Diagnostic Accuracy and Impact of Computed Tomographic Coronary Angiography on Utilization of Invasive Coronary Angiography

Summary: Currently, invasive coronary angiography (ICA) is the gold standard for the diagnosis of obstructive coronary artery disease (CAD). However, ICA is best reserved for patients who benefit most from coronary revascularization. Identifying a noninvasive modality that can be used to accurately diagnose obstructive CAD is desirable. Coronary CT angiography (CCTA) is an emerging modality that has a high negative predictive value and given its ability to rule out CAD, may play a role as a gatekeeper for ICA. To better understand the impact of cardiac CT on clinical practice, a study was undertaken to determine the diagnostic accuracy and clinical impact of CCTA on the use of ICA. CCTA had excellent per-patient sensitivity (99%), positive predictive value (92%), and negative predictive value (95%) for obstructive CAD. As expected (because of referral and verification bias), the specificity (64%) was lower than that of previously published studies; however, the normalcy rate of CCTA was 94%. After adjusting for referral bias, the adjusted sensitivity was 90%, and the adjusted specificity was 95%. With the implementation of a cardiac CT program, the frequency of normal ICA decreased significantly from 31.5% to 26.8%, which was significantly different from centers without dedicated cardiac CT (30.0% to 31.0%) during the same time periods. The results of this study confirm the potential utility of CCTA for the diagnosis of obstructive CAD and its potential for improving use of ICA by reducing the frequency of patients with nonobstructive CAD requiring ICA.

Conclusions: The clinical implementation of CCTA appears to positively affect ICA by reducing the frequency of normal ICA. The operating characteristics of CCTA support its potential role as a tool useful in ruling out obstructive CAD.

Editor’s Comment: CCTA potentially is an effective noninvasive gatekeeper to cardiac catheterization. This study was the first to demonstrate that when applied to appropriate patients, CCTA can help to reduce the rate of downstream normal ICA by ~15%, which has potential important cost implications.1

Rapid Initial Reduction of Hyperenhanced Myocardium After Reperfused First Myocardial Infarction Suggests Recovery of the Peri-Infarction Zone: One-Year Follow-Up by MRI

Summary: Delayed contrast-enhanced MRI currently is considered the gold standard for myocardial infarction (MI) visualization in vivo. The present study shows that it is important to consider the timing of the first MRI examination after reperfusion therapy because there is a considerable decrease in the amount of hyperenhanced myocardium during the first week after acute MI. Thus, to enable accurate comparison among patients examined during the first week after infarction, a narrow window of inclusion is desirable. This is important to consider when designing clinical trials using final infarct size determined by delayed contrast-enhanced MRI as a clinical end point. Furthermore, infarct characteristics such as infarct transmurality may be overestimated if assessed early after reperfusion therapy, affecting the predicted prognosis of functional recovery and clinical decision-making. In fact, 30% of the myocardial segments with 76% to 100% transmural extent of hyperenhancement the day after infarction showed functional improvement at 1-year follow-up.

Conclusions: The early reduction of hyperenhanced myocardium may reflect recovery of hyperenhanced, reversibly injured myocardium, which must be considered when predicting functional recovery from delayed contrast-enhanced MRI findings early after infarction. Additionally, the time course and magnitude for reduction of hyperenhanced myocardium were associated with normalization of infarct-related ECG changes.

Editor’s Comment: Late gadolinium enhancement (LGE) cardiac magnetic resonance (CMR) is used routinely to assess myocardial viability. Timing of viability assessment often is within the first week after MI to assist with revascularization decision-making in patients with left ventricular (LV) systolic dysfunction. This work confirmed that a small, but significant reduction in transmural extent of myocardial hyperenhancement occurs during the year after MI. Demonstration that most of this reduction occurs in the first week after MI suggests that viability imaging obtained at least 1 week after the acute event more accurately reflects the extent of irreversibly injured muscle unlikely to improve with revascularization.2

Strain-Encoded MRI for Evaluation of Left Ventricular Function and Transmurality in Acute Myocardial Infarction

Summary: Identification of the extent and degree of contractile dysfunction and myocardial scar in patients after acute MI has important prognostic implications. In this study, strain-encoded imaging is introduced as a novel MRI technique for myocardial deformation imaging that enables the quantification of regional deformation of tissue as a result of cardiac motion. The study demonstrated that strain parameters obtained from strain-encoded MRI can be used to analyze regional contractile function and...
transmurality states in patients with acute MI. As quantification of regional myocardial function becomes more and more important in clinical routine, strain-encoded imaging provides rapid and objective strain analysis without the need for time-consuming postprocessing.

**Conclusions:** Strain-encoded imaging provides rapid and objective quantification of regional myocardial function and allows discrimination among different transmurality states in patients with acute MI.

