DETECTION AND SIZE ESTIMATION OF ACUTE MYOCARDIAL INFARCTION USING ^{99m}Tc-GLUCOHEPTONATE

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Twenty-seven patients with suspected acute myocardial infarction were studied by precordial scanning after intravenous administration of ^{99m}Tc-glucoheptonate 2–48 hr after the onset of chest pain. Fifteen of the patients had clinically documented acute myocardial infarctions. Twelve of these 15 (80%) had areas of distinctly increased tracer uptake in the region of the heart. The three infarctions not identified by scan had peak serum CPK values of less than 300. In seven patients without infarction, no distinct areas of increased tracer uptake were found in the region of the heart. Five patients could not be classified as to whether infarction had or had not occurred. Three had abnormal scans, the significance of which is uncertain. Infarct size was estimated from the area of increased ^{99m}Tc-glucoheptonate concentration on scan and compared to peak serum CPK values. A linear correlation with a correlation coefficient of 0.77 was found. Technetium-99m-glucoheptonate scanning was useful for the identification and size estimation of moderate- to large-sized transmural and nontransmural acute myocardial infarctions.

Serial electrocardiographic and serum enzyme changes are useful for the diagnosis of acute myocardial infarction and the estimation of its extent. The diagnostic information obtained from these techniques is often delayed because of the necessity for serial determinations over several days. Radioactive tracer techniques might enable early infarct detection and estimation of infarct size. This would be of value in selecting therapy and in establishing prognosis.

Three noninvasive radioactive tracer techniques have been developed that may be used for the scintigraphic diagnosis and size estimation of acute myocardial infarction. Gated cardiac blood pool studies demonstrate infarcted areas as regions of ventricular akinesis or dyskinesis (*1,2*). Radiopotassium and its analogs concentrate in the myocardium in proportion to blood flow and demonstrate infarcts as areas of reduced tracer concentration (*3–6*). Neither gated cardiac blood pool studies nor myocardial perfusion scans can distinguish between acute myocardial infarction or severe ischemia and old fibrosis. Two ^{99m}Tc-labeled tracers, ^{99m}Tc-tetracycline and ^{99m}Tc-pyrophosphate, have been shown to concentrate in acutely infarcted myocardium in amounts sufficient to permit external scintigraphic detection of an infarcted area (*7,8*). These radiopharmaceuticals have been shown to concentrate in acutely infarcted myocardium for no longer than 2 weeks after the acute attack. Approximate correlation between infarct size, as determined by serum CPK determination, and by scans performed with ^{99m}Tc-tetracycline and ^{99m}Tc-pyrophosphate, has been noted. Studies in animals have demonstrated that ^{99m}Tc-glucoheptonate also accumulates in regions of acute myocardial infarction (*9,10*). The present study reports our experience with ^{99m}Tc-glucoheptonate for the detection, localization, and initial sizing of acute myocardial infarction in patients.

MATERIALS AND METHODS

The study population consisted of 27 patients admitted to the Johns Hopkins Hospital Coronary Care Unit with the diagnosis of either actual or suspected acute myocardial infarction. Informed consent was obtained in every case. Each patient received 15 mCi of ^{99m}Tc-glucoheptonate intravenously between 2 and 48 hr (mean, 15 hr) after the onset of chest pain. Scintillation camera imaging was performed 1–5 hr after tracer injection with a high-resolution scintillation camera using a parallel-hole, medium-resolution collimator. Scintiphotos containing 200,000–300,000

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TABLE 1. TECHNETIUM-99m-GLUCOHEPTONATE SCANS: TRANSMURAL INFARCTION

Patient	Age	Sex	Scan	Location of scan abnormality	Location of EKG abnormality	Anterior + LAO area tracer uptake (cm^2)	Peak CPK	Time from onset of chest pain to injection (hr)	Time from injection to imaging (hr)
CS	65	M	Positive	Anteroseptal and inferior	Inferior	27	1910	6.5	5
SC	56	M	Positive	Anteroseptal lateral and inferior	Anteroseptal, lateral, inferior extension	52	1810	11 (died at 36 hr)	5
TF	38	M	Positive	Anteroseptal lateral	Anteroseptal lateral	33	2270	12	5
FR	46	M	Positive	Anteroseptal apical	Anteroseptal	38	1580	8.5	4.5
LM	80	F	Positive	Inferior	Inferior	23	498	15	4
HG	65	M	Positive	Inferior	Inferior	19	1560	48	5
JJ	65	M	Positive	Anteroseptal	Anteroseptal	18	1050	2	3
JC	58	M	Positive	Anteroseptal inferior extension	Anteroseptal	27	1492	9	1

