Noninvasive Assessment of Coronary Artery Disease
Anatomy, Physiology, and Clinical Outcome*

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In this issue of *JACC*, Hamdan et al. (1) compare noninvasive coronary angiography with a state-of-the-art magnetic resonance system (3.0-T, 32-channel) and a standard 64-slice computed tomography (CT) scanner in 120 patients with stable or suspected coronary artery disease. In a selected patient population (excluding patients with acute coronary syndromes, advanced heart failure, stents, bypass surgery, arrhythmia, body mass index >40 kg/m²) 95% and 97% of segments could be adequately visualized with magnetic resonance angiography (MRA) and CT, respectively. Compared with invasive coronary angiography, the data demonstrate comparable diagnostic accuracy of the noninvasive modalities, with a slight advantage of CT (significant for the left circumflex artery).

The anatomic reference standard in this comparison is invasive coronary angiography. Invasive angiography allows precise description of coronary luminal stenosis as the basis for planning coronary revascularization and is relatively safe; and its invasiveness allows access for potential transcatheter revascularization (percutaneous coronary intervention). Therefore, at this time it remains the imaging modality of choice for symptomatic, high-risk patients. However, invasive angiography has 2 significant limitations.

First, the correlation between anatomic stenosis severity and physiologic, hemodynamic significance is only modest (2). In the catheterization laboratory, this limitation can be overcome by the combination of angiography with fractional flow reserve, which allows reliable assessment of lesion significance and improves planning of revascularization (3).

Second, invasive angiography is limited in the evaluation of the disease process in the vessel wall, including plaque burden and vulnerable plaque (4). These 2 limitations reduce the ability of invasive angiography to predict future cardiovascular events, particularly in intermediate risk populations. This has important clinical implications, because recent clinical studies demonstrate that deferring percutaneous coronary intervention on the basis of fractional flow reserve or lesion location, combined with optimal medical management, improved or at least did not negatively impact clinical outcome including mortality (3,5).

These results demonstrate that assessing coronary artery disease is complex and requires evaluation of anatomy, physiology, and eventually clinical end points. This also holds true for noninvasive coronary assessment with magnetic resonance imaging (MRI) and CT. Noninvasive coronary angiography is challenging, because of the small vessel size and rapid motion during the cardiac cycle. Therefore, in general, temporal resolution, spatial resolution, and diagnostic accuracy for anatomic assessment of luminal stenosis are lower than with invasive angiography. In recent years, MRA has suffered more from these challenges than computed tomography angiography (CTA), resulting in lower overall accuracy of MRA versus CT. However, in addition to the assessment of luminal stenosis, noninvasive imaging provides additional prognostic...

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information, which allows decisions about optimal medical management.

After proof-of-concept and smaller clinical trials, the first multicenter coronary MRA trial was published in 2001 (6). It used targeted volume acquisitions of individual coronary arteries (3-dimensional spoiled gradient-echo sequence), which allowed visualization of 84% of segments. Since then, coronary MRA has advanced significantly with significantly improved accuracy versus invasive angiography. Importantly, the main difference of accuracy between MRA and CTA is the higher positive predictive value of CT rather than the negative predictive value, with very small differences in patients with low pre-test probability (7). Further improvements are achieved with combining 32-channel technology, higher field strengths (3.0-T), and receive-transmit systems to optimize the signal-to-noise ratio (SNR) and minimize artifacts, as described in the current report (1).

The main strength of MRI, however, is its ability to provide additional, comprehensive physiological/functional assessment of coronary artery disease, including stress perfusion (8). Previous studies using stress perfusion demonstrate that absence of ischemia portends good prognosis (9). In contrast, MRA is limited in the assessment of coronary plaque.

The first multicenter CTA trial was published in 2006 (10). With 16-detector technology, only 71% of segments were evaluable, but subsequent 64-slice multi-center trials showed improved results. Although 64-slice CT is currently considered the clinical standard, state-of-the-art results are described with more advanced CT systems, including wide z-coverage (volume) scanners and dual source technology (11,12). The historically high radiation exposure has been significantly decreased with prospective triggering, reduced tube voltage, and iterative reconstruction (13,14).

A strength of CT is the additional assessment of calcified (“calcium scoring”) and noncalcified plaque burden. Recent studies demonstrate its diagnostic value for future cardiovascular events (15). Although recent CT studies describe the potential for stress perfusion imaging (16), clinical assessment of physiology is currently limited with CT.

Reflecting these data, current guidelines recommend invasive coronary imaging in high-risk patient populations. Noninvasive coronary imaging is recommended in certain intermediate risk populations, in particular if functional tests are not feasible. In lower pre-test populations, techniques with high negative predictive value are most appropriate. Although this has been mainly interpreted as using Calcium Scoring or CTA, MRA might also play a role, especially if the assessment of vessel wall alterations becomes more readily available.

In summary, both MRA and CT can assess the anatomy of coronary artery stenoses, with high negative predictive value. Comparing diagnostic accuracy of CT and MRI for anatomic coronary assessment as described in the report by Hamdan (1) is important. However, to fully understand the value of these noninvasive modalities in the assessment of coronary artery disease, their additional prognostic value needs to be considered. In the case of MRA and CT, this is focused on physiology and (plaque) anatomy, respectively. Future prospective studies will assess the value of these modalities in a more comprehensive fashion against clinical outcome. Such clinical trials are currently enrolling patients (17–19). Over the next several years, such data will define the role of these modalities in the context of existing invasive and noninvasive modalities.

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