**Editor’s Comment:** Transmural extent of infarction is an important predictor of myocardial viability and typically is defined using LGE CMR techniques. This proof-of-concept study suggests that noncontact strain-encoded cine-derived peak circumferential strain can be applied to distinguish infarcts with >75% transmural extent of hyperenhancement from infarcts with <75% transmural extent of hyperenhancement. Whether this is a suitable surrogate for viability assessment early after MI, especially considering the role of other factors, such as edema, on regional myocardial deformation, may be illuminated by longer-term studies.¹

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**Infarct Tissue Heterogeneity Assessed With Contrast-Enhanced MRI Predicts Spontaneous Ventricular Arrhythmia in Patients With Ischemic Cardiomyopathy and Implantable Cardioverter-Defibrillator**

**Summary:** This study evaluated the relation between infarct tissue heterogeneity on contrast-enhanced MRI and the occurrence of spontaneous ventricular arrhythmia in patients with previous MI who were scheduled for implantable cardioverter-defibrillator (ICD) therapy. Ninety-one patients aged 65±11 years underwent cine MRI to evaluate LV function and volumes and contrast-enhanced MRI to characterize scar tissue (infarct gray zone as a measure of infarct tissue heterogeneity, infarct core, and total infarct size). Appropriate ICD therapy was documented in 18 (20%) patients during a median follow-up of 8.5 months (interquartile range, 2.1 to 20.3 months). Multivariable Cox proportional hazards analysis revealed that infarct gray zone was the strongest predictor of the occurrence of spontaneous ventricular arrhythmia with subsequent ICD therapy (hazard ratio, 1.49/10 g; 95% CI, 1.01 to 2.20; χ²=4.0; P=0.04). These data suggest that in patients with previous MI, infarct tissue heterogeneity on contrast-enhanced MRI is a strong predictor of spontaneous ventricular arrhythmia with subsequent ICD therapy (as a surrogate of sudden cardiac death), even after adjusting for other clinical and MRI variables (ie, total infarct size and LV function and volumes).

**Conclusions:** Infarct tissue heterogeneity on contrast-enhanced MRI is the strongest predictor of spontaneous ventricular arrhythmia with subsequent ICD therapy (as a surrogate of sudden cardiac death) among other clinical and MRI variables (ie, total infarct size, LV function and volumes) in patients with previous MI.

**Editor’s Comment:** Although ICD therapy after MI is life saving, there is increasing recognition that using LV ejection fraction as the only criterion for ICD therapy is inadequate. Several other clinical and nonclinical characteristics, such as infarct tissue heterogeneity, may have an important role in decision making for ICD therapy with respect to risk stratification and clinical outcomes.¹

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**Applicability of Appropriateness Criteria for Stress Imaging: Similarities and Differences Between Stress Echocardiography and Single-Photon Emission Computed Tomography Myocardial Perfusion Imaging Criteria**

**Summary:** Stress echocardiography appropriateness criteria were applied to patients undergoing stress echocardiography at an academic medical center. The results were compared with those obtained using the single-photon emission CT (SPECT) myocardial perfusion imaging (MPI) criteria in the same patients. With these criteria, patient indications can be classified as appropriate, uncertain, inappropriate, or not classifiable. Applying these criteria was feasible, with good interrater agreement. One in 5 patients was not classifiable, however, suggesting significant gaps in the stress echocardiography criteria. Of the patients, 19% were classified as inappropriate. The clinical situations that were most often inappropriate by these criteria, such as asymptomatic patients with low-risk Framingham risk scores, symptomatic patients with low pretest probability of CAD, an interpretable ECG, the ability to exercise, and patients scheduled for low-risk surgery, are instances that do not warrant screening with stress echocardiography according to existing guidelines. Efforts aimed at minimizing the overuse of stress imaging could focus on these clinical situations. Fewer patients were classified as appropriate by the stress echocardiography criteria (54%) than by the SPECT MPI criteria (64%). Confirmed and uncertain stress echocardiography appropriateness criteria are more strict. Future refinements of the appropriateness criteria for stress imaging should address gaps in the criteria and disparities between the stress echocardiography and SPECT MPI criteria.

**Conclusions:** Applying stress echocardiography appropriateness criteria to a patient population is feasible, although 1 in 5 patients was not classifiable. Overall, the stress echocardiography criteria classified patients differently compared with the SPECT MPI criteria. Future refinements of the appropriateness criteria for stress imaging should address gaps in the criteria and disparities between the stress echocardiography and SPECT MPI criteria.

