



Role of MDCTA in quantification of carotid artery stenosis and assessment of atheromatous plaques

Thesis

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By

Susan Adil Ali Abdul Rahim

M.B., B.Ch, M.Sc Ain Shams University

Supervised By

Prof. Dr. Faten Mohamed Mahmoud Kamel

Professor of Radiodiagnosis
Faculty of Medicine – Ain Shams University

Assist. Prof. Dr. Sameh Abd El Raouf mahdy

Assistant Professor of Radiodiagnosis
Faculty of Medicine – Ain Shams University

Dr. Nivine Abdel Moneim Chalabi

Lecturer of Radiodiagnosis
Faculty of Medicine – Ain Shams University

Faculty of Medicine
Ain Shams University
Department of Radiodiagnosis

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دور تصوير الشرايين بالأشعة المقطعية متعددة المقاطع في القياس الكمي لضيق الشريان السباتي و تقييم التراكومات الدهنية

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سوزان عادل علي عبد الرحيم
بكالوريوس الطب و الجراحة و ماجستير الأشعة التشخيصية
جامعة عين شمس

تحت إشراف

أ. د/ فاتن محمد محمود كامل
أستاذ الأشعة التشخيصية
كلية الطب - جامعة عين شمس

أ. م. د/ سامح عبد الرؤوف مهدي
أستاذ مساعد الأشعة التشخيصية
كلية الطب - جامعة عين شمس

د/ نيفين عبد المنعم شلبي
مدرس الأشعة التشخيصية
كلية الطب - جامعة عين شمس

كلية الطب
جامعة عين شمس
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List of Abbreviations

2D	Two-dimensional
3D	Three-dimensional
CCA	Common Carotid Artery
CD-US	Colour Dopplr Ultrasound
CEA	Carotid endarterectomy
cm	Centimeter
CM	Contrast medium
CT	Computed Tomography
CTA	Computed tomographic angiography
DSA	Digital subtraction angiography
ECST	European Carotid Surgery Trial
EDV	End diastolic velocity
FOV	Field of view
HU	Hounsfield Unit
ICA	Internal carotid artery
IV	Intravenous
Kv	Kilovolt
mA	Milliamper
MCA	Middle cerebral artery
MIP	Maximum intensity projection
ml/s	Milliliter per second
mm	Millimeter
MDCT	Multidetector computed tomography
MPR	Multiplanar reformation
MRA	Magnetic resonance angiography
MRI	Magnetic resonance imaging
MSCT	Multislice computed tomography
MSCTA	multislice computed tomographic angiography

NASCET	North America Symptomatic Carotid Artery Trial
PSV	Peak systolic velocity
PACS	Picture archiving and communication systems
ROI	Region of interest
Sec	Second
SSD	Shaded surface display
TIA s	transient ischemic attacks
US	Ultrasonography
VR	volume rendering

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Introduction

Stroke is a dramatic medical problem, in fact, when considered separately from other cardiovascular diseases , stroke ranks third among all causes of severe disability and death after heart disease and cancer creating an enormous economic burden on society (**Saba and Mallarin, 2008**). Ischemic cerebrovascular events are often due to atherosclerotic narrowing at the carotid bifurcation (**Catalano and passariello, 2005**). Improved methods of diagnosis, treatment, and prevention of these diseases would result in significant improvement in quality of life and decrease in healthcare costs. (**Miller and Yuan, 2003**)

The results of two large randomized trials – the North American Symptomatic Carotid Endarterectomy Trial (NASCET) and the European Carotid Surgery Trial (ECST) – have shown carotid artery endarterectomy to yield a considerable benefit in patients with 70–99% stenosis and a small benefit in patients with 50–69% stenosis. In these studies, angiography was the gold standard technique used to quantify the carotid artery stenosis degree.

But angiography is also associated with an increased risk of thromboembolic events and a marked financial cost. Consequently, non-invasive techniques, such as sonography (US) , magnetic resonance (MR) and multi-detector-row computed tomography angiography (MDCTA) are now employed to quantify carotid artery stenosis (**Puchner et al, 2009**).The importance of a reliable, noninvasive 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. (**Catalano and passariello, 2005**)

Sonography and MRA have shown promising results, but each has some limitations: operator dependency for ultrasound and flow dependence for MRA, especially when performed without contrast. (*Puchner et al, 2009*)

The recent introduction into the clinical practice of multidetector-row spiral CT (MDCT) with simultaneous acquisition of multiple channels has a substantial effect on CT angiography, providing acquisition of large volumes at high resolution, with excellent visualization also of small branches, reducing the amount of iodinated contrast agent. (*Catalano and passariello, 2005*)

Also, MDCTA overcome important limitations of single-slice CTA, such as motion artifacts, and limited reconstruction feasibility. It provides high-quality reformats [multiplanar reformation (MPR), curved planar reformation (CPR), volume rendering threshold (VRT), and virtual angiography (VA)] on the basis of axial source images.

