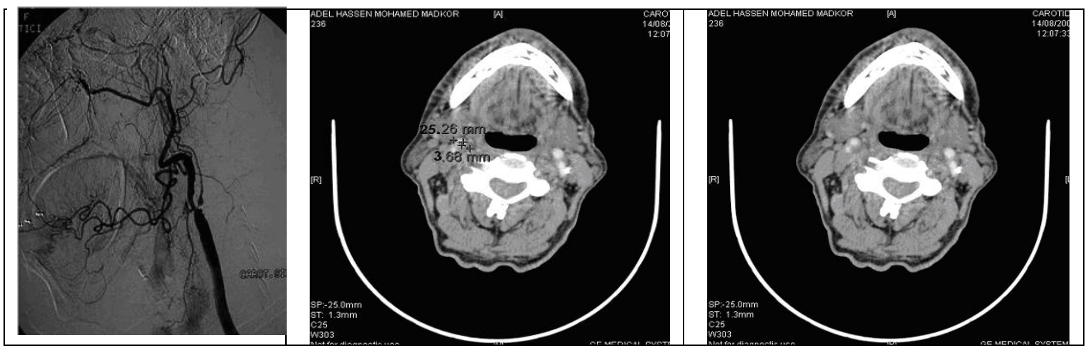
2. Patients and Methods

The study starts from August 2007 till July 2009 on forty five patient (90 arteries) suffering from stroke, TIA or other neurological symptoms suggestive of neurovascular disease. Those patients were referred from the Neurology Departments in Ain Shams University Specialized Hospital for Doppler sonography and were found to have significant disease in the form of a stenotic lesion causing more than 60% narrowing of lumen at site of stenosis compared to distal normal segment of the affected artery or doubling of velocity at site of stenosis.

Those patints were furtherly evaluated by CT angiograrhy and conventional angiography .CT scanning was performed with 120 kV and 250 mAs. The other imaging parameters were 1.6 mm section thickness, 3 mm collimation, 12-19 cm field of view, 3 mm/sec table feed, and 0.5 second gantry rotation time. Spiral scanning included the volume between the seventh cervical vertebra and the circle of Willis. The patients were asked to breathe evenly and smoothly without swallowing or moving.

The non-ionic iodinated contrast agent used is iopromide (Ultravist) 300 mg of iodine/mL; Bayer Health Care (formerly Schering AG). The volume for CT angiography was 120 mL, with a saline chaser bolus of 30 mL by using a flow rate of 3 mL/s with a 1.3-mm (18 gauge) cannula through the median cubital vein. The bolus-tracking method was used for assessment of the optimal time delay for CT scanning, to optimize contrast material enhancement in carotid arteries; the region-of-interest indicator was placed on a reference image obtained from the aorta.

Fig (1). Sever stenosis of proximal right ICA seen by conventional angiogram and axial source images of CT angiogram.



Fig(2): Moderate stenosis of right internal carotid seen by conventional angiogram and axial source images of CT angiogram.

Table (1). Compraison of degree of stenosis on Conventional and CT angiograms

	Stenosis category at CT angiographgy			
Stenosis category at conventional angiography	Mild	Moderate	Sever	Occluded
Mild	35	4	0	0
Moderate	8	14	2	0
Sever	0	4	22	0
Occluded	0	0		0

Scanning started 5 seconds after enhancement in the aorta reached 70 HU.

A radiologist, blinded to patient data, interpreted the CTAs. Each artery was evaluated using magnified axial sections at a computer workstation. No three-dimensional reconstructions were used in evaluation. Using magnification, a measure (dmin) was taken of the diameter of the narrowest portion of the cervical internal carotid in the axial plane. This was compared with the maximal diameter (dnorm) of the cervical internal carotid artery distal to the carotid bulb at a location in which the imaging plane was orthogonal to the artery, the arterial walls were parallel, and where there was no arterial disease (figure 1, A and B). The degree of cross-sectional stenosis was calculated in percent as: percent stenosis =(1 - [narrowest ICA diameter/diameter normal distal cervical ICA])x 100%. analogous to the method used in the North American Symptomatic Carotid Endarterectomy Trial (NASCET). The stenosis was graded as mild = 0-19%diameter reduction, moderate = 20-69% sever = 70-99% and occlusion = 100%.