**Editor’s Comment:** Appropriate use of testing is a major focus of healthcare reform and patient safety. This study assessed the reproducibility and utility of stress echocardiography appropriateness criteria and compared them to the slightly more “liberal” nuclear myocardial perfusion criteria. In this cohort, 20% of the patients undergoing stress echocardiography were not classifiable, and although the nuclear criteria categorized a larger number of patients as appropriate, both sets of criteria categorized a substantial number of patients as uncertain by the SPECT MPI criteria (64%), confounding the determination of whether the criteria are optimal, but some of the detailed analysis suggest that more-appropriate testing could have been ordered initially with education or appropriate decision support.⁵

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**Are Shades of Gray Prognostically Useful in Reporting Myocardial Perfusion Single-Photon Emission Computed Tomography?**

**Summary:** SPECT MPI is 1 of the most commonly used cardiac imaging tests, yet the way it is reported is not uniform. Although semiquantitative analysis of the global perfusion deficit has been shown to be prognostically important, it is not universally used, and the implication of nonzero scores that fall below the threshold of abnormal is unclear. The study sought to determine whether expression of the level of certainty regarding presence of abnormality (5-point score from definitely normal to definitely abnormal) had prognostic value. Based on the analysis of the clinical and prognostic data of 18,200 patients who underwent rest-stress dual-isotope SPECT MPI, the authors demonstrated that the final level of clinical scan certainty is an independent multivariable predictor of cardiac death in the study population. The use of multigrey reporting of SPECT MPI results incorporating nonperfusion SPECT MPI results and clinical information enhances risk stratification compared with both a dichotomous normal/abnormal approach and an approach based solely on summed perfusion scores and results in a smaller group of patients whose scans are deemed equivocal.

**Conclusions:** The use of multigrey reporting of SPECT MPI results incorporating nonperfusion SPECT MPI results and clinical information enhances risk stratification compared with both a dichotomous normal/abnormal approach or approaches based solely on segmental categories of perfusion scores. Whether this enhanced risk
stratification based on the clinical certainty of the SPECT MPI interpretation leads to a more effective therapeutic regimen, tailored to the individual patient’s need, requires further prospective evaluation.

Editor’s Comment: Although in clinical practice, myocardial perfusion scintigraphic results often are reported as positive or negative, current procedural guidelines advocate the use of multicategory reporting by adding more-detailed levels of reader certainty, including “probably normal” and “probably abnormal” categories. This study demonstrated in a large cohort of patients referred for nuclear perfusion imaging that the use of such multicategory reporting offers an improved risk prediction gradient, which may have implications for selection of appropriate management strategies.

Viability Assessment With Global Left Ventricular Longitudinal Strain Predicts Recovery of Left Ventricular Function After Acute Myocardial Infarction

Summary: The extent of viable myocardial tissue is recognized as a major determinant of recovery of LV function after MI. In this study, the role of global LV strain (as a marker of viable myocardium) assessed with novel automated function imaging (AFI) to predict functional recovery after acute infarction was evaluated. Baseline AFI global LV strain was strongly related to viability assessed with SPECT. Importantly, baseline AFI global LV strain (within 48 hours after infarction) was a predictor for change in LV ejection fraction at 1-year follow-up. A cutoff value for baseline AFI global LV strain of −13.7% yielded a sensitivity of 86% and a specificity of 74% to predict LV functional recovery at 1-year follow-up. An advantage of this novel echocardiographic technique is the fact that quantification of AFI global LV strain only is performed at rest. No additional acquisitions during exercise are needed. Furthermore, patients are not exposed to radiation. Therefore, assessment of AFI global LV strain using echocardiography may be used as an accessible imaging technique to determine viability and subsequent probability of recovery of LV function after acute MI.

Conclusions: AFI global LV strain early after acute MI reflects myocardial viability and predicts recovery of LV function at 1-year follow-up.

Editor’s Comment: The extent of viable (stunned) myocardium is an important determinant of improvement in LV ejection fraction after acute revascularization for MI. Although viability assessment traditionally has been performed using SPECT, PET, MRI, or dobutamine stress echocardiography, this study has offered a simpler approach based on automated assessment of global LV strain using resting speckle tracking echocardiography. The study not only reported a significant correlation between resting global strain and improvement in LV ejection fraction, but also suggested a cutoff value with good sensitivity and specificity for predicting improvement, thus providing a radiation-free method for assessing viability in the peri-infarct period.

Relationship Between Regional Myocardial Oxygenation and Perfusion in Patients With Coronary Artery Disease: Insights From Cardiovascular Magnetic Resonance and Positron Emission Tomography

Summary: The impairment of myocardial oxygenation during stress traditionally has not been described as part of the continuum of events that characterize the ischemic cascade. However, ischemia classically is defined as the mismatch between oxygen supply and oxygen demand at stress. The study used PET to measure regional myocardial perfusion (absolute myocardial blood flow) and CMR to assess regional myocardial oxygenation in patients with known CAD and in normal volunteers. The findings indicated that although conceptually, impairment of both perfusion and oxygenation occurs early in the ischemic cascade, it may not always occur simultaneously in CAD. Therefore, the authors speculated that the addition of oxygenation assessment using blood oxygen level-dependent CMR to the noninvasive imaging armamentarium will better identify functionally significant coronary stenoses. Finally, given the recent concerns over gadolinium contrast safety in patients with severe renal disease, the assessment of myocardial oxygenation with blood oxygen level-dependent CMR might be an attractive alternative to first-pass perfusion imaging in such patients.

