

Acute Myocardial Infarct Imaging with Tc-99m Pyrophosphate

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This is the third article in the nuclear cardiology series. After reading and studying the article, the nuclear medicine technologist will be able to: (1) discuss the Tc-99m pyrophosphate myocardial imaging procedure, including optimal imaging times, instrumentation, and procedural details, and (2) describe basic normal and abnormal imaging results.

It is sometimes difficult to confirm the presence or absence of acute myocardial infarction (MI) in patients who, on the basis of presenting signs and symptoms, are clinically suspected of having suffered an MI. Common clinical settings in which diagnosis may be difficult include:

- delay in the patient's hospital admission after the onset of symptoms,
- previous infarction in the same general location as the new damage,
- presence of conduction abnormalities, such as left bundle branch block,
- subendocardial infarction, or
- recent cardiac surgery.

It is not surprising, therefore, that investigators have sought to develop methods in addition to electrocardiography and serum enzyme assay to help confirm the clinical suspicion of myocardial infarction. Several groups have worked to develop noninvasive radionuclide imaging techniques that will permit the physician to identify an acute myocardial infarct, determine its size, document its impact on ventricular performance, and predict short-term survival in patients who have suffered an MI.

A previous continuing education article in this series discussed the application of Tl-201 imaging in the acute setting to help evaluate patients with suspected MI. In this article, we will discuss another technique, which—unlike thallium imaging—relies on localization of a tracer within infarcted myocardial tissue.

A number of agents—including Tc-99m gluceptate sodium (glucoheptonate), Ga-67 citrate, and Tc-99m tetracycline—have been found to localize in infarcts in animal preparations, but imaging sensitivity with these agents has been poor in clinical settings.

Several bone-imaging agents, most notably Tc-99m pyrophosphate, have been found to localize in infarcted myocardium in humans at approximately 12 hr to 1 week following the

acute event. Clinical experience has shown, however, that the most optimal time for imaging is 24–72-hr postinfarction.

The exact intracellular mechanism of Tc-99m pyrophosphate localization is not completely understood; it binds to various forms of calcium within the cell, which is not unique to the myocardium. Technetium-99m pyrophosphate has been observed in infarcted tissues within the skeletal muscle, gastrointestinal tract, and central nervous system.

Many investigators feel that Tc-99m pyrophosphate scintigraphy can be a sensitive indicator of acute myocardial necrosis in certain clinical settings. As with other nuclear cardiology procedures, however, satisfactory clinical results depend to a very significant degree on appreciation of the underlying physiologic process. It is important to bear in mind the following when imaging with Tc-99m pyrophosphate:

- The pathophysiology of an infarction is constantly changing and the test results depend greatly on the time and stage of the infarction.
- Due to the changing pathophysiology, serial imaging should be performed for optimal sensitivity.

Performing the Study

Technetium-99m pyrophosphate imaging should be performed with a modern scintillation camera equipped with a parallel-hole, low-energy, medium-sensitivity collimator. The pulse height spectrometer should have a 20% window centered around the 140-keV photopeak. Images using a standard field of view camera should be collected for at least 400,000 counts; more counts should be acquired when using a large field of view camera.

Imaging is usually performed in the same views as a thallium perfusion study or a radionuclide wall motion study: anterior, 40° left anterior oblique (LAO), 70° LAO, and left lateral projections. In addition to providing the best visualization of tracer distribution within the myocardium, these views enable comparison with the results of other nuclear cardiology studies. Imaging may commence 2–3 hr following the intravenous injection of 15 mCi of Tc-99m pyrophosphate. It is critical that the Tc-99m be well bound so that there is no free [^{99m}Tc] pertechnetate in the blood pool. Blood pool activity can obscure visualization of an infarct or, possibly, result in a false-positive study.

Interpreting the Images

Technetium-99m pyrophosphate images are generally reported on a scale of 0 to 4+, depending on the level of radioactivity in the region of the heart. Thus, 0 represents no increase above background; 1+ represents a faint, indefinite increase; 2+ represents a definite increase in activity but less than that of bone level; 3+ represents an activity level equal to that of bone (Fig. 1); and 4+ represents a level of activity greater than that of bone (Fig. 2). An abnormal study shows a level of activity equal to or greater than 2+. A normal study visualizes only the bony structures of the thorax, with the region of the myocardium showing no uptake of radioactivity. Occasionally, stomach or breast uptake or a bony abnormality may be interpreted as myocardial uptake.

