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Research Article

Role of Non-Invasive CT Angiography in Improving Risk Stratification for Patients with Coronary Artery Diseases: A Retrospective Study

Mousa Q Hussein[1], Qays A Hassan[2*] and Husain M Abdullateef[3]

Abstract

Background: Coronary computed tomography angiography (CCTA) has become an effective tool for noninvasive evaluation of coronary artery plaque characteristics. The objective of this study was to identify both "culprit" and "stable" coronary lesions by CCTA, aiming to improve risk stratification in patients who had coronary artery disease (CAD).

Methods: This retrospective study was conducted in Ibn Al-Nafees cardiac center in Baghdad on 40 patients who had conventional percutaneous coronary intervention (PCI) angiography within 4-10 days after CCTA. We traced the hospital records of these patients. One-way ANOVA test was applied to measure relevant variables (Plaque Area, Lumen Area and Remodeling Index).

Results: Our results show that culprit unstable lesions in patients with ACS (n=14) had more plaque area and a better remodeling index (RI) than each stable lesions in patients with ACS (n=13) and in patients with SA (n=13), showing plaque area as follows; (15.2 ± 2.2 mm^2 VS. 9.1 ± 4.8 mm^2 VS. 13.5 ± 10.7 mm^2) p= 0.020; and RI (1.4 ± 0.2, 1.0 ± 0.4, 1.2 ± 0.3) p= 0.040, respectively.

Conclusion: Our statistics advocate that noninvasive visualization of coronary atherosclerotic plaque through CCTA may enhance hazard stratification of sufferers with suspected CAD.

Keywords

Coronary computed tomography angiography; Coronary artery plaque; Coronary artery disease; Stable angina; Acute coronary syndrome

Introduction

Notwithstanding the advance in medical therapy and use of different interventional procedures, acute coronary syndrome (ACS) continues to be one of the chief causes of morbidity and death in developed nations [1]. In the occurrence of coronary episodes, atherosclerotic plaque characters (including the rate of stenosis as well as composition and morphology) have been shown to play a crucially significant role. Based on pathological studies of these victims of unexpected cardiac death, lesions comprising a substantial quantity of necrotic core with an overlying thin fibrous cap have been associated with plaque rupture [2]. With consideration to the grade of stenosis, ACS may often result from lesions with only mild to moderate stenosis as these lesions may be more frequent than the severe obstructive lesions [3].

In vivo imaging of patients with ACS shown that culprit lesions [the coronary atherosclerotic lesion that usually by plaque rupture produces the acute episode] had frequently a distinguished morphology and is characterized via the presence of thrombus, a tiny residual vessel lumen, better plaque burden, and greater high-quality tremendous transforming [4]. Also, it has been proposed that characterization of culprit lesion morphology could aid to give hints to distinguish possibly vulnerable plaques.

Consequently, *in vivo* discovery of possibly vulnerable plaques may promote inhibition of cardiovascular episodes. Both invasive and non-invasive procedures were offered for this purpose. Intravascular ultrasound (IVUS) is a widely used invasive imaging modality with high diagnostic accuracy for detection and quantification of CAD [5]. Despite IVUS is the conventional evidence for the assessment of coronary plaque composition and progression in medical considerations [6,7], it is an invasive method which is not usually done in everyday clinical work and therefore may be restricted to research studies. Coronary CT angiography (CCTA) has been extensively utilised as a practical non-invasive imaging modality to diagnose CAD [8,9]. In addition, CCTA with the aid of commercially accessible software tools gives an objective and quantitative evaluation of atherosclerotic plaque composition [10,11] .

In this study we intended to evaluate the coronary artery lesions in patients who has CAD both in a qualitative and quantitative form, utilizing non-invasive multi-slices computed tomography (MSCT), for the goal of recognizing both "culprit" (it may be unstable or stable) and "stable" coronary lesions, proposing to enhance the risk stratification in patients exhibiting chest pain or other IHD symptoms.

