

Morphologic Assessment of Coronary Atherosclerotic Plaques Using Multidetector CT (MDCT)

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Abstract

Multidetector computed tomography (MDCT) has emerged as a promising non-invasive imaging technique for assessing vascular anatomy and characterizing atherosclerotic plaque morphology across various arterial regions. MDCT allows for comprehensive assessment of the entire arterial system and enables visualization of the vessel wall, including quantification of both calcified and non-calcified plaques. This study aimed to evaluate the morphological characterization of atherosclerotic plaques in coronary artery disease using MDCT in patients clinically diagnosed with ischemic heart disease (IHD). This study included 72 patients (56.9% male, 43.1% female), aged between 46 and 80 years, who were scanned using a 64-slice MDCT scanner (TOSHIBA Aquilion system). All scans were performed in the axial plane at the Radiology Department of Royal Care International Hospital (RCIH), Khartoum, Sudan, between March 2014 and May 2016. Post-processing was performed using Vetrea software to obtain multiplanar reconstructions (MPR) and three-dimensional images. Analysis of the CT scans revealed calcified plaque in 19.4% of cases in the right coronary artery (RCA), 16.7% in the left anterior descending artery (LAD), and 13.9% in the left circumflex artery (LCx). The findings indicate that 64-slice MDCT is an effective modality for identifying and differentiating between calcified and non-calcified coronary artery plaques.

Keywords: Multidetector computed tomography, Atherosclerotic plaque, Coronary artery disease, Morphology

Introduction

Atherosclerosis is a chronic, progressive condition that often begins early in life and is a key contributor to coronary artery disease (CAD). It develops when lipid-rich plaques—composed of cholesterol, phospholipids, and calcium—accumulate within arterial walls, leading to reduced elasticity and narrowed vessel lumens. This impairs normal blood flow, potentially resulting in chest pain (angina). In more severe cases, plaque rupture and

subsequent arterial blockage may trigger myocardial infarction (heart attack) [1].

Cardiac computed tomography (CT) has become an essential tool in the evaluation of patients with suspected coronary artery disease. Significant advances in cardiovascular diagnostics have emerged from the use of noninvasive coronary imaging [2]. Both invasive and noninvasive techniques are capable of providing reliable data regarding lumen diameter, vessel wall thickness, and plaque volume [3]. However, although some techniques aim to reconstruct plaque histology in three dimensions, their accuracy remains limited [4].

Modern noninvasive imaging methods, particularly with the latest generation CT scanners, offer new opportunities for understanding the pathophysiology of atherosclerosis. These technologies enable high-resolution imaging of coronary arteries and detailed evaluation of plaque morphology and composition, all with minimal risk or discomfort to patients [5].

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Unlike conventional angiography, which is limited to assessing luminal narrowing, cross-sectional contrast-enhanced imaging with multidetector computed tomography (MDCT) allows for accurate assessment of plaque burden and characteristics. Among these imaging modalities, MDCT stands out for its superior capability in visualizing plaque morphology and related histopathologic features [5].

This study aims to evaluate the morphological characterization of atherosclerotic plaques in coronary artery disease using multidetector computed tomography (MDCT) in patients clinically diagnosed with ischemic heart disease (IHD).

Materials and Methods

This study included patients diagnosed with ischemic heart disease (IHD) who were referred for coronary CT angiography (CTA) at the Radiology Department of Royal Care International Hospital (RCIH) between March 2014 and May 2016. The study sample comprised 72 individuals, including 41 males and 31 females, aged between 46 and 80 years. All participants gave their consent before data collection.

For the imaging procedure, the patients underwent 64-slice multidetector computed tomography (MDCT) using a TOSHIBA Aquilion scanner. Imaging was performed in the axial plane, and subsequent post-processing involved multiplanar reconstructions (MPR) and 3D reconstructions, facilitated by specialized software (Vetrea).

The CT protocol was as follows: The scanner utilized 64 detectors (32×2), with a collimation of 0.6 mm (voxel size of 0.4 mm^3). The settings for the tube were 120 kV for voltage and 140 mAs for current. A rotation time of 330 ms and a pitch of 32 were applied. The slice thickness was 0.6 mm, with a reconstruction increment of 0.4 mm. The field of view ranged between 250 and 300 mm, and a medium convolution kernel was used. Contrast agents were administered with a volume between 75 and 85 mL, at a rate of 4 to 5 mL/s, with a contrast concentration of 300 to 350 mg/mL. A bolus of physiological saline was injected as a chaser at a rate of 4 mL/s. The antecubital vein was used for venous access.

Results and Discussion

All 72 patients successfully underwent MDCT without any complications. The sample included 56.9% males

and 43.1% females, with age categories distributed as follows: 9.7% were aged 40-49 years, 25% were in the 50-59 years age range, 37.5% were aged 60-69 years, and 27.8% were between 70-80 years old.

