Use of Blood-pool Imaging in Evaluation of Diffuse Activity Patterns in Technetium-99m Pyrophosphate Myocardial Scintigraphy

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It has been suggested that diffuse Tc-99m pyrophosphate precordial activity may be due to persistent blood-pool activity in routine delayed views during myocardial imaging. To answer this question, we reviewed myocardial scintigrams recorded 60-90 min following the injection of 12–15 mCi of Tc-99m pyrophosphate for the presence of diffuse precordial activity, and compared these with early images of the blood pool in 265 patients. Diffuse activity in the delayed images was identified in 48 patients: in 20 with acute myocardial infarction and in 28 with no evidence of it. Comparison of these routine delayed images with early views of the blood pool revealed two types of patterns. In patients with acute infarction, 95% had delayed images that were distinguishable from blood pool either because the activity was smaller than the early blood pool, or by the presence of localized activity superimposed on diffuse activity identical to blood pool. In those without infarction, 93% had activity distribution in routine delayed views matching that in the early blood-pool images. The usefulness of the diffuse TcPPi precordial activity in myocardial infarction is improved when early blood-pool imaging is used to exclude persistence of blood-pool activity as its cause. Moreover, it does not require additional amounts of radioactivity nor complex computer processing, a feature that may be of value in the community hospital using the technique to "rule out" infarction 24-72 hr after onset of suggestive symptoms.

J Nucl Med 20: 496–501, 1979

Myocardial imaging with technetium-99m pyrophosphate (TcPPi) has been increasingly used in the identification of acute myocardial-infarction, and initial reports have indicated its reliability (*1-3*). Although subsequent studies have confirmed a consistent correlation of discretely localized Tc-99m activity with recent myocardial infarction, the pattern of diffuse activity has been less specific, and has been observed in a significant but variable proportion of patients with both unstable and stable angina (*4-7*), and in some with no apparent heart disease (*7*). The possibility that diffuse precordial activity may occasionally be due to delayed clearance of the tracer from the blood pool has been suggested (*7*), but the only reported study of blood-pool activity and its relation to diffuse precordial activity required an additional injection of Tc-99m as pertechnetate and extensive data-processing capabilities (*8*). The present study reports our experience with TcPPi myocardial scintigraphy using early blood-pool imaging for the evaluation of diffuse precordial activity in patients with and without myocardial infarction.

Received June 20, 1977; revision accepted Dec. 22, 1978.

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MATERIALS AND METHODS

Myocardial scintigrams performed in 265 patients were reviewed for the presence of the pattern of

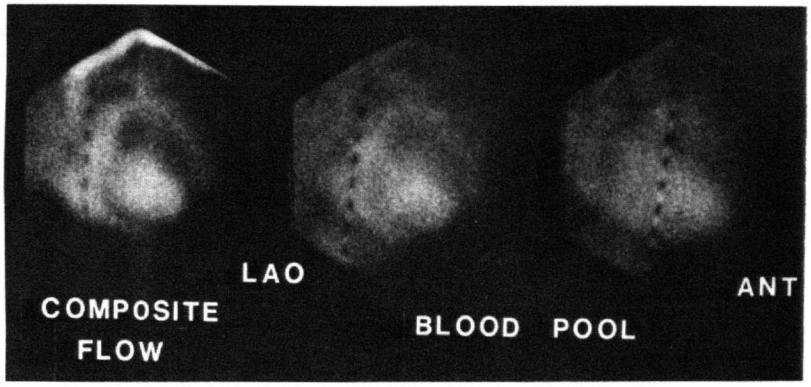

FIG. 1. Composite TcPPi flow study (left) and early blood-pool images (right and center). Delineation of right and left ventricles by ventricular septum seen in composite flow is less apparent in LAO blood-pool image (center), due to distribution of activity within septum. Septum is not seen in anterior view (right). Radioactive ruler is positioned vertically upon sternum. Ant = anterior, LAO = left anterior oblique.

diffuse TcPPi activity. The study population consisted of patients hospitalized for the evaluation of chest pain or other symptoms of coronary heart disease. Patients with suspected acute myocardial infarction and unstable angina pectoris were admitted to the research center. All patients with suspected infarction had serial electrocardiograms and serum enzyme determinations, including creatine kinase MB isoenzyme assays. The diagnosis of myocardial infarction was made when elevated serum levels of this enzyme were present, accompanied by diagnostic serial electrocardiographic changes. Electrocardiographic evidence of tansmural myocardial infarction included ST segment elevation, T-wave inversion, and the development of 0.04-sec Q waves in appropriate leads. Subendocardial infarction required ST segment depression and T-wave inversion persisting for more than 48 hr. Unstable angina was subclassified as crescendo (increased frequency, duration, or severity of angina and/or the development of rest pain) or as preinfarctional (pain of more than 30 minutes duration with previous stable angina).

