

EDITOR'S PAGE

Is it Form or Function?

We, interventionalists and angiographers, are visual people. We study the geography of the terrain. Some of the most discriminating and, therefore, most successful questions on the interventional cardiology boards are those that require integration of 2-dimensional images into 3-dimensional concepts. Beauty to us is a perfectly curved and symmetrical coronary artery tree at the completion of a percutaneous coronary intervention (PCI). But in addition to the form, we, as an architect, must also appreciate function. Now in the case of the coronary circulation, we are asked to favor function over form. It may not come naturally to the visually gifted, but it is necessary.

Hemodynamics used to be a much more prominent component of cardiology training. With the ascent of coronary angiography, coronary anatomy took center stage in the catheterization laboratory. However, we should remember that interventional cardiology was born with the experiments that documented that a pressure drop across an artificially-created stenosis could be eliminated by balloon expansion (Fig. 1). Now 35 years after the first angioplasty cases were performed with balloons mounted on fluid-filled catheters attached to pressure manometers, we have gone back to the future and pressure measurements or fractional flow reserve (FFR) is reasserting the importance of function. This time it is not so much to document the result of angioplasty (stenting), but to determine if the unattractive form (the stenosis), nonetheless, has appealing function (adequate flow reserve).

In this issue of *JACC: Cardiovascular Interventions*, we once again present a mini-focus on FFR with 4 original papers and 2 editorial comments. Truly we could fill the entire issue with papers investigating or using this technology. The evaluation and application of FFR will undoubtedly occupy significant space in issues to come. Despite the clear documentation that visually identified stenoses may not reflect functional significance, the technology is underutilized. Some laboratories still do not have FFR and some operators do not use it. Guidelines have endorsed the use of FFR in stenoses of intermediate severity, especially when noninvasive ischemia in that zone has not been documented. Correctly performed, FFR measurements often surprise the angiographer, but provide clear documentation that an interventional procedure on that lesion can or cannot improve the flow capability. Most lesions do not require this measure as they are so severe as to almost always restrict flow, or so mild as to seldom do so. Also, perfusion information may be clear from noninvasive testing. Instrumenting such lesions would be inappropriate. The performance of FFR is critical in obtaining accurate measures at the time of maximal hyperemia. Although central venous administration is the gold standard for FFR, peripheral venous or intracoronary administration are often practiced for convenience. A previous publication documented that increasing doses of intracoronary adenosine from 60 to 720 μg resulted in progressively decreasing FFR values (1). Alternative agents have also been tested (2). Serial stenoses in arteries (3) and left main stenosis (4) provide special challenges. However, the attention to FFR would not be so great if it only improved the assessment of the lesion significance. The current excitement is because of the use of this technology to guide interventions in trials that measure clinical outcomes. The Deferral Versus Performance of PTCA in Patients Without Documented Ischemia (DEFER) trial (5), that showed patients with lesions having FFR >0.75 were not benefited by stenting, and the FAME trial (6) that showed that the use of FFR to guide intervention was associated with better outcomes and lower costs than using angiography alone, are prime examples.

I was at the presentation of the Fractional Flow Reserve versus Angiography for Multivessel Evaluation (FAME) II results during the European Society of Cardiology (ESC) meeting in



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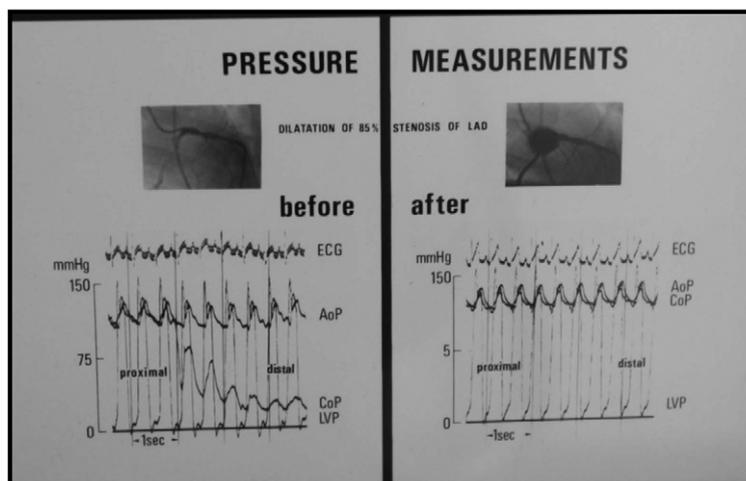


Figure 1. Experimental PTCA From Andreas Gruentzig's Presentation at American Heart Association Scientific Session, November 1976.

Munich. Much of the drama of this trial and whether it would be a counterweight to the Clinical Outcomes Utilizing Revascularization and Aggressive Drug Evaluation (COURAGE) trial was dampened by the earlier press releases announcing its premature termination. As everyone now knows, the trial, using FFR to confirm that the lesions were truly capable of producing ischemia in a major territory, was positive. The disappointment was that the early termination based on urgent revascularization excess in the medically treated group made this the component that drove the decision for termination. It appeared from the Kaplan-Meier curves of myocardial infarction that this more universally accepted endpoint could have achieved a difference if the trial continued. Nonetheless, stopping was the call of the trialist and we should not second guess that decision. This was not a trial of FFR, but used the technology to establish a population who we would expect to benefit from PCIs to a greater extent than would have those in the COURAGE trial. Also at the ESC meeting, papers were presented on computed tomography angiography (CTA)-FFR and on CTA combined with perfusion measures. It is unclear which of these methods of noninvasively measuring form and function of coronary stenoses will prevail, but it is clear that the technology is progressing and some day there may be integrated diagnostic tests that establish both form and function to enable selection of appropriate interventions for stable coronary disease patients. When that day comes, will we be finished? Not by a long shot. The next step will be to add to form and function the capability to predict the future behavior of the lesions. Plaque composition and its predictive value

will be the next frontier and may require invasive investigation. We welcome with anticipation papers reporting the results of studies using all of these technologies to improve our clinical decision making. I am sure that regardless of the accuracy of these measures of anatomy, functional significance, and plaque behavior, the integration of these features will still require the judgment of the increasingly well-informed cardiologist. And, that is a good thing!

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