All conventional angiographic procedures were performed in an angiographic interventional room with high resolution C-arm - fluoroscopy, and digital subtraction angiography on GE medical system Advantx LCA Single Plane Angio-Cath Labs.

Angiograms were obtained by using a femoral approach. After arch aortograms with two oblique cervical views were obtained, selective catheterisation of the common carotid artery was performed to evaluate the degree of common or internal carotid artery stenosis. The carotid artery studies included at least three projections (posteroanterior, lateral, and ipsilateral 45° oblique), and two images per second were acquired with a 512 x 512 matrix and a 20 cm field of view. For each projection, an 8 mL bolus of iohexol (Omnipaque 300) was injected at a rate of 4 mL/sec by using a power injector. The contrast material dose for the entire study did not exceed 150 mL.

The degree of stenosis was determined and was defined as the ratio of the perpendicular diameter of the stenosis at its narrowest point to the normal internal carotid artery diameter wall cranial to the stenosis. Percentage of ICA stenosis was calculated by using electronic digital callipers according to the method used in the North American Symptomatic Carotid Endarterectomy Trial (NASCET). With this technique, the single view with the highest degree of stenosis is used, and the minimal diameter of the residual lumen at the site of greatest stenosis is compared with the normal ICA wall beyond the arterial bulb where the arterial walls become parallel. The degree of stenosis on both CT and convetional angiography were compared for each of the 90 carotid artries,(FIG 1,2).

3. Results

Ninety carotid arteries were evaluated in forty five patients in this study .35 arteries were categorized as mildly stenotic on conventional and CT angiograms while 14 arteries were categorized as moderate stenosis on both conventional and CT angiograms and 22 were categorized as severely stenotic by both modalities . 8 arteries with mild stenosis on CT were found to be moderately stenotic on conventional angiogram and 4 arteries with moderate stenosis were found to have sever stenosis on conventional angiography.4 cases of mild stenosis on CT were found to be only midly stenotic on angiograpgy and 2 cases with sever stenosis on CT were only moderately stenotic on conventional angiograpgy. One case of total occlusion on angiography was found to be severly stenotic yet patent on CT. In retrospect, a “string sign” of pseudo-occlusion has been present on the angiography, in which case angiography was falsely positive for occlusion.

Thus conventional angiograms and CT angiograms were in agreement in 71 arteries (79 %). Disagreement was found in the remaining eighteen arteries were CT angiogram showed the stenosis to be one category less in 13 arteries (14.4%) and one category more sever in 6 arteries (6.66%). Sensitivity and specifity for detecting sever stenosis or occlusion was 85% and 97 %.

4. Discussion

Stroke is the third leading cause of severe disability and death in the Western world, creating an enormous economic burden on society. Ischaemic cerebrovascular events are often due to atherosclerotic narrowing at the carotid bifurcation. The severity of atherosclerosis may be determined by assessing both luminal stenosis and lesion morphology.(2)

Digital subtraction angiography (DSA) is the current standard of reference for the evaluation of carotid artery disease. DSA is a relatively expensive technique that uses numerous resources. So because of the costs and risks of this procedure, non-invasive techniques such as computed tomography (CT) have been developed. The importance of a reliable, non-invasive imaging modality is also related to the recent development of less invasive means than carotid endarterectomy to treat carotid artery occlusive disease with angioplasty and stenting. Relevant preoperative information can be achieved with CT. (2)