Since its introduction, MDCTA has become an important diagnostic tool owing to its high sensitivity and specificity for detecting high grade ICA stenoses. (*Puchner et al, 2009*)

Lumen stenosis (the degree to which the vessel is narrowed as a result of plaque growth) is an indirect measure of the severity of atherosclerosis and is not the only indicator of overall plaque burden. Histological study has shown that a class of plaque (**vulnerable plaque**) is prone to rupture, causing a thromboembolic event. Such plaque is believed to have a large necrotic lipid-rich core separated by a weakened or ruptured fibrous cap. Other plaque features have also been implicated in causing thromboembolic events, such as calcium nodules on the lumen surface and intraplaque hemorrhage. All these are features of the plaques themselves. Additionally, plaque progression may be in the form of outward expansion as compensatory remodeling, creating a significant plaque

burden but leaving the lumen relatively unchanged .Measurements of vessel stenosis tell us little about plaque morphology, features, or constituents, all of which may be factors in the “vulnerable” plaque. (**Miller and Yuan, 2003**)

Considering these characteristics we can state that even low-grade stenosis can result in a cerebrovascular event, so it is important to look beyond the lumen to plaque morphology as well (**Wasserrman et al ,2005**). Several recent studies, however, have provided evidence of the need to assess additional morphological parameters in order to better define the most correct therapeutic treatment. Most important are: plaque ulceration, the presence of a fissured fibrous cap, and the type of plaque (fatty, mixed or calcified). (**Nandalur et al, 2005**)

Doppler ultrasound is widely used clinically to measure lumen stenosis in carotid arteries and also to measure or identify atherosclerotic plaque size, size of the fibrous cap, wall thickness, and plaque compositions or ulceration Ultrasound has been used to differentiate “stable” from “unstable” plaque. But overall the results for identifying unstable plaques “has been largely unsuccessful. (Miller and Yuan, 2003). Also, this technique suffers from inter-observer and intraobserver variability determined by several parameters (e.g. sonographer experience and type of sonographic scanner). However, because of its relative insensitivity in detecting some plaque characteristics of risk and relative insensitivity in stenosis quantification, it would be unwise to rely on the Color Doppler-US (CD-US) exam alone. It would be appropriate to undertake an MDCTA exam in those patients who are candidates for carotid endarterectomy. (**Saba et al, 2010**)

Nowadays MDCTA sensitivity in the evaluation of stenosis degree, may be compared with angiography but with less risks and in particular, MDCTA sensitivity for stenosis

between 70 and 99% reaches excellent results. (***Saba et al, 2009***)

Besides stenosis degree, MDCTA clearly depicts carotid arterial wall thickness (CAWT), showing a great efficacy in the detection of plaque complications such as ulcerations and fissuration of the fibrous cap (***Saba et al, 2010***). MDCTA has a very high sensitivity (93.7%) and specificity in detection of carotid plaque ulceration and is superior to CD-US (sensitivity only 37.5%) and is recommended as a useful step for presurgical planning. (***Saba et al, 2007***)

AIM OF WORK

To assess the performance of MDCTA in quantification of carotid artery stenosis and evaluation of atherosclerotic plaques with Doppler findings used as the reference standard.

ANATOMY OF CAROTID ARTERIAL SYSTEM

The common carotid, internal carotid, and external carotid arteries provide the major source of blood to the head and neck. Additional arteries arise from branches of the subclavian artery, particularly the vertebral artery.

The common, internal and external carotid arteries and accompanying veins and nerves, all lie in a cleft that is bound posteriorly by the transverse processes of cervical vertebrae and attached muscles, medially by the trachea, oesophagus, thyroid gland, larynx and pharyngeal constrictors, and anterolaterally by sternocleidomastoid and, at different levels, omohyoid, sternohyoid, sternothyroid, digastric and stylohyoid muscles. The common and internal carotid arteries lie within the carotid sheath, accompanied by the internal jugular vein and the vagus nerve.

(Standring, 2008)