TABLE 2. TECHNETIUM-99m-GLUCOHEPTONATE SCANS: NONTRANSMURAL INFARCTION

Patient	Age	Sex	Scan	Location of scan abnormality	Location of EKG abnormality	Anterior + LAO area tracer uptake (cm^2)	Peak CPK	Time from onset of chest pain to injection (hr)	Time from injection to imaging (hr)
IB	42	M	Positive	Apical	Apical	7.5	530	17.5	3
IB	45	M	Negative	—	Apical	—	131	5.5	4
EH	29	M	Positive	Inferior	Inferior	14.5	80	12	5
PW	73	F	Disagreed	—	Anterolateral	—	82	48	3
SE	44	M	Positive	Disagreed	Apicolateral	19.5	1080	48	4
RP	31	F	Positive	Disagreed	Inferior	9	304	18	1
EF	65	M	Negative	—	Apicolateral	—	157	9	5

counts were obtained in the anterior, LAO, and RAO views, and in some cases the left lateral view. They were read independently by two observers who had no knowledge of the patients' clinical diagnoses. Studies were defined as abnormal only if both observers agreed on the presence of an area of increased tracer uptake in the region of the heart. Contrast enhancement of the images was performed with a commercially available data-analysis system. The final interpretation, however, was made from the study of the unprocessed image.

Clinical diagnosis of the presence or absence of acute myocardial infarction was made by historical, physical, electrocardiographic, and serum enzyme (CPK, SGOT, and LDH) criteria. The upper range of normal for CPK is 50; SGOT, 19; and LDH, 300. Categories of acute transmural infarction, acute nontransmural infarction, no acute infarction, and a clinically indeterminate group were defined. Transmural infarcts were diagnosed by the appearance of new Q waves of at least 0.04-sec duration. Serum enzyme elevation plus ST-segment and T-wave changes without the appearance of new Q waves indicated acute nontransmural infarctions. Patients with neither EKG changes nor serial enzyme changes suggestive of acute infarction were classified as having no infarct. In the "clinically indeterminate" group

TABLE 3. TECHNETIUM-99m-GLUCOHEPTONATE SCANS: NO ACUTE INFARCTION

Patient	Age	Sex	Scan	Time from onset of chest pain to injection (hr)	Time from injection to imaging (hr)
JC	58	F	Negative	15	5
AP	69	M	Negative	5	5
RJ	57	M	Negative	12	5
WB	40	M	Negative	19	4
RC	65	M	Disagreed	11	4
JH	48	F	Negative	6	5
JO	48	M	Negative	24	4.5

TABLE 4. TECHNETIUM-99m-GLUCOHEPTONATE SCAN: INDETERMINATE CLINICAL STATUS

Patient	Age	Sex	Scan	Location of scan abnormality	Location of EKG abnormality	Comments	Time from onset of chest pain to injection (hr)	Time from injection to imaging (hr)
NE	80	F	Disagreed		LBBB	No CPK rise for 2 days after the scan, then large CPK rise	7	5
SF	56	M	Disagreed		None	No EKG change; CPK peak, 56	12	3
BD	54	F	Positive	Disagreed	Inferior	New Q waves on EKG; no enzyme elevations; patient with angina; age of inferior infarct unknown	6	2.5
RH	53	M	Positive	Anterior	None	CPK rise to 106; after syncopal episode with mild chest pain in patient with angina; no EKG changes	4	2.5
MA	46	M	Positive	Anterior	Anterior and lateral ST and T-wave abnormalities	Anterior and lateral ST and T-wave abnormalities; CPK persistently elevated in hundreds	12	1