Materials and Methods

This study was a retrospective analysis of images in patients who underwent CCTA within 4-10 days earlier to selective catheter-based PCI angiography and who had at least one coronary artery stenosis >70% identified by quantitative coronary angiography. An approval from the constitutional scientific and ethics committee was obtained before commencing this study.

Patient's data and CCTA data acquisition

Forty patients (35 men and 5 women, mean age: 60 ± 5 years) suspected of CAD undergoing CCTA were entered in this study. Cardiovascular risk profile, previous medical history and clinical exhibition leading to the recent hospital admission were taken from hospital documents. An expert cardiologist stratified patients on the base of the clinical exhibition, electrocardiograms (ECGs), and cardiac biomarkers, having non–ST-section elevation myocardial infarction (NSTEMI)/unstable angina or stable angina in keeping with the American College of Cardiology (ACC) and American Heart Association (AHA) definition [12].

***Corresponding author:** Qays A. Hassan, University of Baghdad, Al-kindy College of Medicine, Al-Nahdha square, Baghdad, Iraq, 10071, Tel: 9647722604163; E-mail: qtimeme@yahoo.com

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Multi-detector computed tomography data was obtained with a 64-slice CCTA scanner (Toshiba A quinolone 64-slice CT machine). The images had been acquired with 64 × 0.5 mm slice collimation, a gantry rotation time of 400 ms, table feed of 2.8 mm/rotation, tube electricity of 120 kV and an effective tube current of 500 mAs. 100 mm of contrast agents were infused intravenously at a rate of four ml/s. Overlapping trans-axial images had been reconstructed by using a medium sharp convolution kernel (B35f) with an photo matrix of 2048 × 2048 pixels, slice thickness of 1 mm and an increment of 0.5 mm using an ECG-gated half-test set of rules with a resulting temporal decision of 210 ms in the center of rotation. Image reconstruction becomes retrospectively gated to the ECG at 70-80% R-R interval to reduce the artifacts. For patients with a heart rate more than 70 beats per minute, a beta-blocker (5 mg metoprolol) was applied to slow down the heart rate earlier to the CT scan.

CCTA image evaluation and lesion classification

Two skilled radiologists who were blinded to the patient's name and clinical exhibition analyzed CCTA images. Radiologists rated image quality of coronary segments as assessable or not assessable. Only sufferers with assessable photograph satisfactory in all coronary segments with lesions of stenosis >70% were integrated within the analysis. Readers have been given the precise area of the largest luminal narrowing of every lesion as decided through quantitative coronary angiography by using anatomical landmarks (branches and Ostia). To examine lesions, unique axial pictures, multi-planar reconstructions perpendicular to the vessel centerline, and go-sectional reconstructions (1 mm thickness) have been rendered at the site of maximal lumen narrowing and at reference site proximal and distal to the lesion. Contiguous 1-mm-thick move-sectional photographs of the coronary arteries were rendered and first of all displayed with a fixed setting (700 Hounsfield units [HU] window, 200 HU level). The photo display settings have been adjusted on an individual basis to match variations in assessment enhancement or photo noise in some sufferers. In my view optimized window width (among 600 and 900 HU) and level (among 100 and 250 HU) settings (grey scale show) have been reserved for each measurement. One lesion from every patient was chosen to be the most significant and the most assessable lesion, so 40 lesions with >70% luminal narrowing in 40 patients were re-evaluated and analyzed. In patients with ACS (risky angina pectoris or NSTEMI) with an single substantial stenosis (>70%), this lesion turned into appeared the perpetrator lesion (the lesion causing the intense episode). In ACS sufferers with many lesions of >70% diameter lumen reduction, the culprit lesion turned into diagnosed on the idea of the correlation of angiographic lesion appearance with ECG changes of myocardial ischemia as prominent at some stage in stress trying out (TMT). Usually, the lesion with the maximum wonderful luminal narrowing turned into labeled as the culprit lesion. In sufferers who had two vast lesions in the offender's vessel, the culprit lesion was judged to be the most seriously narrowed lesion or the lesion with complicated morphology or both.

