Editor's Note

Selective Coronary Angiography: 42 Years Later

"The primary goal of coronary arteriography is the identification, localization and assessment of obstructive lesions present within the arteries of the heart."—Gofredo Gensini, 1975¹

Key words: coronary angiography

In 1958 Mason Sones, working at the Cleveland Clinic, opened the door for the modern diagnosis and therapy of coronary artery disease when he inadvertently power injected contrast into the right coronary artery. Following that observation, catheters were designed to engage the coronary arteries selectively in order to inject contrast intentionally to assess the presence, location, and severity of coronary artery disease.^{2,3} In 1962 Sones wrote,

Coronary arteriography is indicated when a problem is encountered which may be resolved by the objective demonstration of the coronary artery tree provided competent personnel and medical facilities are available and the potential risks are acceptable to the patient and his physician.³

Sones also deserves credit for combining ventriculography with coronary angiography to assess the clinical significance of a given stenosis in a given area of the ventricle. For Sones, ventriculography was an integral part of the evaluation of the coronary arteries.

The purpose of this editorial is to point out that coronary angiography is not on the way out as a scientific or diagnostic tool, nor will it be for some time. Coronary angiography is still the only practical method of assessing the precise location of coronary pathology in the living patient.

What Does Coronary Angiography Teach Us?

Since over a million patients undergo coronary angiography per year, much can be learned from it if time is taken to assess the angiogram properly. Coronary angiography, which is lu-

menography, tells us a great deal about the lumen of the vessel and some things about the vessel wall in the living patient. In the living person, coronary angiography can define precisely lumen stenosis severity; location of the stenosis—for example, ostial, proximal, mid, distal, or at bifurcations; the morphology of the stenosis; the number of vessels involved; the number of lesions in the same vessel; TIMI flow grade; presence or absence of collaterals; and the relationship of vessel pathology to left ventricular function. Since a catheter is in the aorta, pressure measurements in the aorta and the left ventricle can be made and that important information can be integrated with ventricular size, contraction, and regional wall motion determined by ventriculography. All sorts of morphologic assessments can be made including the contours of the lesions, that is, irregular or smooth; presence or absence of ulcerations; thrombi and dissections; stenosis length; division branches within the stenosis; and stenosis area symmetry.

Fluoroscopy can attest to the presence or absence of coronary calcification.

No other single diagnostic test that I know of provides this type of information for the clinical cardiologist. I truly believe that if coronary angiography were inexpensive and without hazard it would be the diagnostic study of first choice in patients with chest discomfort and as a routine follow-up assessment of medical therapy, revascularization procedures, and clinical trials.

Evaluation of the Microcirculation

Although quantification of abnormalities in the coronary microcirculation remains a problem, evaluation still can be done in a qualitative manner. One needs to allow the cine camera to run a little longer to assess perfusion of the distal coronary circulation. Often a microcirculatory blush can be seen just prior to the venous phase of the coronary angiogram. In my view this is useful information since it suggests perfusion of viable myocardium even though the ventricle may not be contracting normally in that coronary distribution. Coronary flow reserve using a Doppler flow wire introduced through the coronary catheter also provides information about the microcirculation.

TIMI flow parameters are also semiquantitative but they do provide the clinician with some notion of normalcy, particularly after an angioplasty has been performed or after thrombolysis of an occluded coronary artery.

The presence of visible collaterals is also important and, in my opinion, defines an ischemic but viable myocardium. Collaterals are relatively easy to identify but grading collaterals is quite subjective.

Spin-Off Opportunities from Coronary Angiography

The fact that catheters are in the aorta and in the coronary arteries provides an opportunity to use other methods to assess plaque stenosis and plaque morphology as well as assessing the pathologic anatomy of the vessel wall. The most obvious example is intracoronary ultrasound.

When intracoronary ultrasound is introduced through a coronary catheter, it can identify changes such as coronary dissection, expanding hematomas, smooth muscle proliferation, plaque thickness or thinness, plaque eccentricities, and location and extent of calcification.

Coronary angiography also provides the opportunity to assess vascular responses to drugs such as intracoronary nitrates, ergometrine, acetylcholine, and so forth, using change in coronary angiographic diameter or changes in coronary flow velocity as estimated by a Doppler wire.

Detecting Coronary Artery Disease Using Noninvasive Tests

Noninvasive tests, when positive, identify a surrogate that suggests that the patient has pathophysiologically significant coronary artery disease. Current clinically useful noninvasive tests are designed to detect some index of myocardial ischemia, but not coronary pathologic anatomy. Any coronary disease not resulting in myocardial ischemia or heterogeneity of coronary blood flow is not detected by the noninvasive test. Thus, coronary stenoses of 30–50%, which may be the stenoses most prone to rupture, are not detected because they rarely result in myocardial ischemia under conditions of stress.

I use noninvasive testing as much as any cardiologist. However, I find it most useful in the patient with chest pain of uncertain etiology or whose coronary angiography reveals a “borderline coronary stenosis.” In this latter instance, the physiologic assessment of that stenosis—that is, a perfusion abnormality or a transient wall motion abnormality that determines the magnitude of the myocardium at risk due to ischemia—is an important complementary study.

It should be obvious that even in centers where noninvasive testing is a high priority for basic and clinical investigation, the catheterization laboratories of these same centers are not lying idle.

How Does Coronary Artery Angiography Help in the Assessment of the Vessel Wall?

In recent times much energy has been directed toward assessing the vascular wall. As mentioned previously, coronary angiography is lumenography, but it can provide access to the vessel in which other techniques, for example, intracoronary ultrasound, can assess the vascular wall. The most exciting technique with, I believe, the greatest potential to assess the coronary vessel wall is magnetic resonance imaging. When this imaging system is perfected, clinicians and scientists will have a much clearer understanding of the vascular biology of the coronary circulation. They may be able to identify the unstable coronary plaque that is prone to rupture and quantitate plaque changes after aggressive medical therapy that results in stabilization of the plaque.

Will Noninvasive Techniques Replace Coronary Angiography?

For all the foregoing reasons, I have serious doubts that coronary angiography is on the way out. So long as catheter interventions such as angioplasty and other revascularization techniques require precise location of lesions at the time of the intervention, coronary angiography will remain the reference standard for revascularization.

However, in other areas, such as preoperative evaluation of older patients with valvular disease and long-term repetitive evaluation of coronary artery disease, it might come to pass that noninvasive anatomic assessment (e.g., MRI to assess the vascular wall and computed tomography to assess the lumen) combined with noninvasive physiologic assessment of the coronary circulation using something other than cardiac catheterization and coronary angiography will be the method of choice.

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