EDITORIAL

Acute myocardial infarction: diagnostic and prognostic applications of two-dimensional echocardiography

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OF THE DIAGNOSTIC METHODS that have emerged in medicine in the past two decades, imaging techniques — both invasive and noninvasive — have played the undeniably dominant role. This phenomenon has been particularly true in cardiovascular medicine: diagnosis (and therapy) of coronary and peripheral vascular disease, valvular heart disease, and congenital heart disease are now intimately interlocked with imaging technology. In such an era it appears an anomaly that acute myocardial infarction (AMI), the most prevalent and dramatic of the complications of coronary disease, is rarely evaluated in its earliest stages by an imaging modality.

The need for imaging in AMI. During the past few years an increasing emphasis has been placed on attacking the earliest pathophysiologic events that culminate in AMI. No longer are we satisfied with admitting a patient to a coronary care unit for monitoring, chiefly to prevent or treat arrhythmias. Coronary angiography has shown us that AMI is most often associated with acute thrombotic occlusion of a diseased coronary artery. Powerful lytic agents and percutaneous transluminal angioplasty can provide reperfusion in short order,1,2 and experimental studies show that early reperfusion leads to important degrees of myocardial salvage.3 A number of anecdotal reports strongly imply that similar salvage is possible in man and have spurred major clinical trials here and abroad to evaluate thrombolysis as standard therapy in AMI.4,5

The most recent clinical reports indicate important survival benefits and preservation of ventricular function when thrombolysis is instituted within 3 hr of symptom onset.6,7 In short, we are now poised to take an offensive posture against AMI. In addition to focusing on prevention of unnecessary complications, we are attuned to attacking the underlying inciting event to preserve the anatomic and functional integrity of myocardium.

The promise of thrombolytic therapy has brought an important challenge to our traditional diagnostic measures for AMI, since the object of therapy is now directed to preservation of anatomy. Clinical evaluation, electrocardiography, and serum enzyme determinations — the mainstays of emergency diagnostic evaluation for more than a generation — are hardly adequate to the task of precise anatomic characterization. The anatomic information these techniques convey is inferential, inaccurate about infarct size (particularly when the process is affected by reperfusion), and in the case of enzyme determinations fraught with retrospective delay. If AMI is to be managed as an anatomic event, a prospective image of the area at risk provides the optimal basis for therapy.

Available imaging techniques: practical considerations. A number of imaging techniques can be and have been applied in the setting of AMI. Wall motion abnormalities, coronary flow, myocardial perfusion, and metabolic abnormalities can be demonstrated by one or another of several techniques. Two-dimensional echocardiography, radionuclide angiography and perfusion imaging, left ventricular contrast and coronary angiography, positron emission tomography, and magnetic resonance imaging have been touted for unique advantages, and indeed each has contributed further in some way to our understanding of AMI. However, the rapidity of evolution of AMI (there is good evidence to believe that most of the damage of a single occlusive coronary event occurs within 2 to 3 hr),8,9 and the availability of the more complex of these techniques

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importantly limits feasibility for most of them as baseline studies that may be used to guide and to assess myocardium-sparing interventions. Because echocardiography is the least expensive and the most widely available of these imaging techniques, it merits special attention for its potential contribution to managing AMI as a myocardial salvaging process.

The advantages of echocardiography. Immediately after coronary occlusion, myocardium ceases to function in the area subserved by the involved vessel. Using echocardiography one can see that the affected left ventricular wall fails to thicken during systole and in fact may thin, producing systolic bulging of the ischemic segment. Such a regional wall motion abnormality can be detected in AMI with approximately 90% sensitivity by echocardiography.10, 11 There is universal consensus from experimental studies that such wall motion abnormalities overpredict anatomic infarct size.12-14 Viewed conversely, given a single occlusive coronary event, the associated infarct size is never larger than the wall motion abnormality.

Although detecting such an abnormality is often superfluous for diagnosis, the prognostic implications of the presence and extent of echocardiographically detected wall motion abnormalities during the early phases of AMI are not widely appreciated. Many investigators have shown an important relationship between the two-dimensional echocardiographic extent of acute dysfunction and serious in-hospital AMI complications — death, shock, heart failure, and arrhythmias.10, 11, 15, 16 Patients with no detectable or anatomic limited functional impairment are at four to five times lower risk for these in-hospital complications.11, 16 When functional impairment exceeds 20% of the left ventricle or involves multiple noncontiguous regions, in-hospital complications rise substantially. As opposed to other techniques, this functional anatomic information is obtainable at the bedside by a skilled echocardiographer in 15 to 20 min. Furthermore, some present day two-dimensional echocardiographic instruments are so compact that they can be readily transported to emergency room settings to obtain this information. A baseline study serves not only as an index of prognosis but also as a frame of reference for specific complications, e.g., murmurs appearing during the course of hospitalization, sudden hypotension, etc. Recognized abnormalities can be tracked, if necessary, over the course of an admission without exposure to radioisotopes and at no risk to the patient. Most important in our estimation is that an initial assessment of prognosis made on functional anatomic grounds during the first 2 hr after symptom onset can be used as a guide to aggressiveness of management. As confirmed by serial radionuclide ventriculography, patients with an early small echocardiographic wall motion abnormality will evolve small infarcts17; such patients have a good in-hospital prognosis.11, 15-18 Hence they are much less likely to benefit from thrombolytic therapy or emergent invasive intervention. Patients with large anatomic areas of abnormal wall motion have more myocardium at risk. Although the extent of some of these may improve spontaneously with time, the vast majority do not.17, 19 Tracking early and late wall motion abnormalities in 82 patients with both echocardiographic and nuclear techniques and using 0.05 ejection fraction units to represent a physiologically significant difference, van Reet et al.17 found 40 patients unchanged, 22 improved, but 16 worsened. Furthermore, when myocardial infarction is not complicated by extension, serial improvements are on the average minor — from 32.5% to 28.6% of the left ventricle in one recent series of 23 patients.20 It is not surprising, then, that patients with large early segmental wall motion abnormalities prove to have significantly higher mortality and complications. Hence an early large wall motion abnormality provides a basis for more aggressive intervention.