All different lesions >70% in patients with strong angina and non-culprit lesions in sufferers with risky angina or NSTEMI have been labeled as stable lesions.

Presence and composition of coronary atherosclerotic plaque

The cross-sectional image at the site of biggest luminal narrowing was evaluated for the presence of atherosclerotic plaque. The coronary atherosclerotic plaque was visually classified as non-calcified and/or calcified plaque. The non-calcified plaque become described as any observable shape that might be connected to the coronary artery wall, with a CT attenuation beneath the contrast enhanced coronary lumen however above the neighboring connective tissue/epicardial fat in as a minimum unbiased ranges. To maximize sensitivity for the invention of calcified atherosclerotic plaque, any structure with a CT attenuation of ≥ 130 HU that would be visualized incredibly from the contrast enhanced coronary lumen was assigned as calcified atherosclerotic plaque.

Degree of coronary stenosis

The diplomas of stenosis become determined on cross-sectional snap shots just like IVUS exam. The evaluation-improved portion of the coronary lumen was manually traced at the site site of maximal luminal narrowing and a proximal and distal reference site (imply calculated). The reference site have been described because the segments without detectable plaque proximal and distal to and as close as feasible to the corresponding coronary lesion. The charge of stenosis was calculated as the ratio among the luminal region at the site of maximal stenosis and the mean luminal area of the proximal and distal reference site.

Plaque area and coronary remodeling

The plaque area and the rate of coronary remodeling have been decided on move-sectional pictures just like IVUS. Plaque area was detailed via manual tracing as the discrepancy between the vicinity inclusive of both plaque and vessel lumen (equals the external elastic membrane location in IVUS) and the area of the vessel lumen (equals the inner elastic membrane area in IVUS) on the site of maximal luminal narrowing. Coronary arterial remodeling was defined as a difference in the vessel diameter at the plaque site in assessment to the reference segment set (mean of closest proximal and distal ordinary segments) to the lesion in a regular-appearing vessel phase (reference region/diameter). Manual inspection, in each move-phase and longitudinal reconstruction, was used for defining the remodeling index (lesion area/reference area). The remodeling index (RI) is stated as positive remodeling if the diameter at the plaque site was at least 5-10% larger than the reference section (>1.05 value).

Statistical evaluation

Data was processed by using PC statistics software SPSS program, one-way ANOVA test was applied to measure relevant variables (Plaque Area, Lumen Area and Remodeling Index). P-value<0.05 was regarded significant. Same Processing has been used to determine the variations in demographics and threat factors amongst sufferers with stable angina and ACS.

Results

The CT measurements in offender lesions in sufferers with ACS (n=14), stable lesions in patients with ACS (n=13) and stable lesions in sufferers with stable angina (n=thirteen) are summarized in Table 1. The outer vessel place (corresponds to the external elastic membrane-EEM-region in IVUS) at the site of greatest luminal narrowing was substantially different among the groups (p=0.010). Culprit lesions in sufferers with ACS had much larger outer vessel region than each stable lesions in sufferers with ACS and stable lesions in patients with stable angina.

Table 1: CCTA measurements of coronary vessel lumen and atherosclerotic plaque.

	Culprit lesions in ACS (n=14)	Stable lesions in ACS (n=13)	Stable lesions in SA (n=13)	p-Value
Outer vessel area at stenosis (mm^2)	18.9 ± 3.6	11.8 ± 5.7	15.6 ± 10.5	0.010
Luminal area at stenosis (mm^2)	3.7 ± 1.6	2.7 ± 3.3	2.1 ± 1.4	0.180
Plaque area (mm^2)	15.2 ± 2.2	9.1 ± 4.8	13.5 ± 10.7	0.020
RI	1.4 ± 0.2	1.0 ± 0.4	1.2 ± 0.3	0.040

Note**:** CCTA: Coronary Computed Tomography Angiography; ACS, Acute Coronary Syndrome SA, Stable Angina; RI, Remodeling Index

Table 2: Demographic and clinical characteristics.