Conclusions: Regional myocardial perfusion and oxygenation may be dissociated, indicating that in patients with CAD, reduced perfusion does not always lead to deoxygenation.

Editor’s Comment: Demonstration of myocardial ischemia down-stream of epicardial coronary artery stenosis is important in the selection of patients who will benefit prognostically from revascularization. This study measured myocardial oxygenation in a cohort of patients with CAD and healthy volunteers using blood oxygen level-dependent CMR at rest versus during adenosine infusion and compared the results to myocardial blood flow measurements at rest and with vasodilator stress as measured by PET. Moderate agreement suggests that the 2 measures may provide distinct information. Continued technical improvements in blood oxygen level-dependent CMR to overcome inherent difficulties related to low signal-to-noise and susceptibility-to-field inhomogeneity may improve the utility of this approach for clinical and translational investigations.

Microvascular Obstruction Remains a Portent of Adverse Remodeling in Optimally Treated Patients With Left Ventricular Systolic Dysfunction After Acute Myocardial Infarction

Summary: Adverse LV remodeling after acute MI may be limited by early achievement of patency of the infarct-related artery. Despite this, microcirculatory dysfunction—observed on contrast-enhanced CMR as microvascular obstruction (MO)—remains common. This study showed in a population of 100 survivors of acute MI with resultant LV systolic dysfunction that early MO on first-pass imaging occurred in 69% of patients and persisted as late MO on LGE imaging in 56% of patients, despite restoring optimal angiographic coronary flow in the majority. Moreover, the presence of early and, particularly, late MO was strongly associated with progressive remodeling over a 24-week period despite optimal invasive and noninvasive management, including aggressive medical therapy. Additional characteristics of the acute infarct on contrast-enhanced CMR that predicted functional outcome included infarct volume, transmurality, and endocardial extent, all of which were independently associated with greater medium-term remodeling. The addition of eplerenone to conventional therapies, including angiotensin-converting enzyme inhibitors and β-blockers, evoked a greater antiremodeling effect in patients with MO than in those without MO, suggesting a potential selective role for aldosterone antagonists in the postacute MI setting outside current indications. The presence of MO on contrast-enhanced CMR early after acute MI, therefore, remains an ominous portent of adverse outcome despite successful reperfusion and may be useful for risk stratification after acute MI. It may also represent a more predictive end point than infarct-related artery patency in future studies assessing the success of reperfusion therapies.

Conclusions: Late MO on predischarge contrast-enhanced CMR remains an ominous predictor of adverse LV remodeling despite powerful antiremodeling therapy and may be useful in the risk stratification of survivors of acute MI.

Editor’s Comment: Microvascular obstruction has long been associated with worse outcomes after MI, and this study has provided mechanistic insights into this association. Structural measurements over the course of 24 weeks were obtained in a large post-MI cohort receiving standard-of-care therapies such as angiotensin-converting enzyme inhibitors and β-blockers, evoked a greater antiremodeling effect in patients with MO than in those without MO, suggesting a potential selective role for aldosterone antagonists in the postacute MI setting outside current indications. The presence of MO on contrast-enhanced CMR early after acute MI, therefore, remains an ominous portent of adverse outcome despite successful reperfusion and may be useful for risk stratification after acute MI. It may also represent a more predictive end point than infarct-related artery patency in future studies assessing the success of reperfusion therapies.

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enzyme inhibitors, angiotensin receptor blockers, and β-blockers, with one half of patients also receiving eplerenone. MO, readily recognizable on LGE CMR images, portends progressive remodeling despite excellent medical therapies and likely identifies a subgroup at highest risk of developing heart failure after MI.9

**Detection and Quantification of Myocardial Scars by Contrast-Enhanced 3D Echocardiography**

**Summary:** In patients with chronic LV dysfunction, the identification and quantification of scarred myocardium is important to determine the ischemic or nonischemic origin of cardiomyopathies, to determine patient prognosis, and to predict functional recovery after revascularization or resynchronization therapy. The aim of this study was to test the hypothesis that 3D echocardiography can detect and quantify myocardial scars using delayed enhancement CMR as the reference standard. The results indicated that contrast-enhanced 3D echocardiography allows for the segmental identification of myocardial scars with a sensitivity of 78% and a specificity of 99%. Good correlation and limits of agreement were found between the assessment of scar mass and transmurality by contrast-enhanced 3D echocardiography and delayed enhancement CMR. Finally, intraobserver, interobserver, and test-retest reproducibility was comparable with both techniques. This study demonstrated that contrast-enhanced 3D echocardiography is a promising alternative to delayed enhanced CMR in the field of scar imaging and has opened the way for further research protocols. Nonetheless, future developments are needed to improve the sensitivity of the technique, particularly in the anterior and lateral walls where attenuation and rib artifacts are common.

