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MORPHOLOGIC CHARACTERIZATION OF ATHEROSCLEROTIC PLAQUE OF CORONARY ARTERIES DISEASES BY MULTIDETECTOR COMPUTED TOMOGRAPHY (MDCT)

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ABSTRACT

A multidetector row computed tomography (MDCT) image is being considered as a possible alternative to current imaging methods for evaluating vessel anatomy and morphology of atherosclerotic plaques in a variety of arterial beds. It is possible to evaluate the entire arterial vasculature using MDCT. Furthermore, MDCT is capable of visualizing the vessel wall and of quantifying calcified and noncalcified plaques. In total, 72 patients (56.9% male and 43.1% female) with consecutive ages ranging from 46 to 80 years old were scanned using TOSHIBA medical system (Aquilion) 64 Slice MDCT, and images were acquired in the axial plane. In the radiology department of the Royal Care International Hospital (RCIH), Khartoum, Sudan, images were acquired for post-processing multiplanar reconstruction (MPR) and three-dimensional reconstruction using special software (Vetrea). The research was conducted between March 2014 and May 2016. Post-processing multiplane reconstruction (MPR) was performed on CT images acquired in the axial plane. An analysis of 72 CT cross-sections revealed 19.4% calcified plaque in the right coronary artery, 16.7% calcified plaque in the left anterior descending artery, and 13.9% calcified plaque in the left circumflex artery. The findings of the present study suggest that 64-slice MDCT can be used to characterize different types of coronary plaque. A 64-slice MDCT study can reliably differentiate calcified from noncalcified atherosclerotic plaque components.

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Introduction

Atherosclerosis, a slow, progressive disease that begins early in life, is a hallmark of coronary artery disease. It occurs when fat-containing plaque accumulates in the arteries, causing them to lose their elasticity due to cholesterol, phospholipids, and calcium. As a result of narrowing arteries, blood is not able to flow smoothly. If blood flow is not adequately limited, it can lead to angina, while if the plaque ruptures and suddenly blocks an artery, it can lead to a heart attack [1].

As cardiac computed tomography can play an imperative role in the evaluation of such patients. A significant advance in cardiologic diagnosis has been made through noninvasive imaging of the coronary arteries [2]. It is generally accepted that the

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currently used invasive and noninvasive techniques can provide adequate information on the diameter of the lumen, the thickness of the wall, and the volume of the plaque [3]. Although sufficient techniques exist for reconstructing the histological composition of the plaque in three dimensions, they are not sufficiently accurate [4]. A noninvasive coronary imaging modality may open up new horizons in our understanding of atherosclerotic plaque pathophysiology. The newer-generation CT (computed tomography) scanners enable exquisite imaging of coronary arteries, coronary plaque morphology, and details of atherosclerotic lesions quickly, with minimal patient discomfort or risk [5].

In contrast to conventional angiography, cross-sectional contrast-enhanced images allow the assessment of atherosclerosis plaque load accurately. The multidetector row computed tomography (MDCT) is the most advanced and provides a degree of accuracy in the study of plaque morphology and histopathology within certain limits [5]. The present study aims to assess the Morphological Characterization of Atherosclerotic Plaque in Coronary Arteries Disease (CAD) by Multidetector Computed Tomography (MDCT) in clinically diagnosed Ischemic Heart Disease (IHD).

Materials and Methods

The study population consisted of patients with clinically established Ischemic Heart Disease (IHD) who were referred for CTA coronary procedures to the radiology department of the Royal Care International Hospital (RCIH) from March 2014 to May 2016. A total of 72 patients (41 males and 31 females) were included in the study. Their ages ranged from 46 to 80 years old. A consent form was obtained from each participant before the collection of data.

MDCT Imaging Protocol

Patients underwent MDCT with a TOSHIBA medical system (Aquilion) 64 Slice MDCT, images were acquired in the axial plane and using a special software workstation (Vetrea) multi-plane reconstructions and 3D reconstructions were performed in post-processing.

CCT protocol with detector (64 (32x2), collimation (0.6 (voxel 0.4 mm3)), tube voltage (120 kV), tube current (140 mAs), rotation time (330 ms), detector pitch (32), x-ray beam pitch, effective slice thickness (0.6 mm), reconstruction increment (0.4 mm), field of view (250-300 mm), convolution kernel (medium), window (width = 600 / level = 200), contrast agent volume (75-85 mL), the injection rate (4-5 mL/s), contrast concentration (300-350 mg/mL), bolus chaser (physiologic solution) (50 mL @ 4mL/s), venous access (antecubital) was used.

Results and Discussion

MDCT was performed on all patients without complications. **Table 1** summarizes the clinical characteristics of the patients. A total of 43.1% of the study participants were females and 56.9% were males, with 9.7% aged 40 to 49 years, 25% aged 50 to 59 years, 37.5% aged 60-60%, and 27.8% aged 70 to 80 years.

It was observed that coronary arteries were affected by atherosclerotic plaques. A calcified plaque was found in the right coronary artery (RCA) (19.4%), while a non-calcified plaque was found in the RCA (8.3%). The left main coronary artery (LMCA) had 1.4% calcified plaque. The left anterior descending artery contained 16.7% calcified plaque and 9,7% non-calcified plaque, and the left circumflex artery contained 13.9% calcified plaque and 1.4% non-calcified plaque.