In addition to the 0 to 4+ scale, positive images are read as showing discrete or diffuse uptake. Diffuse uptake appears as a generalized increase in activity in the region of the heart from sternum to apex, not unlike the appearance of blood pool activity. This pattern has been shown by many investigators to lack specificity for acute myocardial infarction. Many other cardiac conditions, including both stable and unstable angina, ventricular aneurysm, congestive cardiomyopathy, chest irradiation, calcified intracardiac valves, pericarditis, and cardioversion, may result in diffuse myocardial uptake of pyrophosphate.

An area of discrete radioactivity within the region of the myocardium appears to be relatively specific and quite sensitive for detection of acute infarctions. An acute subendocardial infarction may also appear as either a discrete abnormality on the scan or as a diffuse pattern of uptake.

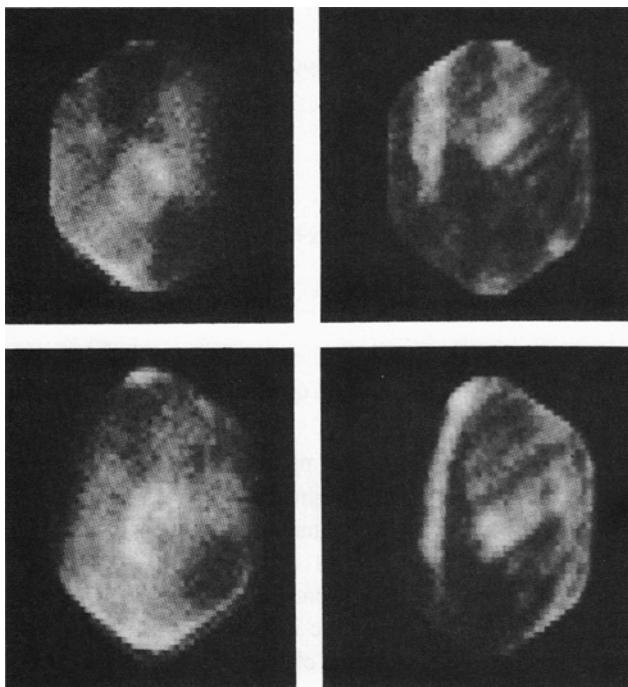


FIG. 1. This patient was admitted to the CCU with signs and symptoms of acute MI. Admission Tl-201 scan demonstrated an apicoinferior defect on the anterior view and a defect involving the inferoposterior region on the 60° LAO view. The following day, a Tc-99m pyrophosphate study showed 3+ uptake in defect regions noted on the thallium study.

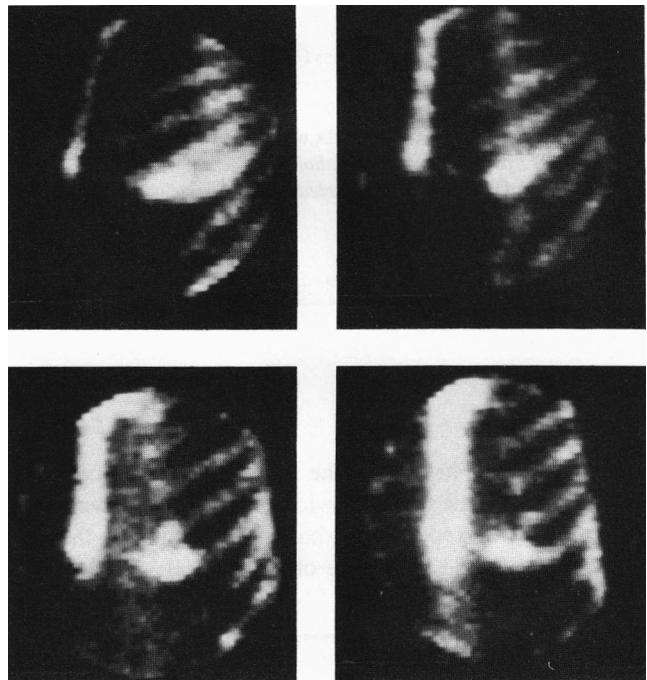


FIG. 2. These images demonstrate 4+ uptake in a patient admitted the day before with ECG evidence of an inferior wall MI. Although the technical quality of the study is excellent, it is clearly rather difficult to localize the area of infarction.