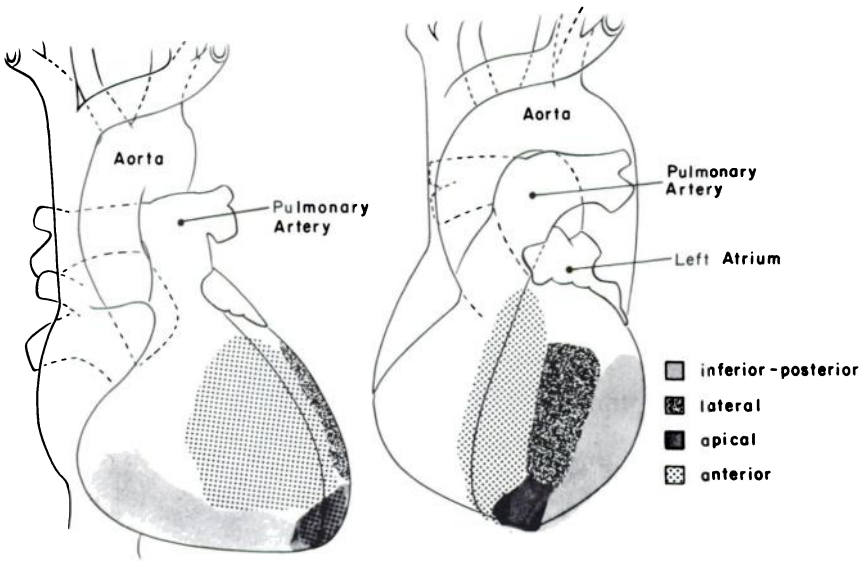

FIG. 1. Scintiscan location of ^{99m}Tc-glucoheptonate in patients with anterior, apical, lateral, and inferior-posterior acute myocardial infarct as seen in anterior and left anterior oblique views.

were the patients with serial EKG changes suggestive of infarction but without serial enzyme changes, and patients with slight serial enzyme changes but without serial EKG changes.

The quantity of infarcted tissue was estimated in the following manner. The scan was projected to life size. The boundaries of abnormal tracer concentration were outlined in the anterior and LAO projections. Areas of abnormal tracer uptake were then determined by planimetry. The abnormal areas in the anterior and LAO view were summed, and the sum was divided by 2. These values were compared to the peak CKP value for each patient. Area of tracer uptake rather than the intensity of tracer activity was selected to represent infarct size since we have shown in dogs that the absolute concentration of ^{99m}Tc-glucoheptonate in the infarcted tissue is variable, even when blood flow is practically absent.

RESULTS

Identification and location of acute myocardial infarction. Of the 27 patients studied, 8 had acute transmural infarctions (Table 1); 7, acute nontransmural infarctions (Table 2); 7, no acute infarction

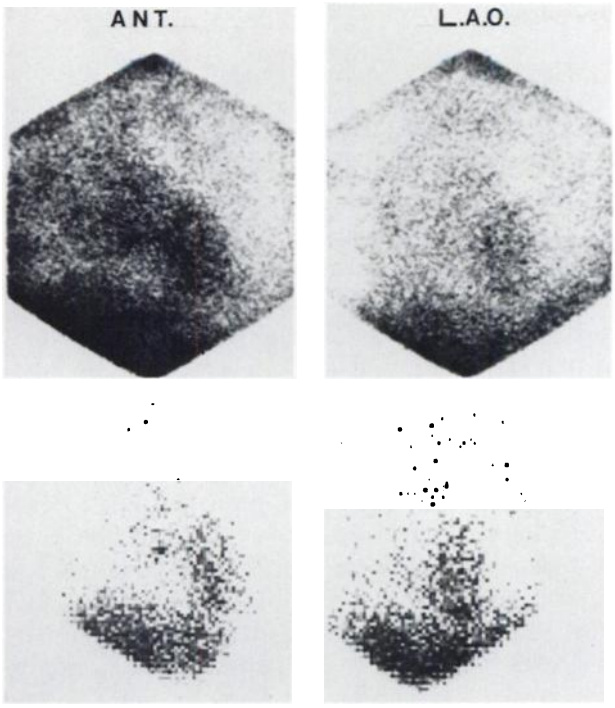

FIG. 2. Anterior and left anterior oblique scans in patient with acute anteroseptal transmural myocardial infarct. Unprocessed views are seen above. The effect of contrast enhancement on the scans is shown below.