	ACS (n=14)	SA (n=26)	p-Value
Age (years)	60 ± 6	63 ± 7	0.134
Men (%)	87.5	91	0.345
Hypertension	9/14 (64%)	18/26 (69%)	0.188
Hypercholesterolemia	13/14 (93%)	22/26 (84%)	0.975
Diabetes mellitus	5/14 (35%)	7/26 (27%)	0.913
Smoking	4/14 (28%)	9/26 (34%)	0.240
Family history of premature CAD	5/14 (35%)	12/26 (46%)	0.112
HR (beats/min)	60 ± 11	65 ± 12	0.182

Note: ACS: Acute Coronary Syndrome; SA: Stable Angina; CAD: Coronary Artery Disease; HR: Heart Rate

Culprit lesions in patients with ACS had greater plaque location (p=0.020) and a better RI (p=0.040) than both stable lesions in patients with ACS and in patients with stable angina.

There were no statistically huge variations with recognize to age, gender, cardiovascular chance profile, and heart rate between sufferers with ACS and stable angina (Table 2).

Discussion

In this study, we present the concept of noninvasive discovery and characterization of atherosclerotic lesion and plaque feature in patients with CAD.

The study shows indication that CCTA can measure plaque location, RI and the degree of stenosis with properly correlation to coronary angiography respectively in selected sufferers with desirable and assessable CT picture. Our work provides additional evidence to the belief that morphology and composition of coronary atherosclerotic plaque are different among patients with ACS and stable angina. Earlier, an angiographic study recorded a high prevalence of complex plaques in patients with ACS [13], and numerous IVUS studies propose that positive remodeling of plaque and presence of thrombus are independent predictors of ACS [5]. Our study confirms these observations with the noninvasive CCTA imaging technique.

Our study has revealed that the RI of culprit lesions in sufferers with ACS become extensively larger than in stable lesions in patients with ACS and in stable lesions in patients with stable angina. In stratified analysis, 12 out of 14 culpritlesions and 6 out of 13 stable lesions in sufferers with ACS had an RI above 1.05, developing the hypothesis that the detection of definitely remodeled coronary lesions through CCTA might be beneficial to become aware of the offender lesion in patients with ACS. Larger prospective studies, even clinical trials, might be required, however, to prove that positive remodeling as determined by CCTA has sufficient specificity to detect culprit lesions on a individual foundation, especially in patients with known records of coronary artery disease or multi-vessel sickness.

Our study revealed that the Majority of both stable and culprit lesions incorporate both calcified and non-calcified plaque and this suggests that the absence of calcified plaque alone might not be safe to exclude ACS. Leber et al. [14] made similar observations in regard to incidence frequency of non-calcified and calcified plaque at the same time as assessing the difference of basic plaque burden amongst patients with ACS and stable angina on a in keeping with-patient basis. There is controversy, however, as to whether or not the presence of calcification in atherosclerotic lesions is a trademark of lesion stability. According to the AHA classification of atherosclerotic plaque, calcified plaque is gift in the advanced tiers of atherosclerosis, but histopathology studies have confirmed that calcification is present in greater than 50% of stable and prone plaques in addition to in acute ruptured plaques and plaque with healed rupture [15]. One of the most interesting new theories on the function of calcium in culprit lesions is that calcification creates a place of mechanical instability at the interface among calcified and non-calcified plaque. Thus the role of calcification desires to be similarly studied specifically with appreciate to its localization inside a plaque and relation to plaque rupture sites.