An image showing an infarct usually reverts to normal within a week after the acute event; persistence of the abnormal uptake may indicate a poor prognosis.

In clinical practice, Tc-99m pyrophosphate imaging has been useful to diagnose and localize acute myocardial infarction and to confirm the findings of enzymatic and electrocardiographic studies in patients suspected of having suffered an MI. Technetium-99m pyrophosphate scans have also been found useful in patients suspected of having right ventricular infarction extending to the inferior wall of the left ventricle; accurate diagnosis is important in this case since patients may benefit from fluid administration rather than diuretic therapy.

Tc-99m Pyrophosphate Scintigraphy vs. Other Noninvasive Modalities

Infarct scintigraphy may provide an early (after 12 hr) reliable indication of acute infarction and may be of use as an additional diagnostic aid in symptomatic patients with enzymatic and electrocardiographic evidence of infarction. Infarct scintigraphy may enable diagnosis of an acute infarction when electrocardiographic and enzymatic indicators are unavailable or ambiguous—i.e., after bypass surgery, abnormal conduction patterns, etc. Infarct scintigraphy may also help in determining infarct size. Persistence of abnormal uptake may be useful as a prognostic indicator. A disadvantage of Tc-99m pyrophosphate infarct imaging is the delay required from the onset of symptoms to the time imaging can be performed. Echocardiography, radionuclide ventriculography, and Tl-201 perfusion imaging can be performed immediately. However, Tc-99m pyrophosphate imaging aids in determining the age of infarction, thereby providing complementary data.

Additional Reading

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- Holman BL, Lesch M, Zweiman FG, et al. Detection and sizing of acute myocardial infarcts with Tc-99m (Sn) tetracycline. *N Engl J Med* 1974;291:159.
- Kramer RJ, Goldstein RE, Hirshfeld JW, et al. Accumulation of gallium-67 in regions of acute myocardial infarction. *Am J Cardiol* 1974;33:861-67.
- Prasquier R, Taradash MR, Botvinick EH, et al. The specificity of the diffuse pattern of cardiac uptake in myocardial infarction imaging with technetium-99m stannous pyrophosphate. *Circulation* 1977;55:61.

CE ARTICLE TEST

For each of the following eleven questions select the best answer. Then circle the number on the reader service card that corresponds to the answer you have selected. Keep a record of your responses so that you can compare them with the correct answers, which will be published in the next issue of the Journal.

A. Which of the following imaging agents does not localize within regions of acutely infarcted myocardium?

151. Tc-99m glucoheptonate.
152. Tl-201 chloride.
153. Ga-67 citrate.
154. Tc-99m tetracycline.

B. Optimum imaging time following the acute event of maximal uptake in the infarcted myocardium with Tc-99m pyrophosphate is _____.

155. 0-12 hr.
156. 12-24 hr.
157. 24-72 hr.
158. 72-120 hr.

C. The abnormal scan should revert to normal within _____.

159. 24 hr.
160. 2-4 days.
161. 7-10 days.
162. 14-21 days.

D. Technetium-99m pyrophosphate imaging has been useful in which of the following conditions?

163. previous infarction in the same general location.
164. left bundle branch block.
165. recent cardiac surgery.
166. all of the above.

E. Which of the following techniques is able to distinguish acute from chronic infarction?

167. thallium-201 perfusion imaging.
168. radionuclide ventriculography.
169. Tc-99m-pyrophosphate imaging.
170. echocardiography.

F. Diffuse uptake of Tc-99m pyrophosphate may be the result of _____.

171. digoxin therapy.
172. cardioversion.
173. a recent chest x-ray.
174. the presence of a pacemaker.

G. A disadvantage of Tc-99m-pyrophosphate scanning is:

175. myocardial uptake of pyrophosphate in patients after infarction or with angina has been noted to revert to normal after coronary artery bypass surgery.
176. abnormal pyrophosphate uptake occurs in 2% of patients undergoing bone imaging.
177. the exact mechanism of tracer uptake is still being studied.
178. the delay required from the onset of symptoms to the time of imaging.