Plaque characterization by optical coherence tomography and correlation with clinical presentation

Thesis submitted for partial fulfillment of Master Degree in

Cardiovascular Medicine

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Mina Samy

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List of abbreviations

ACC	American College of Cardiology
ACCF	American College of cardiology foundation
ACS	Acute Coronary syndrome
AHA	American Heart Association
AMI	Acute Myocardial Infarction
ATP	Adenosine Tri-Phosphate
BMS	Bare Metal Stent
BVS	Bioresorbable Vascular Scaffold
CABG	Coronary Artery Bypass Graft
CAD	Coronary Artery Disease
CCS	Canadian cardiovascular society
CI	Confidence Interval
CK-MB	Creatine Kinase myocardial band
CMR	Cardiac Magnetic Resonance
CRP	C - Reactive Protein
CT	Computed Tomography
CTA	Computed Tomography Angiography
DES	Drug Eluting Stent
ECG	Electro-Cardio Gram
ESC	European Society of Cardiology

List of abbreviations

FD-OCT	Fourier Domain Optical Coherence Tomography
FFR	Fractional Flow Reserve
FPS	Frame per second
HR	Hazard Ratio
ICA	Invasive Coronary Angiography
ICT	Intracoronary Thermography
IC	Intracoronary
IVOCT	Intra Vascular Optical Coherence Tomography
IVUS	Intra-Vascular Ultra-Sonography
IV	Intra-Venous
LAD	Left Anterior Descending Artery
LBBB	Left Bundle Branch Block
LCX	Left Circumflex
LDL	Low Density Lipoprotein
LMCA	Left Main Coronary Artery
LV	Left Ventricle
LVEDV	Left Ventricular End Diastolic Volume
LVEDP	Left Ventricular End Diastolic Pressure
LVEF	Left Ventricular Ejection Fraction
MD-CT	Multi-Detector Computed Tomography
MI	Myocardial Infarction
MIT	Massachusetts Institute of Technology
MLA	Minimum Luminal Area
MPI	Myocardial Perfusion Imaging

List of abbreviations

MMP	Matrix Metallo-Proteinases
MR	Magnetic Resonance
MRA	Magnetic Resonance Angiography
NPV	Negative Predictive Value
NSTEMI	Non-ST segment Elevation Myocardial Infarction
OCDR	Optical Coherence Domain Reflectometry
OCT	Optical Coherence Tomography
PCI	Percutaneous Coronary Intervention
PIT	Pathological Intimal Thickening
PPV	Positive Predictive Value
PTCA	Percutaneous Trans-luminal Coronary Angioplasty
PTP	Pre-Test Probability
RCA	Right Coronary Artery
SAP	Stable Angina Pectoris
SCAD	Stable Coronary Artery Disease
SD	Standard Deviation
SERCA	Sarco-Endoplasomic Reticulum Calcium ATPase
SMCs	Smooth Muscle Cells
STEMI	ST-Elevation Myocardial Infarction
TCFA	Thin Cap Fibro-Atheroma
TD-OCT	Time Domain Optical Coherence Tomography

List of abbreviations

UA	Unstable Angina
VH-IVUS	Virtual Histology Intra-Vascular Ultra-Sonography

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Abstract

Background Optical coherence tomography is a new intravascular imaging method with high resolution. This may allow us to assess the vulnerable plaques in detail in vivo.

Objectives The aim of the present study was to evaluate the ability of optical coherence tomography (OCT) for assessment of plaque characteristics and vulnerability in patients with acute coronary syndrome compared to stable angina patients.

Methods and results Patients undergoing cardiac catheterization were enrolled and categorized according to their clinical presentation: recent acute coronary syndrome (ACS), or stable coronary artery disease (SCAD). OCT imaging was obtained using the commercially available Frequency Domain-OCT C7XR system and the Dragonfly catheter (St Jude Medical system, Lightlab Imaging Inc., Westford, Massachusetts). Two observers independently analyzed the images using the previously validated criteria for plaque characterization. Of 48 patients enrolled, 27 with ACS, and 21 with SCAD. In the ACS, and SCAD groups, lipid-rich plaque (was observed in 96.3%, and 66.7%, respectively (P=0.015). The median value of the minimum thickness of the fibrous cap was 70, and 100 μm, respectively (P=0.064). The frequency of thin-cap fibroatheroma (defined by lipid-rich plaque with cap thickness ≤65 μm) was 33.3%% in the ACS group, and 14.3% in the SCAD group (P=0.185). No procedure-related complications occurred.

Conclusion The current FD-OCT study demonstrated the differences of the culprit lesion morphologies between ACS and stable CAD. There was a trend toward a higher frequency of TCFAs in patients with ACS compared to SAP patients. The morphological feature of lipid rich plaque content, plaque rupture and the intracoronary thrombus could relate to the clinical presentation in patients with acute coronary disease. Plaque erosion was a frequent finding in patients with ACS not in SCAD patients. This is consistent with previous pathological studies.

Keywords: OCT, ACS, SCAD, vulnerable plaques, TCFAs.

Introduction

Cardiovascular disease has long been the leading cause of death in developed countries, and it is rapidly becoming the number one killer in the developing countries[1].

It is accepted that clinical evaluation of luminal stenosis in coronary arteries, even using invasive angiography, is unable to predict the future development of ACS. Accordingly, a detailed understanding of the tissue characteristics of coronary atherosclerotic plaques is essential for identifying potentially vulnerable coronary plaques and then establishing strategies to prevent the progression and deterioration of coronary artery disease (CAD)[2].

Because many of the determinants of plaque vulnerability are structural abnormalities, a high-resolution imaging technique may offer promise as a method of detecting vulnerable plaques. Presently, however, a reliable method of identifying such plaques is not available[3].

Based on this clinical perspective, several groups have tried to elucidate the features of vulnerable coronary plaques by using intravascular ultrasound (IVUS), virtual histology-IVUS, angioscopy, and non-invasive multidetector computed tomography[4 5 6 7].

However, even IVUS studies have not clearly identified the specific changes in the fine morphological characteristics of plaque components or the arterial wall, or which changes predict future plaque progression and the development of ACS. This may be due partly to the limited spatial resolution (as low as 100mm) of the IVUS technique.

Since intravascular ultrasound was introduced in the early 1990s,[8 9]it has been used not only as adjunctive device to percutaneous coronary interventions (PCI), but also as research tool to evaluate vessel structure in detail. Although IVUS helped broaden our understanding of coronary artery structure, its limited spatial resolution doesn’t allow for assessment of microstructures, which is important for identification of vulnerable plaques. Optical coherence tomography (OCT) is analogous to ultrasound, except that it generates images by measuring the echo time delay and magnitude of back scattered light instead of sound[10].

The recent introduction of optical coherence tomography (OCT) into the catheterization laboratory was received with great expectation, as this light based imaging modality offers 10 times higher resolution and 40 times faster imaging acquisition compared with other modalities such as IVUS[11].

Different studies have shown that OCT can assess coronary plaque morphology and identify thrombus, intimal rupture, lipid-laden plaques, and determine accurately the thickness of the fibrous cap. Thus, it has been applied for the assessment of culprit lesion morphologies and understanding the thrombosis-prone vulnerable plaques in patients with acute coronary syndrome (ACS)[12 13].

Despite the increasing rate of atherosclerotic coronary artery disease particularly ACS in Egypt, there are no data about the prevalence of different underlying pathogenesis for ACS in Egyptian population.