Myocardial imaging was performed within 18-36 hr of admission or of onset of symptoms. Imaging was performed at the patient's bedside with a mobile gamma camera equipped with a high-resolution collimator. The 20% window was centered on the Tc-99m 140-keV photopeak. Following i.v. injection of 12-15 mCi of TcPPi a composite flow study, using the left anterior oblique view, was recorded on FM tape and displayed on Polaroid film; images of blood-pool activity were then similarly obtained 2-5 min later (Fig. 1). The blood-pool images were obtained in the anterior and left anterior oblique (15–45°) view, accumulating 400,000–600,000 counts in each projection. Imaging at 60–90 min after injection was performed in the anterior, left anterior oblique, and left lateral views, and selected patients had further studies at 2–5 hr after injection. Routine 60–90 min delayed scintigrams were interpreted as positive when localized myocardial tracer was present or when there was diffuse precordial activity that was clearly distinguishable from persistent blood-pool activity by comparison with the early (2- to 5-min) images. Delayed scintigrams were classified as negative for infarction when there was no detectable precordial tracer uptake, or when diffuse activity was identified as persistent blood-pool activity. Residual blood-pool activity was considered present when 60–90 min images demonstrated activity corresponding in size and distribution to the early images in the anterior and/or left anterior oblique views.

TABLE 1. Comparison of Delayed Images with Blood-Pool Activity Diffuse Tc-PPi activity—48 Patients

No infarction—28 patients		
Identical to BP	26	(92.8%)
Smaller than BP	0	
Indeterminate	2	(7.2%)
Myocardial infarction—20 patients		
Smaller than BP	16	(80.0%)
BP + localized	3	(15.0%)
Identical to BP	1	(5.0%)

BP = Blood Pool; Tc-PPi = technetium-99m pyrophosphate

RESULTS

Forth-eight of the 265 patients had myocardial scintigrams showing diffuse precordial tracer activity on routine 60–90 min delayed images (Table 1.) Forty-five patients had only diffuse activity, while three had localized activity superimposed on a diffuse pattern.

Twenty-eight patients had no clincal, electrocardiographic, or enzymatic evidence of myocardial infarction. In 26 of these, images recorded at the usual 60–90 min interval matched the early blood-pool images in the distribution of Tc-99m activity, although the amount of activity was diminished in each instance (Fig. 2). When classified according to the system of Parkey et al. (*1*), all were 2+ or

greater. The cardiac activity in each was distributed in a homogeneous pattern and outlined the total cardiac silhouette as defined by the early blood-pool images. In each of the patients with further delayed views at 2–5 hr continuing disappearance of the precordial activity was demonstrated (*8*). Twenty-four of these 26 patients had precordial activity extending beyond the right sternal border in the anterior view (Fig. 3). In two patients the rightward extent of the blood-pool activity was obscured by the sternum in the anterior view but was identified in the left anterior oblique view, in which the delayed images matched the early left anterior oblique blood-pool images. In two of the 28 patients with no evidence of myocardial infarction, the rightward extent of precordial activity could not be seen in either the anterior or left anterior oblique projections because of overlapping sternal activity, and persistence of blood-pool activity could not be distinguished from infarction by imaging techniques alone.

The clinical features of these patients with persistent blood-pool activity are shown in Table 2. When we compare the noninfarcted patients with others similar (*9*) but showing no persistent blood-pool activity, there are no statistical differences in the incidence of either stable or unstable angina, or in the occurrence, extent, or severity of coronary artery disease, defined as greater than 70% narrowing of at least one major coronary vessel. Four patients with diffuse activity and no evidence of infarction had normal coronary arteriograms, and one additional patient, who has undergone saphenous-vein bypass graft surgery 6 mo earlier and had no subsequent angina, had a normal treadmill exercise for 2 days after scintigraphy.