A head to head comparison of CCTA with IVUS further confirms the diagnostic accuracy of CCTA inside the quantitative evaluation of coronary plaques. Nakazato et al. [16] carried out an instantaneous assessment between CCTA and IVUS with reference to the quantification and characterization of coronary plaque quantity and unfavorable plaque features in 27 consecutive sufferers with a complete of 30 individual coronary plaques. They found an excessive correlation among total plaque volumes as quantified via CCTA in comparison to IVUS without an extensive difference among the two strategies. Furthermore, consequences have shown that CCTA has excessive diagnostic accuracy for identity of unfavorable plaque characteristics (low-attenuation plaque, positive remodeling, and spotty calcification) with no tremendous differences among CCTA and IVUS. Similarly, Papadopoulos et al. [17] compared 64-slice CT angiography with IVUS in 32 sufferers together with 44 coronary arteries which had been co-registered for quantitative evaluation of the diagnostic performance of CCTA. They analyzed 1364 co-registered 1 mm move-sections and 255 segments of five mm duration. The sensitivity and specificity of CCTA have been 86% and 71% at cross-sectional level assessment and ninety six% and 88% at segment level evaluation, respectively. A drastically sturdy correlation

was discovered among CCTA and IVUS within the quantification of plaque volumes.

CCTA characteristics confirm histopathological information

Plaques vulnerable to rupture had many pathological characteristics including the voluminous extent, large necrotic cores, expansive positive remodeling of the diseased vascular segment, and covering by thin and inflamed fibrous caps [18,19]. The larger the plaque extent and necrotic core size, the higher is the likelihood of vulnerability of the plaque to rupture.

Whereas the majority of ruptured plaques occupy at the least one-half of the vessel vicinity in a pass section, much less than 1/2 of the ruptured plaques most effective involve greater than three-fourths of the go-sectional vascular region. The plaques which might be prone to rupture additionally show large plaque regions, however the dimensions are rather smaller than the ruptured plaques, suggesting that the bigger the plaque size, the more vulnerable is the lesion. The CCTA characteristics as observed on this study additionally reflect comparable findings of the 27 plaques that have been taken into consideration to be unstable, the plaque length was notably large in plaques that brought on the activities in comparison with plaques that did not lead to acute activities. Although plaque quantity is frequently good sized in unstable plaques, plaque burden might not always compromise the lumen diameter considerably, and sparing of the lumen happens due to a positive or an outward vessel remodeling.

Not most effective plaques which might be liable to rupture are larger in volume; these plaques also harbor big necrotic cores. The low attenuation regions, which might be anticipated to represent necrotic cores, had been drastically large in the plaques associated with ACS compared with the risky plaques that did no longer [18,19]. The CCTA information from our study is also similar to the descriptions available from an IVUS study, wherein the plaques leading to an acute coronary event subsequently exhibited a large eccentric plaque containing an echo-lucent zone by IVUS [20].

Clinical implications

This study showed that in patients presenting to the emergency department and/or CCU with chest pain of uncertain origin, 64-slice CCTA scanning had high positive and negative predictive value for identifying patients with ACS. Although not all emergency department patients with chest pain require CCTA imaging for risk stratification, our study demonstrates the applicability of the technique to selected patients in the population with intermediate risk in whom the incremental value of noninvasive imaging may have a significant impact on patient management.

Limitation of the study

The major limitation of our study was it does not include more details about characteristics of patients with the acute coronary syndrome, for example, the severity of angina and indication of coronary CT angiography, coronary calcium score, and fractional flow reserve (FFR) measurement. So we recommend further studies in the future including these details.

Conclusion

We introduce the concept of noninvasive detection and characterization of coronary atherosclerotic lesions in sufferers with ACS by way of 64-slice CCTA as a tool for risk stratification for both high and medium- risk groups of patients with CAD presenting to emergency department or cardiac care units. We identified differences in lesion morphology and plaque composition among culprit lesions in sufferers with ACS and stable lesions in sufferers with ACS or stable angina, regular with preceding research performed with IVUS, emphasizing the capability of CCTA to improve noninvasive danger stratification in patients with acute chest pain.

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Author Affiliations

Top

[1]*Department of Medicine, Al-kindy College of Medicine, University of Baghdad, Baghdad, Iraq*

[2]*Section of Radiology, Department of Surgery, Al-kindy College of Medicine, University of Baghdad, Baghdad, Iraq*

[3]*Ibn Al-Nafees Cardiac Center, Rusafa Health Department, Baghdad, Iraq*