Although DSA remains the gold standard for assessment of carotid stenosis however, findings in previous reports showed that DSA has limited use for measuring the degree of arterial stenosis. Researchers in ex vivo studies who observed carotid artery specimens that were removed during carotid endarterectomy documented discrepancies between the cross-sectional lumina of the specimens and those depicted at DSA. These discrepancies are probably due to the wide variety of shapes of the lumen, although the morphologic features of the specimens can change during and after surgical removal because of shrinkage and manipulation. Researchers who conducted in vivo studies in which evaluation was performed with colour duplex US showed that DSA has a tendency to underestimate the degree of carotid stenosis .(5)

The introduction of multidetector-row CT (MDCT) scanners further advanced the revolution started by helical CT, and has had its greatest impact on CT angiography, with further decreasing scan time and routine slice thickness, as well as increasing volumetric coverage and improving multiplanar and three-dimensional reconstructions. (9)

MDCT has the advantage of being fast where the entire length of the CCA and ICA can be scanned in under 60 s (the extracranial ICA alone in less than 30 s), minimizing image misregistration from motion and breathing artifacts, and often reducing contrast requirements. Accuracy is also another advantage and CTA provides truly anatomic, non-flow dependent data with regard to length of stenoses and residual lumen diameters.Flow-dependent techniques such as MR angiography (MRA) and ultrasound (US) are not able to provide these data. It also allows the observations of bony structures. MDCT angiography provides excellent results even in pseudo-occlusions, which are difficult to differentiate from total occlusion. CTA also has a lower rate of patient discomfort and has considerably lower risk of stroke and other vascular complications compared to conventional catheter arteriography.

Cumming and Morrow, in a study performed in 1994 (3) on Thirty-five patients referred for evaluation of carotid artery disease who were studied with conventional angiography followed by CT angiography 4-24 hr later, also found a high degree of correlation with catheter angiography. With CT angiography, all occluded Internal carotid arteries were correctly identified, and no arteries were wrongly classified as occluded. The degree of stenosis was overestimated on CT angiograms by greater than 10% in 16 arteries, especially when calcified atherosclerotic plaque was present. In some of these cases, the severity of the stenosis was underestimated on the conventional angiograms. All arteries, except one, with severe disease seen on conventional angiograms were correctly classified on the basis of the results of CT angiography.

Leclerc et al. in a study performed in 1995 (7) on 20 patients with atherosclerotic stenosis of the internal carotid artery, found a very good correlation between catheter and CT angiography, with correct classification of the degree of stenosis in 95% of the cases by axial sections.

Randoux et al., in 2001(8), performed a more complete study, evaluating several parameters, among which were the degree and length of stenosis, and the presence of plaque irregularities and ulcerations. The sensitivity and specificity of CT angiography for the demonstration of stenosis greater than 70% were, respectively, 100% and 100%, with a very good correlation for what regards the length of the stenosis. CT angiography showed more plaque irregularities and ulcerations than catheter angiography, in consideration of the limited number of views obtained with catheter angiography.

In a study by Bartlett et al., 2006(1), on 268 patients, it was concluded that there is a linear relationship between millimetre carotid artery stenosis diameter and derived percent stenosis as used in NASCET., allowing prediction of NASCET-type percent stenosis from directly millimetre carotid artery stenosis measured on CTA. Threshold values of 1.4 – 2.2 mm can be used to evaluate for moderate stenosis (50-69%) with sensitivity of 75% and specificity pf 93.8%. a carotid diameter measurement of 1.3 mm corresponds to 70% stenosis and can be used as a threshold value to test for sever carotid artery stenosis (> 70%) with a sensitivity of 88.2% and a specificity of 92.4%.

In our study we used the axial source images of CT angiography to measuare the degree of stenosis and the persent wes calculated using NASCET method. In 79 % the CT was similar in categorizing the degree of stenosis to conventional angiography and sensitivity and specifity were 85 and 97 % for detecting severs stenosis or occlusion.

Conclusion:

CT angiography is a reliable non invasive method for detecting and categorizing carotid stenosis with adequate specifity and sensitivity. Axial source images can provide enough data for measuring the stenosis.

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