**Conclusions:** Contrast-enhanced 3D echocardiography is a promising new tool for the detection and quantification of MI scars.

**Editor’s Comment:** Myocardial scarring after MI is important prognostically and may influence clinical decision-making. The gold standard for its detection and quantitation is delayed enhancement CMR. This preliminary study suggested that contrast-enhanced 3D echocardiography and delayed enhancement CMR. Finally, intraobserver, interobserver, and test-retest reproducibility was comparable with both techniques. This study demonstrated that contrast-enhanced 3D echocardiography is a promising alternative to delayed enhanced CMR in the field of scar imaging and has opened the way for further research protocols. Nonetheless, future developments are needed to improve the sensitivity of the technique, particularly in the anterior and lateral walls where attenuation and rib artifacts are common.

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**Reduced Left Ventricular Torsion Early After Myocardial Infarction Is Related to Left Ventricular Remodeling**

**Summary:** The systolic twisting motion of the LV along its longitudinal axis, resulting from the opposite rotation of the LV apex compared with the base, is emerging as an important, sensitive parameter of LV systolic function. However, not much data on changes in LV torsion after acute MI are available, and no specific data exist concerning the role of LV torsion in predicting postinfarction LV remodeling. The results of this evaluation showed that LV torsion (evaluated by speckle tracking echocardiography) is significantly impaired early after acute MI because of a reduction of both basal and apical rotation. The infarct size was independently related to LV torsion. In addition, LV torsion early after acute MI was significantly and independently related to the occurrence of LV remodeling at 6-month follow-up, with incremental predictive value over other clinical and echocardiographic variables. By receiver operating characteristic analysis, peak LV torsion ≤1.44°/cm provided the highest sensitivity (95%) and specificity (77%) to predict LV remodeling. According to the study results, this parameter may be used in clinical practice as an early marker for risk stratification of patients with acute MI. Early assessment of LV torsion after acute MI by speckle tracking echocardiography could identify patients (with reduced LV torsion) who may benefit from aggressive medical therapy to prevent LV remodeling, heart failure, and poor outcome.

**Conclusions:** LV torsion is significantly impaired early after acute MI. The amount of impairment of LV torsion predicts LV remodeling at 6-month follow-up.

**Editor’s Comment:** The long-axis wringing motion of the LV, resulting from rotation of the base and apex in opposite directions, is an important element of LV systolic function that can be measured with speckle tracking echocardiography (torsion). This study reported that LV torsion is reduced after infarction because of impaired apical and basal rotation. Additionally, torsion provided modest incremental value over clinical and other echocardiographic predictors of LV remodeling as assessed at 6 months.11

**Influence of Left Ventricular Hypertrophy and Geometry on Diagnostic Accuracy of Wall Motion and Perfusion Magnetic Resonance Imaging During Dobutamine Stress**

**Summary:** The assessment of regional wall motion during high-dose dobutamine stress magnetic resonance (DSMR-wall motion) is an established clinical method with a generally high diagnostic and prognostic value for the evaluation of patients with CAD. This study highlighted the influence of different LV geometric patterns on diagnostic accuracy of DSMR-wall motion and the potential benefit of performing additional first-pass DSMR-perfusion imaging. In patients with increased LV concentricity, DSMR-perfusion imaging improved the diagnostic accuracy compared to DSMR-wall motion, especially with regard to sensitivity for the detection of CAD. In contrast, DSMR-wall motion remained an accurate test in patients with normal geometry and eccentric hypertrophy. Thus, the study authors recommended adding DSMR-perfusion imaging to a routine stress protocol in patients with increased LV concentricity.

**Conclusions:** The accuracy of DSMR-wall motion is influenced by LV geometry. In patients with concentric remodeling and concentric hypertrophy, the addition of first-pass DSMR-perfusion imaging improves the diagnostic accuracy for the detection of CAD.

**Editor’s Comment:** LV geometry has long been associated with impaired reproducibility and accuracy of LV function and anatomy measures, especially with imaging methods based on 2D assessment and geometric assumptions. This study demonstrated that these findings apply to 3D-based MRI and have an impact on the accuracy for the prediction of significant coronary disease. The results suggest that additional measures of myocardial perfusion can help to overcome these limitations in some subgroups.12

**Magnetic Resonance Imaging Delineates the Ischemic Area at Risk and Myocardial Salvage in Patients With Acute Myocardial Infarction**

