Magnetic resonance perfusion imaging for detection of ischemic heart disease

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Abstract

In recent years, magnetic resonance first-pass perfusion imaging (MRPI) has developed from a research technique to a mature clinical application. Sufficient evidence has been presented to demonstrate that a high-quality MRPI scan is at least as good as a single photon emission computed tomography scan for the diagnosis of significant coronary artery disease. The ability of this new technique to assess the hemodynamic relevance of a stenosis has been shown by its close correlation with invasive coronary flow and pressure measurements. Initial data demonstrate that patients with a negative MRPI scan have an excellent prognosis.

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Introduction

The non invasive assessment of myocardial perfusion is one of the most attractive methods for detecting coronary artery disease (CAD), because a decrease in myocardial blood flow is the first event after induction of myocardial ischemia (ischemic cascade) [1]. Currently, single photon emission computed tomography (SPECT) is the technique most widely used to prove or exclude significant CAD. However, several limitations of SPECT, such as attenuation artifacts and its relatively low spatial resolution, make the introduction of a new technique attractive. The techniques used for magnetic resonance first-pass perfusion imaging (MRPI) have been improved considerably in recent years, are sufficiently robust, and yield high-quality images if used with some experience and a state-of-the-art scanner. Several single-center and initial multicenter trials [2,3] have demonstrated the high accuracy of the technique in comparison with invasive coronary angiography. In addition, a close correlation has been shown between the findings of MRPI and the assessment of coronary artery flow reserve or fractional flow reserve. The main limitations of the new technique are the needs to understand potential artifacts and to have sufficient practice to obtain high-quality imaging and image interpretation.

Pathophysiology

Myocardial perfusion depends on the driving pressure gradient and the resistance of the coronary vascular bed. Coronary autoregulation makes it possible to keep myocardial perfusion stable for a wide range of coronary perfusion pressures, even in the presence of a stenosis that narrows the coronary artery diameter by up to 90% [4]. During exercise or pharmacological stress, autoregulation becomes exhausted, leading to a relative reduction in blood flow distal to a coronary artery stenosis. With perfusion imaging, these relative changes in blood flow can be visualized and the hemodynamic significance of a coronary artery...
stenosis demonstrated. It is important to remember that there is no direct correlation between alterations in blood flow and the degree of a coronary artery stenosis. Consequently, there is a limited agreement between MRPI measurements and invasive angiography, but a closer agreement with invasive measurements of fractional flow reserve.

Imaging technique

Usually a T1-weighted sequence is used to visualize the first passage of a gadolinium contrast agent through the myocardium. Three to five short-axis views with an in-plane resolution less than 3 mm x 3 mm are acquired at each heart beat (Figure 1). Images are first acquired during adenosine stress, and then imaging is repeated approximately 10 min later with the patient at rest. At some stage during the procedure, cine wall-motion images are acquired with the patient at rest; finally, delayed enhancement imaging, as described elsewhere [5], is performed.

Image analysis

For clinical purposes, a rapid visual assessment is performed by comparing the contrast enhancement in different myocardial regions. Importantly, the speed of the increase in signal (contrast agent wash-in), rather than the absolute maximum signal, is the most important parameter for visual assessment [6]. Patients with suspected CAD may be considered to be positive for CAD based on a positive late gadolinium enhancement scan, independent of the perfusion results [7]. However, in patients whose condition is complex (known myocardial infarction, previous revascularization), the approach is less straightforward. In these patients, the stress perfusion images need to be compared carefully with the scar images, and only those patients with perfusion defects that are larger than the scar territory are regarded as positive for ischemia.

For a more precise analysis, and for research purposes, semiquantitative or quantitative analyses are available [8].

Accuracy and prognostic value

The overall accuracy of MRPI is about 90% sensitivity and 70–80% specificity compared with invasive angiography. The main reasons for false-positive results are artifacts in patients in whom image quality is suboptimal (a problem that has lessened significantly in recent years) and the physiologic differences between measuring ischemia and coronary artery stenoses (as outlined above). The correlation between MRPI and functional measurements of the severity of stenosis (coronary flow reserve, fractional flow reserve) is good [9] and Kühl et al [10] have reported a sensitivity of 92% with a specificity of 92% for MRPI compared with fractional flow reserve. These findings demonstrate the high accuracy of MRPI. In addition, patients with a negative MRPI scan have an excellent prognosis, with an event rate of only 0.7% for major cardiac events within the next 2 years [11]. Thus this technique can be safely applied in patients referred for invasive angiography without proven evidence of ischemia or who demonstrate an intermediate pretest likelihood of CAD. Recently, MRPI was regarded as an appropriate indication in a variety of situations, most importantly in patients with chest pain, who have an intermediate risk for CAD and are unable to exercise, or in whom the electrocardiogram cannot be interpreted, and in patients who have an intermediate stenosis of unclear hemodynamic significance found by coronary artery imaging (either cardiac computed tomography or invasive angiography) [12].

Summary

Despite the lack of large multicenter trials for the assessment of MRPI, the technique can be regarded at least as not inferior to SPECT. A negative study has an excellent negative predictive value for the occurrence of major cardiac events. The test has several accepted indications, mainly in patients with chest pain, who have an intermediate risk for coronary artery disease and are unable to exercise, or in whom the electrocardiogram cannot be interpreted, and in patients who have an intermediate stenosis of unclear
hemodynamic significance found by coronary artery imaging (either cardiac computed tomography or invasive angiography).

REFERENCES