The Concept of Functional Percutaneous Coronary Intervention

Why Physiologic Lesion Assessment Is Integral to Coronary Angiography

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KEYWORDS

• Fractional flow reserve • Coronary artery disease • Coronary revascularization

KEY POINTS

- The majority of revascularization decisions are based solely on the coronary angiogram.
- Anatomic assessments on coronary angiography often times are discordant with hemodynamic stenosis severity.
- Fractional flow reserve (FFR) is a well validated tool to assess coronary stenosis severity.
- The use of FFR to assess coronary stenoses frequently changes revascularization strategies.
- Patients with physiologically insignificant lesions based on FFR do not benefit from revascularization and have an excellent prognosis with optimal medical therapy alone.

INTRODUCTION

The amount of attention directed toward the appropriateness of medical procedures has been increasing steadily in the past years in a rapidly changing health care environment. Increasing amounts of scrutiny have been placed in particular on the use of percutaneous coronary interventions (PCI), because more than 600,000 of these procedures are performed annually within the United States[1] at substantial direct and indirect costs to the health care system. Consequently, a growing amount of oversight has been directed toward the clinical justification of the perceived benefit from many of these revascularization procedures. Given the scope of this problem, there has been a considerable push at both the public and professional levels to assess the "appropriateness" of such procedures, a movement that has even produced action at the congressional level.

Much of this debate was driven by the findings of the landmark Clinical Outcomes Utilizing Revascularization and Aggressive Drug Evaluation (COURAGE) trial.[2] Patients were enrolled into this study based on angiographic stenosis severity by visual assessment, either with a lesion of greater than 70% in the setting of EKG abnormalities or a prior abnormal stress test or a lesion of greater than 80% with concomitant symptoms of classic angina. The overarching conclusion reached in COURAGE was that PCI offered no significant benefit relative to optimal medical therapy (OMT) alone with respect to mortality or myocardial infarction at 5 years in

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the management of patients with stable coronary artery disease (CAD). Importantly, this trial also suggested that the gold standard for the evaluation of ischemia, namely, coronary angiography, was by itself insufficient in identification of lesions that would benefit from PCI. A subsequent metaanalysis of 12 randomized trials including a total of 7182 patients with stable CAD reaffirmed the absence of benefit of PCI against OMT.[3]

APPROPRIATE USE CRITERIA FOR CORONARY REVASCULARIZATION

Appropriate use criteria have been used as a means to identify the appropriateness of both diagnostic tests and therapeutic modalities in a growing number of medical and surgical specialties. Appropriate use criteria with regard to coronary revascularization procedures were formally introduced in February 2009 in a consensus statement released by the American College of Cardiology Appropriate Criteria Task Force, Society for Coronary Angiography and Interventions, Society of Thoracic Surgeons, American Association of Thoracic Surgeons, American Heart Association, and the American Society of Nuclear Cardiology.[4] Applying these criteria in a multicenter prospective analysis of the "appropriateness" of more than 500,000 interventions performed at 1091 centers in the United States from July 2009 to September 2010, Chan and colleagues[5] found that coronary revascularization was nearly always appropriate in the acute setting of ST-elevation myocardial infarctions, non–ST-elevation myocardial infarctions, and high-risk unstable angina (98.6%). In contrast, only 50.4% of interventions performed on patients with stable angina were deemed appropriate when using the novel appropriate use criteria, whereas 11.6% were found inappropriate (with the remainder being in the "uncertain" category). It has to be noted, however, that the study period was shortly after the initial publication of the appropriate use criteria and thus predated the widespread adoption of these criteria. Nevertheless among the inappropriate PCIs, certain characteristics are notable: 72% had low-risk noninvasive tests, 94% lacked high-risk coronary findings on angiography, and only 6% had lesions in the proximal left anterior descending artery. Furthermore, 54% of patients had no symptoms of angina and 96% of this cohort were either on none (42.3%) or only one (52.5%) antianginal medication at the time of PCI. This analysis suggests that the coronary angiogram either alone or in conjunction with noninvasive testing fails to identify lesions suitable for "appropriate" intervention in a substantial number of cases.

The importance of performing PCI on predominately appropriate patients has been demonstrated in a retrospective analysis of 1625 patients that underwent PCI from 2006 to 2007 in the setting of stable angina and suspected CAD.[6] Using the 2009 appropriate use criteria, appropriate revascularization (either coronary artery bypass grafting or PCI) provided a 26.7% decrease in the composite of death and recurrent acute coronary syndrome at 3 years vs. OMT (11.8% vs 16.1%; $P = .0087$). Additionally, there was a trend toward an increase in adverse events among patients deemed inappropriate for revascularization that nevertheless underwent coronary revascularization (14.2% vs 9.4%; $P = .97$), albeit not statistically significant owing to the low number of events. Aiming to identify lesions appropriate for revascularization thus has a substantial impact on patient outcomes.

NONINVASIVE ISCHEMIC EVALUATION

Noninvasive testing in the evaluation of patients with stable angina remains the standard of care in the diagnostic workup. Exercise myocardial perfusion imaging and exercise echocardiography have high negative predictive values. The absence of myocardial ischemia on these tests is associated with an excellent prognosis and an annual event rate of 0.45% and 0.54%, respectively, for each modality.[7] Similarly, a metaanalysis of 19 studies demonstrated that a normal or low-risk single photon emission CT result was associated with a 0.6% annual risk of major cardiac events.[8] These data demonstrate that, at a population level, noninvasive testing provides a robust means of risk stratification of patients with suspected CAD. However, in individual cases, noninvasive testing may prove to be less reliable, perhaps providing an explanation for the poor use of noninvasive testing before cardiac catheterization. A retrospective analysis of 23,887 patients insured by Medicare aged 65 or older found that only 44.5% underwent stress testing in the 90 days preceding elective PCI.[9] Subgroup analyses demonstrate that the highest volume providers (>150 PCIs annually) were least likely to perform stress testing before PCI (odds ratio, 0.84; 95% CI, 0.77–0.93). In addition, use of stress testing in academic teaching hospitals was similar to that in the overall population, suggesting that the use of noninvasive testing is independent of academic or teaching status. In a more