



ORIGINAL ARTICLE

Noninvasive anatomical and functional assessment of coronary artery disease



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KEYWORDS

Coronary artery disease;
Fractional flow reserve;
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Integrated assessment

Abstract

Introduction and Objective: In suspected coronary artery disease (CAD), invasive coronary angiography (ICA) is traditionally the diagnostic tool of choice. However, patients often have no significant disease. Moreover, assessment of fractional flow reserve (FFR) has been shown to have prognostic implications. Recently, coronary computed tomography angiography (CTA) and cardiac magnetic resonance (CMR) myocardial perfusion imaging (CMR-Perf) have gained increasing attention through their accurate anatomical and functional assessment, respectively. We studied the added value of integrating these tests (CT+CMRint) in the diagnosis of CAD, with FFR as the reference standard.

Methods: We included 101 patients consecutively referred for outpatient assessment of CAD who underwent CTA and CMR-Perf prior to ICA with FFR assessment. Lesions were considered positive by CT+CMRint only if positive in the two tests alone. The mean follow-up was 2.9 ± 0.6 years.

Results: All patients completed the study protocol without adverse effects. Forty-four patients had CAD by FFR. CTA had excellent sensitivity and negative predictive value (100%) but, as expected, its specificity and positive predictive value were lower (61% and 67%, respectively). Diagnostic accuracy by FFR was 78% for CTA, 88% for CMR-Perf and 92% for CT+CMRint. Regarding diagnostic accuracy, CT+CMRint showed statistically significant superiority (AUC=0.917, 95% CI 0.845–0.963) compared with CTA (AUC=0.807, 95% CI 0.716–0.879, $p=0.0057$) or CMR-Perf (AUC=0.882, 95% CI 0.802–0.938, $p=0.0398$) alone. Regarding prediction of revascularization, the integrated protocol maintained its superior performance.

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PALAVRAS-CHAVE

Doença coronária;
Reserva fracional
funcional;
Angio TC cardíaco;
Estudo de perfusão
por ressonância
magnética
cardiovascular;
Avaliação integrada

Conclusions: CT+CMRint showed superior diagnostic accuracy and could thus lead to a considerable reduction in invasive procedures for CAD diagnosis, with less risk and greater patient comfort.

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Avaliação não-invasiva, anatômica e funcional, da doença coronária**Resumo**

Introdução e Objetivo: Na suspeita de doença coronária, o cateterismo cardíaco (CC) é tradicionalmente o exame escolhido mas, frequentemente não surge doença significativa. Também, a avaliação da reserva fracional funcional (RFF) tem implicações prognósticas. Recentemente, tanto o angioTAC (CTC) como a ressonância magnética cardiovasculares (RMC) assumiram o seu lugar pela excelente acuidade, respetivamente, na avaliação anatômica e funcional de doença coronária. Foi nosso objetivo investigar o valor adicional da sua integração, tendo a RFF como referência.

Métodos: 101 pacientes consecutivamente referenciados do ambulatório por suspeita de doença coronária foram submetidos a CTC e a RMC previamente ao CC. A avaliação integrada (CTC+RMCint) foi considerada positiva se anormalidades presentes simultaneamente nos dois testes. O período médio de *follow-up* foi de $2,9 \pm 0,6$ anos.

Resultados: Todos os pacientes completaram o protocolo sem adversidades. Doença coronária por RFF ocorreu em 44 pacientes. A CTC demonstrou uma excelente especificidade e VPN (100%) mas, como esperado, baixa especificidade e VPP (61 e 67%). A acuidade diagnóstica foi de 78% para a CTC, 88% para a RMC e 92% para a CT+CMRint. O protocolo integrado demonstrou superioridade estatisticamente significativa para prever doença coronária definida por RFF (AUC=0,917, IC 95% 0,845-0,963) quando comparado com a CTC (AUC=0,807, IC 95% 0,716-0,879, $p=0,0057$) e RMC (AUC=0,882, IC 95% 0,802-0,938, $p=0,0398$) isoladamente. Tal manteve-se quando considerada a revascularização no *follow-up*.

Conclusão: A CTC+RMCint demonstrou acuidade diagnóstica superior o que poderá levar à diminuição da realização de CC diagnósticos, com menor risco e maior conforto para o paciente.
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Introduction

In suspected coronary artery disease (CAD), invasive coronary angiography (ICA) is traditionally the diagnostic tool of choice. However, patients undergoing this exam often have normal coronary arteries or no significant disease, but the risks and costs associated with this invasive approach are significant.¹ The rapid evolution of computed tomography (CT) after the introduction of multidetector scanners has allowed noninvasive assessment of coronary anatomy. CT angiography (CTA) has expanded in clinical practice and, as expected from an anatomical study, it is associated with high sensitivity and negative predictive value (NPV).²⁻⁴ Nevertheless, its ability to discriminate the degree of stenosis is limited, mainly due to artefacts resulting from calcified and complex lesions and also due to inherent cardiac motion.^{5,6} Thus, CTA is currently mainly reserved for patients with a low likelihood of CAD.²⁻⁴

The main limitation of anatomical assessment is that correlation with functionally relevant disease is not straightforward.^{7,8} The length, number and tortuosity of lesions, as well as collateral flow, influence the

hemodynamic significance of coronary lesions.⁹ Fractional flow reserve (FFR) distal to the lesion on ICA has prognostic implications and influences the decision to revascularize.^{10,11} Myocardial perfusion studies enable functional assessment, and cardiac magnetic resonance (CMR) perfusion imaging has also been adopted in clinical practice, with high diagnostic accuracy.¹²⁻¹⁵ Another advantage of CMR perfusion imaging is its versatility and ability to provide alternative diagnoses.¹⁶

The prospect of incorporating anatomical and functional evaluation in a noninvasive approach is attractive, but it has yet to find a place in clinical practice. The added value of coronary MR angiography over CMR perfusion imaging is doubtful, mainly due to limitations arising from spatial resolution, scan duration and artefacts.^{17,18} Hybrid imaging techniques such as positron emission tomography (PET) and CTA, or CTA combined with single photon emission computed tomography (SPECT) myocardial perfusion scintigraphy, have shown interesting results, though limited by the small number of studies and lack of access in clinical practice.^{19,20} Several groups, including a recent multicenter study, have consistently shown the added value of

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