Twenty patients with diffuse tracer activity in routine delayed views had clinical evidence of acute myocardial infarction substantiated by electrocardiographic and creatine kinase MB enzymatic criteria. Fifteen of these had subendocardial, and five had transmural, infarction, Each of the 15 with subendocardial and one with transmural infarction had diffuse activity that was more restricted than in the early blood-pool images (Figs. 4 and 5). The remaining four patients with transmural infarction each had delayed diffuse activity that agreed with the early blood-pool image, except that three of the four also had clearly defined areas of localized uptake that corresponded to the electrocardiographic site of infarction. In one of these three with both localized and diffuse activity, prominent localized activity corresponding to the electrocardiographic site of infarction was already present in the early blood-pool image (Fig. 6). The remaining patient with transmural infarction had diffuse activity

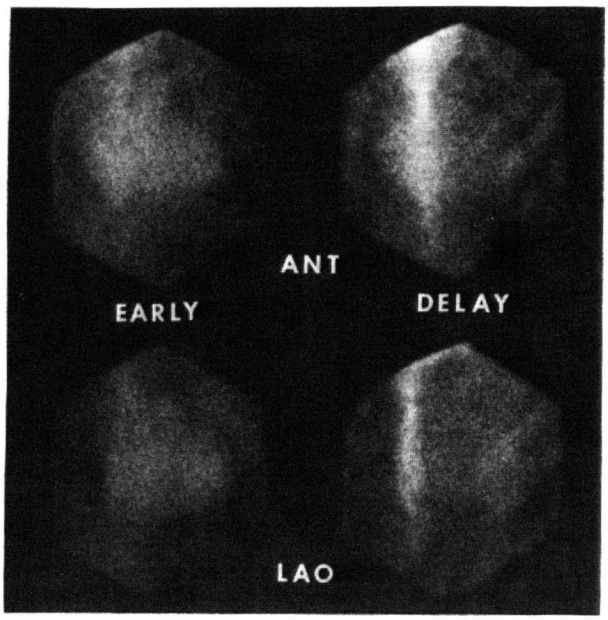

FIG. 2. Persistence of blood-pool activity in patient with normal coronary arteriograms. Delayed anterior and LAO views (right) show diffuse activity that might have been interpreted as abnormal if early views (left) were not available for comparison. Measurement of silhouette shows that portions of both delayed views are obscured by sternum, especially evident in LAO (left anterior oblique).

matching the blood pool and no localized accumulation of technetium. This patient had anterior infarction and had experienced no prior symptoms of ischemic heart disease, as we have reported previously (*9*). In this patient, further delayed views showed disappearance of the activity at 4–5 hr after injection, and followup imaging at 1, 3, 5, and 9 mo after infarction has demonstrated similar delayed clearance from the blood pool on each occasion, despite an uncomplicated clinical course.

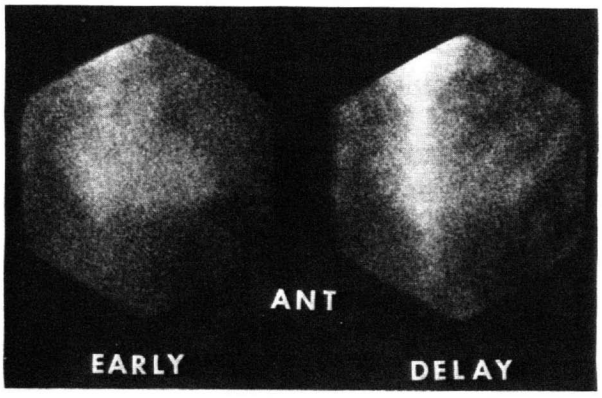

FIG. 3. Early and routine delayed views in patient without myocardial infarction. Delayed view shows activity matching blood-pool image. Activity is present to right of sternum, corresponding to right-sided cardiac structures.

TABLE 2. Patients without Myocardial Infarction

	Normal image			Persistent blood pool		
No. of patients	116			26		
Mean age	55.6			54.5		
Diagnosis						
Unstable angina	56		(48.3%)	13		(50.0%)
crescendo		38	(67.9%)		10	(76.9%)
preinfarction		18	(32.1%)		3	(23.1%)
Stable IHD*	13		(11.2%)	5		(19.2%)
Suspected MI	47		(40.5%)	8		(30.8%)
Coronary Angiography	80 pts			25 pts		
Coronary artery disease	68		(85.0%)	21		(84.0%)
1 vessel		11	(16.2%)		2	(9.5%)
2 vessel		14	(20.6%)		4	(19.0%)
3 vessel		43	(63.2%)		15	(71.5%)
Normal	12		(15.0%)	4		(16.0%)

*IHD = ischemic heart disease

DISCUSSION

In contrast to a consistent correlation of localized TcPPi uptake with recent myocardial infarction, the pattern of diffuse activity has been reported to correlate poorly with clinical findings in patients with suspected myocardial infarction. This pattern was initially observed in patients with subendocardial infarction (*10*), but has subsequently been reported in association with unstable angina (*4-7*), stable angina (*5-7*), and in patients with no apparent heart disease (*7*). As a result, some have concluded that this technique has only limited accuracy in the identification of infarction (*6,7*). It has recently been suggested, however, that at least some cases of diffuse uptake may be due to unsuspected imaging of residual activity in the blood pool (*7,8*).