**Summary:** The extent of myocardium subject to ischemia, also known as the myocardial area at risk (AAR), is a determinant of infarct size and prognosis. Therefore, identification of the ischemic AAR may provide useful information for clinical and research purposes. This study investigated whether MRI measurement of AAR would be correlated with an angiographic AAR risk score in 50 consecutive patients with acute MI treated at a community hospital. Bright-blood, T2-prepared, steady-state, free-precession MRI was used to depict the AAR, whereas infarct size was measured in LGE images. AAR also was estimated by the Alberta Provincial Project for Outcome Assessment in Coronary Heart Disease and Duke angiographic jeopardy scores. Myocardial salvage was calculated as AAR minus infarct size. AAR as measured by T2-weighted MRI correlated well with angiographic measures of myocardial jeopardy. Measurement of AAR and infarct size in the early postinfarct period enabled estimation of myocardium salvage in all patients regardless
of presentation type or history of MI. In multivariable analysis, infarct size was predicted by MRI-derived AAR. The results have potential clinical importance for the following reasons. Bright-blood, T2-weighted MRI can delineate the ischemic AAR and quantify myocardial salvage in patients with MI, including those with prior MI. MRI is the only method that can provide an AAR estimate without using radiation. Because angiographic estimates of AAR are time consuming and not normally used clinically, the study findings open the door to measurement of myocardial salvage after acute MI not only for clinical research purposes, but also for routine clinical practice.

Conclusions: T2-prepared, steady-state, free-precession MRI delineates the AAR and enables estimation of myocardial salvage when coupled with a measurement of infarct size.

Editor’s Comment: Traditional dark-blood imaging methods for T2-weighted CMR have long been hampered by susceptibility to artifact and other limitations, yet myocardial T2 as a marker of edematous, yet not irreversibly injured myocardium holds significant promise in attempts to increase myocardial salvage. This study applied a new bright-blood technique for T2-weighted CMR to a group of patients with acute MI after percutaneous coronary intervention and more precisely delineated AAR compared with angiographic and electrocardiographic scores. These results suggest that T2-weighted CMR with such improved techniques may serve as a useful end point in trials of novel therapeutics directed at increasing myocardial salvage after MI.

Relief of Mitral Leaflet Tethering Following Chronic Myocardial Infarction by Chordal Cutting Diminishes Left Ventricular Remodeling

Summary: One of the key targets of reducing mitral regurgitation is the reduction of otherwise progressive LV remodeling, which exacerbates mitral regurgitation and conveys adverse prognosis. Postinfarction, leaflet closure is restricted by tethering to displaced papillary muscles, with a prominent bend in the basal anterior leaflet (seagull sign) and markedly limited posterior leaflet motion (Carpentier functional classification type 3b). Chordal connections help to maintain normal contractile function but cause mitral leaflet tethering and ischemic mitral regurgitation after MI. Chordal cutting relieves tethering and mitral regurgitation, but its effect on LV remodeling has needed testing. This study demonstrated that cutting secondary chordae to the anterior or both leaflets in the chronic MI setting does not exacerbate long-term LV remodeling; it not only relieves mitral regurgitation, but also limits progressive increases in LV volumes. This study confirmed the long-term safety of this technique, which has entered clinical applications, and its availability as a strategy to relieve both ischemic mitral regurgitation and LV remodeling.

Conclusions: Reduced leaflet tethering by chordal cutting in the chronic post-MI setting substantially decreases the progression of LV remodeling with sustained reduction of mitral regurgitation over a long-term follow-up. These benefits have the potential to improve clinical outcomes.

Editor’s Comment: Ischemic mitral regurgitation is a common and prognostically important complication of MI. It is attributable to an imbalance between closure and tethering forces on the mitral leaflets with resultant excessive apical tethering and impaired leaflet coaptation. Selective chordal cutting has been shown to reduce tethering and improve leaflet coaptation, thus reducing mitral regurgitation in an animal model and small clinical series. This study reported that in a sheep model of ischemic mitral regurgitation, this intervention results in sustained reduction in mitral regurgitation and reduced remodeling to ~6 months of follow-up. If reproducible in patients, this improvement has the potential to favorably affect clinical outcomes.

Prognostic Value of Coronary Computed Tomographic Angiography in Comparison With Calcium Scoring and Clinical Risk Scores

Summary: In recent years, CCTA has emerged as a new, noninvasive imaging modality for the detection and, in particular, exclusion of coronary artery stenosis. In addition CCTA has the unique advantage of depicting not only the vessel lumen, but also the surrounding tissue and has been shown to detect noncalcified plaques. Some studies suggest an incremental value of the detection of these plaques for the prediction of subsequent cardiac events over clinical risk assessment and calcium scoring. In the present study of 2223 mostly symptomatic patients undergoing CCTA for diagnostic purposes, good prognostic value of CCTA was confirmed on the basis of findings of plaque and stenosis for major cardiac events, including death, MI, and late coronary revascularization over 28 months. Moreover, the findings were incremental in prediction of major cardiac events when compared with calcium scoring and clinical risk assessment (Morise score). The results suggest that CCTA not only has excellent diagnostic value for the detection of stenosis, but also has incremental prognostic value and, particularly, enables reclassification of symptomatic patients at intermediate risk for obstructive CAD.

Conclusions: In patients with suspected CAD, CCTA not only detects coronary stenosis, but also improves prediction of cardiac events above and beyond conventional risk scores and calcium scoring. This may result in a reclassification of cardiovascular risk in a substantial proportion of patients.