The present era also demands consideration of the incremental cost of an imaging procedure early in AMI. Echocardiography can be done at a fraction of the cost of other imaging techniques. Its cost relative to electrocardiograms is also reasonable enough so that it may be defrayed in part or fully by a more conservative approach to use of electrocardiograms in AMI, particularly when the course is not complicated by important rhythm disorders. Many patients with AMI leave the hospital having undergone six or more electrocardiograms when half that number would have sufficed for diagnosis and management, particularly when supplemented by anatomic information present in the echocardiogram. A high-quality echocardiogram also makes studies with radionuclide ventriculography redundant when used to derive ejection fraction or to assess residual left ventricular function in the postinfarction patient. By far, however, the greatest savings will come from applying aggressive emergency interventions on a more objective basis. The avoidance of an expensive intervention in a patient with a potentially small infarction identified by anatomic criteria will more than offset the relatively low cost of an echocardiogram early during AMI. Conversely, early application of thrombolysis in the presence of large wall motion abnormalities when electrocardiographic signs of
AMI (i.e., ST segment elevation or q waves) are slow to emerge will be of considerable benefit to the patient with a potentially large AMI.

In addition to an initial echocardiographic study, serial two-dimensional echocardiography after AMI is useful to diagnose anatomic complications and to track return of function after reperfusion therapy. Two-dimensional echocardiography, sometimes in association with Doppler echocardiography, has been shown to be effective in diagnosing the mechanical complications of AMI, including ventricular septal defect, ruptured papillary muscle, papillary muscle dysfunction, cardiac rupture, myocardial infarct expansion, ventricular aneurysm and pseudoaneurysm, and right ventricular infarction. No other available noninvasive technique is capable of assessing these complications with the same ease and cost. As the use of thrombolytic therapy and percutaneous transluminal angioplasty becomes more routine for treating patients with AMI, it will be important to track cardiac function over time. Serial two-dimensional echocardiography is capable of this and both experimental and clinical studies suggest that it can be used to monitor recovery of function after coronary reperfusion.

Caveats about echocardiography. Echocardiography is an interactive examination that depends heavily on the skill of the technologist, state-of-the-art equipment, and the nature of the population being studied. Comprehensive high-quality scans of both ventricles are needed for accurate evaluation. It is widely known that scans of sufficient quality to delineate the amount of dysfunctional myocardium are not obtainable in 100% of cases. Small (usually subendocardial) infarctions may go undetected. Although many have delineated wall motion abnormalities by strictly quantitative approaches, there is no consensus on how quantification is best approached. Furthermore, a recent from a remote infarction may not be readily distinguishable by identifying wall motion abnormalities.

Although the above arguments all weigh importantly against echocardiography as a diagnostic method for an evolving AMI, they are far less substantial when echocardiographic results are considered for their prognostic value. First of all, a skilled operator will obtain adequate images 70% to 90% of the time (the extremes of this range depend on the cross section of the population with AMI and the skill of the examiner). Given the annual incidence of AMI and its toll on life and productivity, an image of the potential damage from an evolving AMI obtained 70% of the time is certainly better than an educated guess from clinical and electrocardiographic criteria pending the availability of enzymatic test results. Missing small infarctions is not a critical consideration when echocardiography is used prognostically — if no wall motion abnormality is detected, the in-hospital prognosis is usually excellent with standard therapy. Many semiquantitative and quantitative methods to assess two-dimensional echocardiograms have been validated by contrast angiography or clinical outcomes, thus consistent application of a published method should yield fruitful results in a given medical center. Distinguishing the damage of remote from that of recent AMIs can be a problem in patients with prior infarction, left bundle branch block, and paced rhythms, but in these settings echocardiography has some advantages over ventriculography because it offers the opportunity to evaluate myocardial qualities directly. Because of collagen deposition and scarring, old infarcts tend to be transmurally thinned and are echo intense; acute infarcts will have normal or increased wall thickness caused by edema and do not show increased echo intensity. Comparison with prior echocardiographic examinations and correlation with new and old electrocardiographic findings regarding infarct location can also be helpful.

Summary and conclusions. Now that we are entering an era when thrombolytic therapy and early invasive interventions appear to offer significant myocardium-sparing effects, it is important to attempt to exploit techniques that bear directly on the issue of anatomy to obtain an objective measure of infarct size and prognosis. Traditional tests for AMI were developed as diagnostic measures and cannot be expected to measure up to issues raised by modern therapy. Despite its pitfalls, echocardiography can be applied prognostically during the first few hours of AMI evolution to far more patients than can any other imaging technique. We believe that an adequate echocardiographic examination can be an important adjunct that should be used in the early risk assessment of any patient with AMI. Those patients with the greatest potential reversible myocardial damage are clearly the best candidates for aggressive interventions, particularly thrombolysis. For patients with small or no detectable regional wall motion abnormalities, a more conservative initial approach is in order.

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