Our results confirm the observation that diffuse precordial activity occurs in patients both with and without acute myocardial infarction. They also indicate that diffuse activity occurs in two distinct patterns. Using early PPi images of blood-pool activity for comparison, we find one type identical in distribution to blood-pool activity and the second distinguishable from blood pool by its smaller size. The importance of this distinction is evident when these two types are compared with the presence or

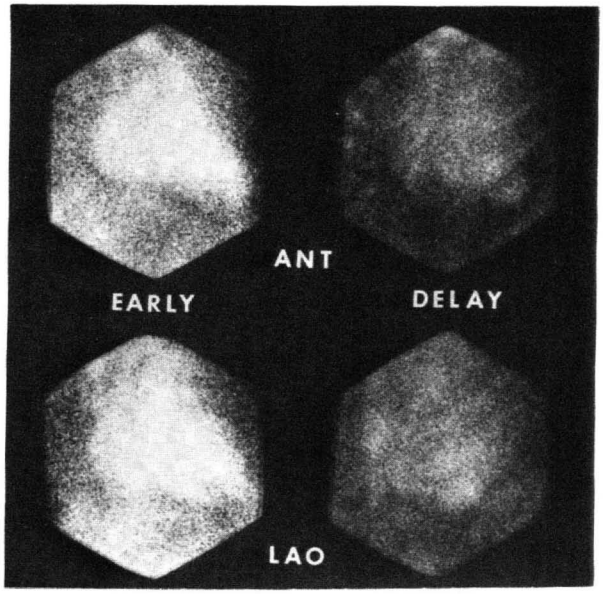

FIG. 4. Early (left, top and bottom) and delayed (right, top and bottom) images in a patient with subendocardial infarction. Delayed views show diffuse activity that is distinguishable from blood pool by its smaller size. Ant = anterior, LAO = left anterior oblique.

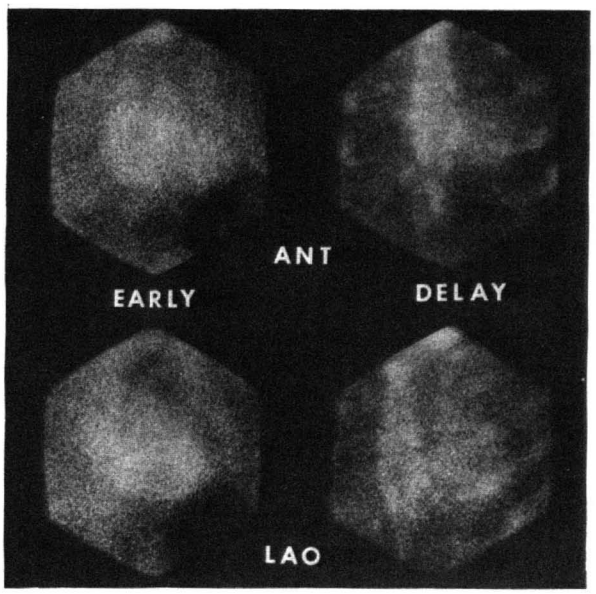

FIG. 5. Blood-pool (left, top and bottom) and delayed (right, top and bottom) images in patient with subendocardial infarction. Diffuse activity in delayed views is smaller than blood pool. In addition, activity in delayed LAO view appears nonhomogenous when compared with blood-pool activity. Ant = anterior, LAO = left anterior oblique.

absence of acute myocardial infarction as determined in this study by sensitive enzymatic criteria (*11*). In patients without myocardial infarction, 92.8% had diffuse activity matching the blood pool, and it is likely that the remaining two patients without infarction also had this type of diffuse activity, since both had similar homogeneous activity, although identical distribution could not be confirmed due to overlapping skeletal structures.