The MDCT imaging revealed the presence of atherosclerotic plaques in the coronary arteries of the participants. Specifically, 19.4% of the right coronary artery (RCA) cases displayed calcified plaques, while 8.3% showed non-calcified plaques. The left main coronary artery (LMCA) had calcified plaques in 1.4% of cases. In the left anterior descending artery (LAD), calcified plaques were found in 16.7% of cases, with 9.7% showing non-calcified plaques. The left circumflex artery (LCX) exhibited calcified plaques in 13.9% and non-calcified plaques in 1.4%.

These results demonstrate the utility of MDCT in effectively characterizing coronary artery plaques and distinguishing between calcified and non-calcified types, which is crucial for diagnosing coronary artery disease (CAD). This imaging technique provides valuable insights that can help guide clinical decision-making and risk assessment in patients with IHD.

The clinical characteristics of the patients are presented in **Table 1**.

Table 1. The clinical characteristics of the patients

Category	Frequency	Percent
Age group (years)		
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%

The primary objective of this study was to assess the effectiveness of 64-slice MDCT in detecting atherosclerotic plaques in coronary arteries. MDCT angiography has emerged as a revolutionary advancement in cardiac imaging, offering new capabilities in diagnosing coronary artery disease (CAD) [6]. This imaging technique helps to identify anatomical abnormalities, evaluate tissue composition, and provide insights into cardiac function, thus playing a crucial role in the diagnosis and understanding of cardiovascular diseases. The focus of this research was to analyze the prevalence of coronary artery abnormalities observed through multi-slice CT imaging within the population of Khartoum, Sudan, considering variables like age, gender, and the specific type of coronary artery involved.

Imaging is indispensable in the identification, quantification, and detailed examination of coronary atherosclerotic plaques. These methods are vital for assessing patient risk, as the rupture of plaques can result in severe cardiac events. While calcium is a component of plaque, non-calcified elements, such as necrotic cores and fragile fibrous caps, are often considered the primary indicators of an increased risk for rupture. Therefore, imaging technologies are gaining significance in understanding the complex nature of coronary atherosclerotic plaques [7].

Coronary plaques can be categorized based on their CT attenuation values into three groups: non-calcified plaques, which have a radiodensity higher than the surrounding soft tissue but lower than the contrast-enhanced lumen; calcified plaques, which have a density greater than that of the calcium found in the arterial walls; and mixed plaques, which contain both calcified and non-calcified elements, with the calcified portion comprising 20% to 80% of the total plaque mass [8].

Researchers have found that lipid-rich plaques are more likely to rupture and cause thrombosis compared to fibrotic plaques. As a result, there is significant interest in identifying and classifying plaques based on their CT attenuation characteristics. A comparison between

MDCT angiography and intravascular ultrasound (IVUS) has shown that MDCT is capable of detecting diverse plaque densities within coronary arteries [9, 10]. In the current study, MDCT successfully identified calcified plaques, as well as both intraluminal and mural plaque components.

MDCT angiography has also been found to offer predictive value for cardiac events and mortality in patients with suspected or diagnosed CAD. Early studies on the short- and mid-term outcomes of 64-slice CT angiography have provided strong evidence for its prognostic capabilities [11, 12]. A specific study showed that the likelihood of future cardiac events was significantly lower in patients with normal cardiac CT scans or mild coronary artery disease (CAD). In contrast, patients with obstructive CAD faced a much higher event rate, as high as 30% [13, 14]. A meta-analysis led by Abdulla *et al.* [15], which reviewed 10 large-scale studies, reinforced the prognostic power of 64-slice CT angiography. Over an average follow-up period of 21 years, the meta-analysis showed that patients with normal MDCT scans experienced only a 0.5% rate of cardiac events, whereas those with non-obstructive CAD had a 3.5% event rate, and those with obstructive CAD had a 16% event rate. This highlights how even mild coronary artery disease increases the risk of adverse cardiac outcomes, with obstructive CAD posing an even greater threat. Because of its strong prognostic value and high negative predictive accuracy, MDCT angiography serves as an effective tool for excluding CAD and predicting outcomes in patients at various levels of risk [15].

While MDCT angiography has revolutionized the field of CAD diagnosis, invasive coronary angiography still holds the status of the gold standard. This is due to its unparalleled ability to provide precise, quantitative measurements of the coronary artery lumen, despite the advancements and improved diagnostic performance of newer MSCT scanners [16].

Conclusion

MDCT angiography stands out as one of the most rapidly advancing imaging techniques in cardiac diagnostics, offering effective results in the detection of coronary artery disease. It excels in identifying coronary calcifications, assessing atherosclerotic plaques, and predicting disease progression with high precision. As CT technology continues to improve, particularly in reducing radiation exposure, it is expected that sequential

CT imaging will become increasingly valuable for evaluating chronic asymptomatic coronary artery disease and noncalcified plaques. For the optimal use of MDCT angiography, it is essential for radiologists and referring physicians, particularly cardiologists, to collaborate in developing precise criteria for patient selection and accurate risk stratification.

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