Editor’s Comment: Emerging evidence supports a prognostic role for CCTA in patients with suspected CAD. However, the incremental prognostic value of this strategy over a more simple assessment of coronary artery calcium score remains controversial. This study in a relatively large cohort of patients with suspected CAD demonstrated that assessments of the extent (multivessel involvement) and severity (degree of stenosis) of CAD by CCTA offers incremental prognostic value over clinical factors, which results in improved risk prediction compared with measures of coronary calcium score.

Features of Disrupted Plaques by Coronary Computed Tomographic Angiography: Correlates With Invasively Proven Complex Lesions

Summary: CCTA can accurately detect the presence of coronary atherosclerosis and assess its impact on luminal narrowing. Although CCTA also has plaque characterization capabilities, there are only scant data regarding its ability to delineate features of frank plaque disruption. Given the use of CCTA for the evaluation of patients with acute chest pain, identifying features indicative of complex ruptured plaque has considerable clinical implications. This proof-of-concept study was designed to establish whether CCTA has the capability to identify morphological features of plaque disruption and to validate these findings using invasive coronary angiography as the reference standard.

Conclusions: In this highly selected group of patients with unstable angina, CCTA can delineate features of plaque disruption, including ulceration and intraplaque dye penetration, which are specific markers of invasively identified complex plaque. Further studies are needed to confirm the generalizability of the results and to explore the clinical and prognostic implications of these findings.

Editor’s Comment: The traditional assessment of coronary stenosis by noninvasive CCTA is based on the description of the degree of luminal narrowing. Although this has practical clinical implications regarding referral to catheterization, a more-detailed evaluation of high-risk plaque morphology may provide important information for risk stratification. This study demonstrated that the presence of ulceration and intraplaque dye penetration on CCTA has modest
sensitivity but high specificity for identification of complex plaques as defined by invasive angiography. The potential incremental prognostic value of these morphological features warrants further investigation.16

**Complementary Prognostic Values of Stress Myocardial Perfusion and Late Gadolinium Enhancement Imaging by Cardiac Magnetic Resonance in Patients With Known or Suspected Coronary Artery Disease**

**Summary:** CMR reversible myocardial perfusion defect (RevPD) has demonstrated not only high accuracy in detection of flow-limiting coronary stenosis, but also strong prognostic value in risk stratifying patients presenting with suspected ischemia. With high tissue contrast and spatial resolution, LGE CMR imaging currently is the most sensitive imaging technique for detecting small subendocardial infarction that elevates a patient’s risk of cardiac events. In a clinical cohort of 254 patients referred for stress CMR imaging, the hypothesis that RevPD and LGE imaging in a single CMR study can provide complementary prognostic values for major adverse events, including cardiac death or nonfatal MI, was tested. Although RevPD and LGE both demonstrated strong unadjusted association with death/MI (hazard ratio, 6.88 and 5.32, respectively; both \( P < 0.0001 \)), robust association with death/MI by RevPD and LGE was maintained when the effects of these variables were adjusted for each other and for patient age and sex. In patients without a history of MI who were found to have no RevPD, the presence of LGE portended a \( > 1 \)-fold hazards increase in death/MI. Patients with both RevPD and LGE absent were found to have the most favorable annual negative event rate for death/MI at \( > 98 \% \). Therefore, it was concluded that CMR stress myocardial perfusion and LGE imaging performed in a CMR study provide a complementary prognostic implication for cardiac death or acute nonfatal MI.

**Conclusions:** CMR imaging provides robust risk stratification for patients who present with symptoms of ischemia. Characterization of RevPD and LGE by CMR provides strong and complementary prognostic implication for cardiac death or acute MI.

**Editor’s Comment:** Outcomes-based validation of imaging is considered critically important in defining the value of a test. This study demonstrated the complementary value of stress CMR-based imaging markers of scar and ischemia for risk stratification in symptomatic patients with suspected CAD. These results need to be confirmed in larger studies, and the incremental value over clinical risk scores needs to be proven. However, these preliminary results should serve as the basis for future prognostic studies with CMR in larger cohorts with longer follow-up.17

**Prevalence of Asymptomatic Coronary Artery Disease in Ischemic Stroke Patients: The PRECORIS Study**

**Summary:** CAD is a significant cause of morbidity and mortality in patients with stroke. Using 64-section CCTA, this study assessed the prevalence of 50% asymptomatic CAD in 274 consecutive patients with ischemic stroke or transient ischemic attack and whether asymptomatic CAD is related to traditional risk factors and cerebrocerebral atherosclerosis. The prevalence of 50% asymptomatic CAD was 18% (95% CI, 14% to 23%). Asymptomatic CAD was independently associated with traditional risk factors assessed individually and through the Framingham risk score, the presence of at least 1 50% cerebrocerebral artery stenosis, excessive alcohol consumption, and ankle brachial index <0.9. The prevalence of 50% asymptomatic CAD also was related to the extent of cerebrocerebral atherosclerosis. The majority (75%) of patients with 50% asymptomatic CAD and 90% of those with 3-vessel disease or left-sided main trunk disease had either a 20% 10-year risk of coronary heart disease according to the Framingham risk score or at least 1 50% cerebrocerebral artery stenosis. This subset of patients with stroke accounted for 40% of the study population. This study could not address the value of screening for asymptomatic CAD. The decision to screen for patients with asymptomatic CAD and stroke and the need for coronary revascularization should be addressed by standard algorithms as suggested by national guidelines.

