NEW USES AND TECHNIQUES:

Nuclear Imaging in Cardiology

by Jeff Johnson, MS

Nuclear cardiology has experienced a rapid growth in its use as a cardiovascular diagnostic tool. This article presents a brief overview of how this technique works as well as some of the new ways in which nuclear cardiology is used as a diagnostic tool.

The basic premise behind nuclear myocardial perfusion imaging centers on the concept that injected nuclear tracer taken up by the myocardium can be imaged in direct proportion to myocardial blood flow. Nuclear tracer activity can then be imaged in a rest-and-stress protocol allowing information on regional myocardial blood perfusion to be obtained under both situations. Areas of poor myocardial blood flow perfusion, resulting in low tracer activity, will image as dark or "cold spots," yielding specific diagnostic information related to potential coronary artery obstruction. Good perfusion images on the rest scan followed by areas of decreased perfusion with the post-stress scan are indicative of cardiac ischemia, while areas of the myocardium that present with poor perfusion on both the rest and stress scans are more indicative of myocardial necrosis or infarction. With recent clinical improvements in nuclear imaging agents, even more clinical uses have emerged.

Advantages of technetium over thallium

These new nuclear agents (cardiolyte and myoview) have two major advantages over the first-line agent, thallium. Technetium tracers have a much shorter half-life and emit much higher levels of energy than does thallium. This permits higher doses of these tracers to be given, allowing for better resolution of imaging. This higher resolution allows for fewer problems with soft-tissue artifact, a major cause for false-positive studies. The shortened half-life also allows more flexibility in protocol, allowing rest-and-stress imaging to occur in a more timely fashion while at the same time posing a much smaller radiation burden to the patient.

Clinical uses of nuclear imaging

Early uses of perfusion imaging centered on the diagnosis of cardiovascular ischemia secondary to coronary obstruction. With these newer tracers, the application has expanded to include prognostic assessment as well. Typical high-risk markers for ischemia would include a reversible perfusion defect indicated by poor tracer uptake with

stress but normal uptake at rest. This is the classic positive criterion for ischemic heart disease.

Reversible and fixed perfusion defects, those noted at rest and with stress, illustrate a mixture of hypoperfused and infarcted tissue. The simple rest perfusion defect that remains unchanged with stress illustrates classic myocardial infarction. Increased lung uptake of the tracer would indicate the presence of pulmonary congestion due primarily from left ventricular dysfunction.

The addition of these higher-resolution tracers, coupled with advanced camera imaging, has allowed the ability to perform "gated" imaging. This image, which essentially connects, or gates, the tracer density with the electrocardiogram (ECG) complex, allows for an evaluation of cardiac function as well. ECG-gated left ventricular function can be assessed at rest and post exercise. This ability allows quantification of ventricular ejection fraction, a primary prognostic indicator, as well as regional ventricular wall motion abnormalities. The combination of wall motion data with ventricular function has emerged as a useful way to risk stratify cardiac patients.

Prognostic assessment

Detection of stunned, yet viable, myocardium has been perhaps the most useful clinical improvement using the new tracers. Patients with acute myocardial infarction who have had blood flow to their myocardium restored through early reperfusion therapy often demonstrate a significant portion of their myocardium that may become stunned or temporarily unable to pump effectively. Over time, particularly with revascularization, this area may return to near-normal function. The ability to differentiate viable myocardium (that which is only stunned) from true infarcted or necrotic tissue has tremendous utility in determining whether the need for aggressive cardiac intervention is warranted. Areas of the myocardium that demonstrate relatively normal retention of tracer uptake yet poor wall motion may indicate stunned but viable tissue, whereas poor wall motion associated with poor tracer uptake is more indicative of true infarcted tissue.

Use of quantification of the tracer uptake post infarction has also emerged as a useful tool in evaluating the potential benefit of revascularization. The presence of large areas of potentially reversible ischemia obviously directs aggressive revascularization efforts, while the presence of large areas of necrosis may argue against the need for revascularization efforts. Quantifying ejection fraction and wall motion through the ECG-gated studies will also provide valuable long-term prognostic data, which will further clarify the type of treatment most beneficial.

Reasons for ordering a nuclear imaging study

There are three primary reasons to order a nuclear imaging study: to diagnose ischemia, to assess treatment, and to evaluate prognosis. Listed below are a more specific list of rationale for nuclear studies:

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- To evaluate myocardial ischemia in patients with baseline ECG abnormalities
- To improve the specificity in patient groups — that is, women who demonstrate high false-positive rates
- To confirm the functional severity of patients with documented coronary artery stenosis

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- To detect post-angioplasty or post-bypass graft reocclusion
- To improve post-myocardial infarction prognostic risk stratification
- To assess acute chest pain syndromes
- To improve the sensitivity of traditional stress ECG evaluation.

Nuclear cardiology has emerged as a centerpiece to cardiac diagnostics. Sensitivity and specificity range from 80–85 percent and are comparable with stress echocardiography. Making a determination between which technique (nuclear or echo) to use often rests with the experience and expertise of each physician and diagnostic laboratory. Radiation exposure, due to very short half-lives of six hours or less, is negligible to both patient and technician. The reliance on a protocol requiring a rest injection and image as well as a post-stress injection and image involves a relatively time-intensive procedure and is perhaps the primary limitation to this technique.

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ADDITIONAL READING

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