(Table 3); and 5, a definite diagnosis could not be made (Table 4). Patterns of anteroseptal, inferior, lateral, and apical tracer uptake are illustrated in Fig. 1.

All eight patients with acute transmural infarctions had areas of increased ^{99m}Tc-glucoheptonate concentration identified on the scintiscans (Table 1). Examples of scintiscans from patients with an acute transmural anteroseptal infarction are shown in Fig. 2. There were no false-negative scans in this group. The range of peak CPK values among these patients was from 498 to 2,270, with a mean of 1,521. Three of the eight patients in this category had anteroseptal and lateral infarction, and three had inferior infarction. In six of these eight patients, the location of the scan abnormality corresponded to the location determined by EKG. In the remaining two patients, the scan demonstrated more extensive involvement than that suggested by EKG.

Of the seven patients with acute nontransmural infarctions, four were correctly identified by ^{99m}Tc-glucoheptonate scintiscanning (Table 2). An example is shown in Fig. 3. Three patients with acute nontransmural infarctions had false-negative scans. There was disagreement between observers as to the presence of increased tracer uptake in one of these three. All three infarcts with peak serum CPK values of greater than 300 were identified by scintigraphy. Of the four nontransmural infarcts in which the peak serum CPK was less than 300, only one was correctly identified by ^{99m}Tc-glucoheptonate scanning (Table 2). Of the four patients with abnormal scans, the scan and the EKG findings agreed in two. One was apical and the other inferior in location. In the other two scans, the location of abnormal uptake was interpreted differently by the two observers. The EKG locations in these two patients were apicolateral and inferior.

Seven patients had neither EKG nor enzyme changes characteristic of acute myocardial infarction. All seven patients were classified as having normal scans (Table 3). An example is shown in Fig. 4. In one of these seven there was disagreement between the two observers as to the presence of abnormal uptake.

It was not possible for a definitive diagnosis to be made on clinical grounds in five patients. Of these five, three had studies that were interpreted as abnormal by both observers. In the remaining two patients, the observers could not agree on the scintiscan interpretation (Table 4).

Infarct sizing. The area of increased tracer accumulation was determined for each patient having a true-positive scintiscan. A linear correlation between the involved area on scintiscan and peak CPK value was found. The correlation coefficient was 0.77 (Fig. 5).

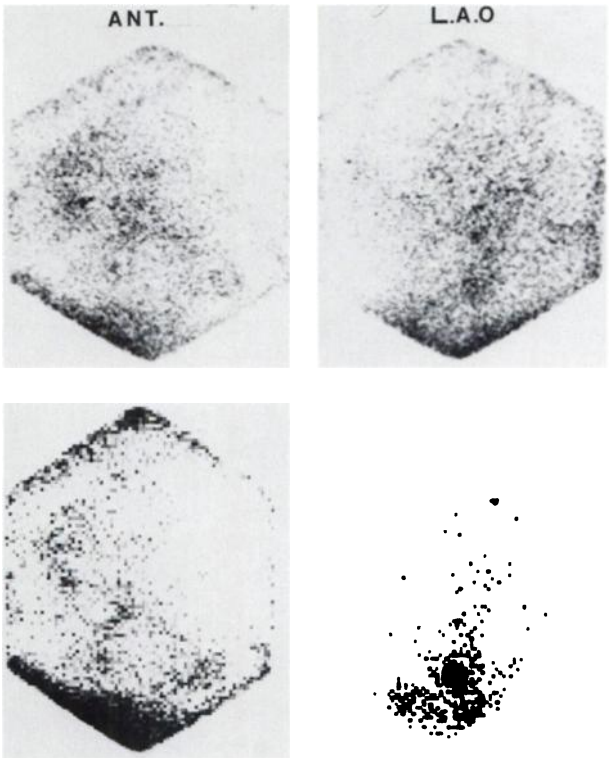

FIG. 3. Anterior and left anterior oblique unprocessed (top) and contrast-enhanced (bottom) scans of patient with acute nontransmural apical myocardial infarct.