Table 1. The clinical characteristics of the patients

	Frequency	Percent
Age		
40-49	7	9.7
50-59	18	25
60-69	27	37.5
70-80	20	27.8
Gender		
Female	31	43.1
Male	41	56.9
Right Coronary Artery (RCA)		
Calcified plaque	14	19.4
Non-calcified plaque	6	8.3
Normal	48	66.7
Stenosis	4	5.6
Left Main Coronary Artery (LMCA)		
Calcifications	1	1.4
Calcified plaque	1	1.4
Intra-luminal and mural plaques	1	1.4
Normal	69	95.8

Left Anterior Descending Artery (LAD)		
Calcified plaque	12	16.7
Non-calcified plaque	7	9.7
Normal	47	65.3
Smaller in caliber and faint at its distal part	1	1.4
Stenosis	5	6.9
Left Circumflex Artery (LCX)		
Calcified plaque	10	13.9
Non-calcified plaque	1	1.4
Normal	59	81.9
Stenosis	2	2.8

According to MDCT-derived parameters, we evaluated the ability of 64-slice MDCT to detect coronary atherosclerotic plaque. A major technological advancement in cardiac imaging, MDCT angiography is increasingly used to diagnose coronary artery disease and represents a major technological breakthrough in cardiac imaging [6]. By visualizing gross anatomical abnormalities, resolving tissue attenuation, and analyzing cardiac function, cardiovascular computed tomography angiography can help assess cardiovascular pathology. The purpose of this study was to diagnose the frequency of coronary artery findings on multi-CT scanner imaging in Khartoum, Sudan, population according to age, gender, and coronary artery type.

It is important to use imaging methods to detect, quantify, and characterize coronary atherosclerotic plaque, thereby enabling risk stratification, since major adverse cardiac events are caused by plaque rupture. Because calcium constitutes only one component of plaque, and noncalcified structures, such as necrotic cores and thin fibrous caps, are often considered to indicate a high risk of plaque rupture, medical imaging has gained increasing attention in the field of identifying and analyzing the components of coronary atherosclerotic plaques [7].

Based on CT attenuation, coronary plaques can be classified into three types: non-calcified plaques have a radiodensity that is significantly higher than that of neighboring soft tissue, but lower than the density of the contrast-enhanced coronary lumen. In contrast to contrast-enhanced coronary artery lumens, calcified plaques show lesions with densities above the density of the calcified plaques; in mixed plaques, there are non-calcified and calcified components within one or more lesion segments of the coronary artery (calcium component between 20% and 80%) [8].

In general, researchers believe that lipid-rich plaques carry a much higher risk of rupture and subsequent thrombosis than fibrotic plaques; therefore, differentiating plaques based on CT attenuation has attracted their attention. A study comparing MDCT angiography with intravascular ultrasound (IVUS) demonstrated that MDCT angiography is capable of detecting variable densities in coronary atherosclerotic plaques [9, 10]. Whereas in the present study, MDCT was able to detect calcifications, calcified plaque, and intraluminal and mural plaques.

MDCT angiography has been shown to provide independent prognostic information for predicting cardiac events and mortality in patients with known or suspected coronary artery disease in early studies investigating the short and mid-term outcomes of 64-slice CT angiography [11, 12]. MDCT angiography has been closely associated with future cardiac events according to findings from a single-center study, with 0% or 1% of cardiac events occurring in patients with normal cardiac CT or mild coronary artery disease, and up to 30% occurring in patients with obstructive CAD in one or more vessels [13, 14]. Abdulla *et al*. reported the results of a meta-analysis of 10 large studies that evaluated the prognostic value of 64-slice CT angiography. Throughout a mean follow-up of 21 years, the meta-analysis indicated a 0.5% rate of cardiac events for patients with normal MDCT angiography, a 3.5% rate for patients with non-obstructive CAD, and a 16% rate for patients with obstructed CAD per 64-slice CT angiography. As compared with a normal MDCT angiography, non-obstructive CAD was associated with a significantly increased risk of major adverse cardiac events, whereas obstructive CAD was associated with a further significant increase in risk. As a result of its excellent prognosis and high negative predictive value, MDCT angiography is an appropriate imaging modality for excluding and prognosizing populations with varying pre-test likelihoods of having CAD [15].

In recent years, MDCT angiography has become one of the most exciting developments in the diagnosis of coronary artery disease. Despite rapid technological advances and improved diagnostic accuracy with satisfactory results achieved with new MSCT scanners, invasive coronary angiography continues to be the gold standard method for diagnosing coronary artery disease (CAD) as it provides quantitative measurements of the coronary artery lumen [16].

A recent development in the diagnosis of coronary artery disease has been MDCT angiography. As a result of rapid technological advances and improvements in diagnostic accuracy achieved with new MSCT scanners, invasive coronary angiography is still considered the gold standard method for diagnosing coronary artery disease (CAD) due to its ability to measure the lumen of the coronary artery quantitatively.

Conclusion

Among the most rapidly developing imaging modalities in cardiac imaging, MDCT angiography has provided satisfactory results in diagnosing coronary artery disease. MDCT angiography is capable of detecting coronary calcium, identifying atherosclerosis plaques, as well as predicting the progression of the disease with high accuracy. As CT technology advances

and radiation exposure decreases, it is hoped that sequential CT imaging will become more useful in the evaluation of chronic asymptomatic coronary artery disease or noncalcified plaques by CT angiography with continued improvements in CT technology.
To develop better selection criteria for patients referred for MDCT angiography, radiologists and referring physicians (primarily cardiologists) must work together to establish accurate risk stratification for MDCT angiography.

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Conflict of interest: None

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