In contrast, 95% of patients with acute myocardial infarction had scintigraphic activity that was distinguishable from early images of blood-pool activity, either because its distribution was smaller than blood pool or because localized uptake was superimposed upon the diffuse activity. In the single patient with infarction and diffuse activity indistinguishable from blood pool, both further delayed views and subsequent myocardial imaging strongly suggest that the study at the time of acute infarction demonstrated only persistent blood pool activity and constituted an unquestionable false-negative study in an individual whose infarction represented an initial coronary event, as we have previously reported (*9*). This finding of persistent blood-pool activity with superimposed localized uptake in patients with transmural infarction indicates that this pattern is not confined to patients without infarction. In addition, the observation that localized tracer uptake was evident in one patient as early as 5 min after injection is of interest in regard to mechanisms of delivery and uptake of TcPPi by injured myocardium.

These results demonstrate that persistence of blood-pool activity in routine delayed studies does occur with TcPPi myocardial imaging. In this series its frequency of 17.1% in patients without myocardial infarction, and in 12.1% of all patients, is similar to the incidence of diffuse activity reported by Prasquier et al. (*7*), both in patients without acute infarction and in those without evidence of heart disease who had routine bone scintigraphy. This suggests that the high incidence of coronary artery disease in our patient population plays no significant causative role in the occurrence of prolonged blood-pool clearance. This is also substantiated by normal coronary arteriograms in four of these patients.

The cause of persistent blood-pool activity is unknown. It may be due to delayed renal clearance of the tracer or to the dissociation of the stannous-technetium component from pyrophosphate and resultant change in binding with either plasma proteins or red blood cells. In addition, it has been suggested that the process might represent intravascular activity related to endothelial adherence (*7*). It is also possible, however, that this activity may represent an unidentified nonselective process of myocardial uptake involving mechanisms other than cell injury.

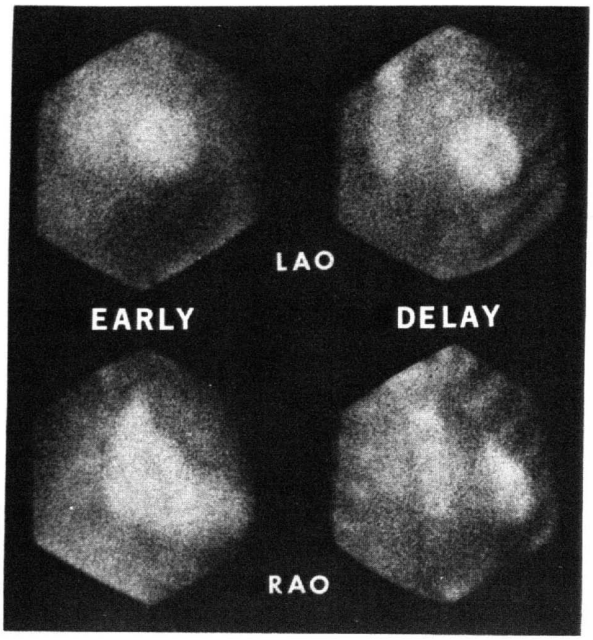

FIG. 6. Early (left, top and bottom) and delayed (right, top and bottom) images in patient with anterior transmural infarction. Delayed views show persistence of blood-pool activity as well as prominent localized activity corresponding to region of infarction. This localized activity is already apparent in early (5 min) LAO view (top left). LAO = left anterior oblique, RAO = right anterior oblique.

These results document the occurrence of persistent blood-pool activity in Tc-PPi myocardial imaging and demonstrate the usefulness of early blood-pool imaging for its proper identification. Moreover, neither additional radioactivity nor sophisticated data processing is required for proper identification of persistence of blood-pool activity, as in the study reported by Berman et al. (*8*). It appears that the limited reliability of myocardial imaging reported by others may frequently be due to unsuspected persistent blood-pool activity and that routine early imaging provides a reliable means of distinguishing this from diffuse activity associated with myocardial infarction. Recognition of residual blood pool significantly improves the reliability of this technique, and these results indicated that improved accuracy can be obtained when diffuse, as well as localized, precordial activity is encountered. Early blood-pool imaging resolves this problem of residual blood-pool activity in routine delayed myocardial scintigraphy. Moreover, it is possible to distinguish clearly between delayed clearance and blood pool without additional tracer,

and in institutions without sophisticated data processing.

ACKNOWLEDGMENTS

This research was supported in part by the National Heart and Lung Institute (Specialized Center of Research for Ischemic Heart Disease, Contract No. 1P17H17667-02; Program Project Grant No. HL 11, 310; Training Grant No. T01LM00154) and the Clinical Research Unit Grant No. M0-RR000-13 (General Clinical Research Centers Program, Div. of Research Resources of the National Institutes of Health).

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