**Conclusions:** About one fifth of patients with nondisabling, noncardioembolic ischemic stroke or transient ischemic attack have 50% asymptomatic CAD. In addition to vascular risk factors, the presence of 50% cervicocephalic artery stenosis is strongly related to 50% asymptomatic CAD.

**Editor’s Comment:** This study contributes to our understanding of atherosclerosis as a systemic disease with local manifestations in several vascular beds. It further supports published data from studies in patients with peripheral artery disease, demonstrating coexistence of significant CAD in a substantial number of these patients. The study emphasizes the importance of integration of information from all vascular beds and supports the concept of global cardiovascular risk.18

**Cardiac Positron Emission Tomography/Computed Tomography Imaging Accurately Detects Anatomically and Functionally Significant Coronary Artery Disease**

**Summary:** Accurate noninvasive assessment of CAD is a challenging task. In a cohort of 107 patients at intermediate clinical risk, this study measured the power of hybrid PET and CCTA against invasive coronary angiography with fractional flow reserve for the detection of obstructive CAD. Although CCTA and PET individually were able to rule out significant CAD (negative predictive value, 97%), both approaches showed only modest positive predictive value. PET perfusion imaging alone could not always separate microvascular dysfunction from epicardial stenoses, whereas CCTA was limited in defining the physiological significance of anatomic stenosis. Hybrid PET/CT significantly improved this accuracy to 98%. This was achieved with a rapid 30-minute imaging protocol with a reasonable radiation dose (<10 mSv) to the patient. These data suggest that hybrid PET/CT imaging of the heart is a feasible, accurate method to assess CAD noninvasively in a symptomatic, moderate-risk patient population.

**Conclusions:** Cardiac hybrid PET/CT imaging allows accurate noninvasive detection of CAD in a symptomatic population. The method is feasible and can be performed routinely with <10 mSv in most patients.

**Editor’s Comment:** Although hybrid imaging combining PET and CCTA can potentially help to improve the diagnosis of CAD, the incremental value of such a strategy is uncertain. Using a gold standard of invasive quantitative coronary angiography combined with fractional flow reserve, this study demonstrated that when applied to patients at intermediate risk, PET/CCTA can potentially improve diagnostic accuracy by correctly identifying flow-limiting epicardial stenosis. Appropriate selection of patients and cost-effectiveness of such a hybrid imaging strategy warrants investigation.19

**Three-Dimensional Contrast-Enhanced Multidetector CT for Anatomic, Dynamic, and Perfusion Characterization of Abnormal Myocardium to Guide Ventricular Tachycardia Ablations**

**Summary:** Identification of areas of scar are useful to guide catheter ablation of ventricular tachycardia. Use of MRI for this purpose is limited by the presence of ICDs in many patients. This study evaluated contrast-enhanced CT to assess LV scar based on analysis of anatomy, motion, and perfusion. Images were integrated into a
clinical mapping system to guide ventricular tachycardia ablation. The regional LV anatomic, dynamic, and perfusion parameters agreed well with areas of abnormal voltage, allowing these regions to be identified before the mapping procedure. Contrast enhanced CT also is able to characterize the transmural extent and intramyocardial location of scar tissue that could potentially help to identify intramural and epicardial arrhythmia substrate, overcomiing a limitation of endocardial voltage mapping. Differentiating low epicardial voltage due to fat also may be possible. Further study may improve understanding of scar geometry as it relates to ventricular tachycardia and facilitate ablation.

**Conclusions:** Anatomic, dynamic, and perfusion imaging using contrast-enhanced CT allows characterization of LV anatomy and 3D scar and border zone substrate. Integration of reconstructed 3D data sets into clinical mapping systems supplements information of voltage mapping and may enable new image approaches for substrate-guided ventricular tachycardia ablation.

**Editor’s Comment:** There is growing evidence that morphological changes of the infarct border zone assessed by MRI after clinical or experimental MI may represent the substrate of disturbed electric conduction and the origin of ventricular tachycardia. This study extended this concept and provided preliminary evidence supporting the notion that similar associations can be evaluated using contrast-enhanced cardiac CT. With the growing availability of precise coregistration, preprocedural cardiac CT may contribute to an increased success of substrate-guided ventricular tachycardia ablation.²⁰

**Disclosures**

None.

**References**


