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REVIEW ARTICLE

Coronary optical coherence tomography: A practical overview of current clinical applications

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Abstract Coronary optical coherence tomography has emerged as the most powerful in-vivo imaging modality to evaluate vessel structure in detail. It is a useful research tool that provides insights into the pathogenesis of coronary artery disease. This technology has an important clinical role that is still being developed. We review the evidence on the wide spectrum of potential clinical applications for coronary optical coherence tomography, which encompass the successive stages in coronary artery disease management: accurate lesion characterization and quantification of stenosis, guidance for the decision to perform percutaneous coronary intervention and subsequent planning, and evaluation of immediate and long-term results following intervention.
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PALAVRAS-CHAVE
Aplicação clínica;
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Tomografia de coerência ótica

Tomografia de coerência ótica coronária: uma revisão prática das aplicações clínicas atuais

Resumo A tomografia de coerência ótica coronária surgiu como a modalidade de imagem *in-vivo* que permite a avaliação estrutural vascular mais detalhada. Trata-se de uma ferramenta valiosa em investigação, tendo contribuído para melhor entendimento da patogénese da doença coronária. Apresenta igualmente um papel importante na prática clínica, e o leque de sua aplicabilidade tem aumentado. Enquadrando na evidência disponível, discutimos neste artigo as principais aplicações da tomografia de coerência ótica coronária na prática clínica, que englobam as diferentes etapas na abordagem da doença coronária, incluindo a caracterização da lesão e quantificação da estenose, o papel na decisão de realizar angioplastia, o contributo na planificação da mesma e a avaliação dos resultados a curto e a longo prazo após a intervenção.
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List of abbreviations

ACS	acute coronary syndrome
DES	drug-eluting stent
FFR	fractional flow reserve
ISA	incomplete stent apposition
ISR	in-stent restenosis
IVUS	intravascular ultrasound
MLA	minimal luminal area
MLD	minimal luminal diameter
OCT	optical coherence tomography
PCI	percutaneous coronary intervention
TCFA	thin-cap fibroatheroma

Introduction

Coronary angiography is the standard invasive imaging method for diagnosis of coronary artery disease and for guiding coronary interventional procedures.[1] In addition to intravascular ultrasound (IVUS), optical coherence tomography (OCT) has emerged as an imaging modality able to evaluate the vessel structure in detail, for which angiography may not suffice.[2–4] The OCT image is formed by the backscattering of emitted near-infrared light, creating cross-sectional images of the coronary vessel.[2] Compared to IVUS, the wavelength used in OCT is shorter, enabling higher spatial resolution (10–20 μm axial resolution and 20–30 μm lateral resolution).[2,5,6] However, except for calcium, penetration depth of OCT is lower than with IVUS, particularly for thrombotic and lipid components.[2] Coronary OCT systems have evolved from first-generation time-domain systems to second-generation frequency-domain OCT.[4] The latter produces images at higher frame rates with slightly deeper penetration, using a short, non-occlusive flush and rapid spiral pullback.[2,4] We had the opportunity to perform the first OCT studies in Portugal. In addition to research purposes, we recognize the invaluable potential of OCT as a diagnostic technique and as an adjunctive tool for percutaneous coronary intervention (PCI).[2,3]

Data relevant to this topic have recently been published and we review the evidence on current clinical applications of OCT from a practical perspective. The potential use of OCT in the successive stages in coronary artery disease management is discussed, including morphologic lesion characterization and quantification of stenosis, guidance for the decision to perform percutaneous coronary intervention and subsequent planning, and evaluation of immediate and long-term results following PCI.

Morphologic lesion characterization

Animal and human post-mortem studies have shown the ability of OCT to accurately characterize coronary atherosclerotic plaques.[2,5] Due to its high spatial resolution, OCT has proved superior to other imaging modalities, including IVUS, for detecting different plaque components.[2,5,6] A landmark post-mortem study showed a high sensitivity and specificity for detecting fibrous, fibrocalcific and lipid-rich plaques in histological specimens.[5] OCT is currently the only method with sufficient resolution to accurately measure the fibrous cap.[7] Historically, thin-cap fibroatheromas (TCFAs) are the substrate of approximately two-thirds of acute myocardial infarctions as presented in pathology series.[8] Recently, this has been validated in vivo in the OCTAVIA study.[9]

Furthermore, macrophage infiltration, which is a marker of plaque instability, may be identified using OCT.[10] In acute coronary syndrome (ACS) OCT is useful for identification of plaque dissection, ulceration, and erosion, calcified nodules and thrombus[7] (Figures 1 and 2). In addition, OCT can differentiate between red and white thrombi.[11] A complete description of the appearance of atherosclerotic and thrombotic components on OCT is beyond the scope of this review and is reported elsewhere.[12]

OCT is particularly valuable in providing insights into the pathophysiological mechanisms of ACS and may help with the development of individualized therapeutic strategies.[13] TCFA, plaque rupture and red thrombus have been detected in most patients with ST-elevation myocardial infarction and are more frequent in comparison to non-ST elevation ACS.[14,15] However, not all ACS lesions showed plaque rupture and the presence of intact fibrous cap was associated with better prognosis.[16,17] Moreover, plaque rupture, intracoronary thrombi, lipid-rich plaques and TCFAs were more frequent in culprit compared to nonculprit lesions.[18]

There are, however, some pitfalls in plaque characterization, mainly related to the low penetration depth. Penetration is lowest for thrombotic material, which may lead to signal-free shadowing, and non-protruding red thrombi may be misinterpreted as necrotic lipid pools due to a similar OCT signal pattern.[12] Furthermore, in the majority of lesions an accurate measurement of lipid pool thickness cannot be performed.[12]

Stable coronary syndrome: predicting physiology and assessing stenosis severity

OCT may be used to assess lesions of intermediate stenosis severity in vessels without a large size.[4] The proposed thresholds of minimal luminal area (MLA) and minimal luminal diameter (MLD) for detecting a hemodynamically significant lesion are based on recent validations against fractional flow reserve (FFR), which is considered the gold standard for assessing hemodynamic significance.[19–22] In most studies, FFR $\leq$0.80 was taken as the threshold and the derived cut-offs of MLA and MLD ranged from 1.59 mm^2 to 2.54 mm^2 and from 1.23 mm to 1.77 mm, respectively.[20–22] Taking FFR <0.75 as the threshold, an MLA <1.91 mm^2 and an MLD <1.35 mm have been identified as the best cut-off values.[23] A recent consensus report suggests a MLA threshold of 1.95 mm^2, which has moderate sensitivity and negative predictive value for hemodynamic significance.[4,24] In small vessels lower thresholds should probably be used.[24] In most studies, however, the correlation between FFR- and OCT-derived measurements was only moderate.[20,21,23] Despite potentially higher precision in determining MLA, this simple cross-section value cannot predict physiology accurately, as shown in a recent meta-analysis.[25] The ability of OCT to automatically segment the lumen through the entire pullback enables volumetric analysis of the vessel for the first

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