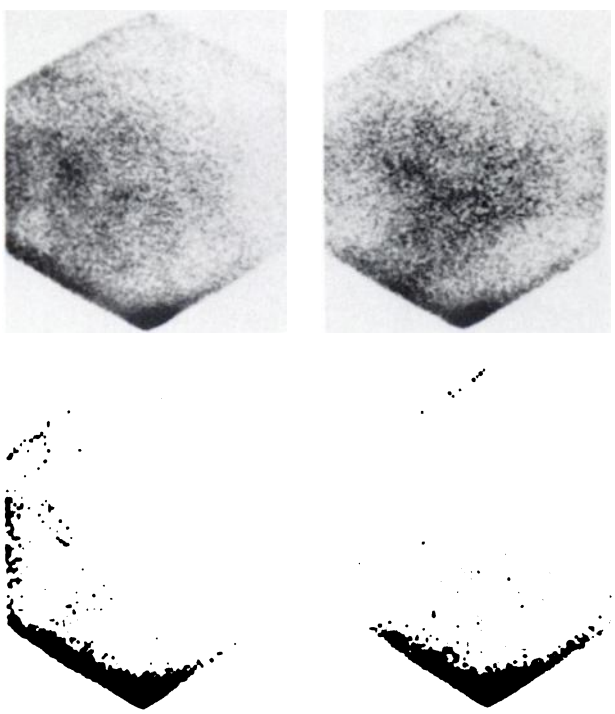

FIG. 4. Anterior and left anterior oblique unprocessed (top) and contrast-enhanced (bottom) scans of patient with old anteroseptal myocardial infarction. No recent myocardial infarction was found on this admission. His ^{99m}Tc-glucoheptonate scan shows no abnormal tracer concentration.

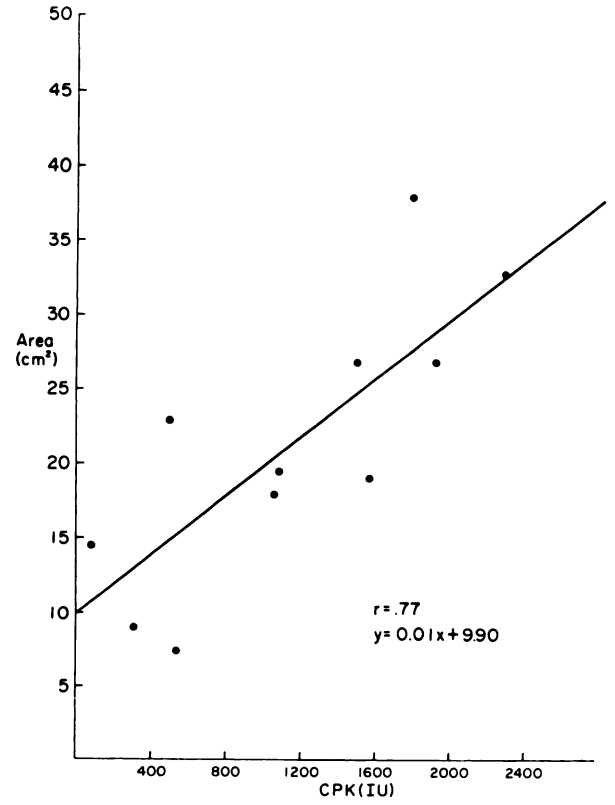

FIG. 5. Graph of correlation of abnormal scan area and peak serum CPK values.

DISCUSSION

This study demonstrates the applicability of ^{99m}Tc-glucoheptonate for the detection of acute myocardial infarction in man. Moderate- to large-sized acute infarcts were consistently identified by ^{99m}Tc-glucoheptonate scanning irrespective of whether they were transmural or nontransmural in type. Early tracer injection did not appear to be a limiting factor in infarct identification. The earliest infarct identification in our group was 5 hr after the onset of chest pain (Patient JJ, Table 1). There were no false-positive studies noted. An estimate of infarct size may be made as early as 5 hr after the onset of chest pain.

Nevertheless, ^{99m}Tc-glucoheptonate is not an ideal agent for acute myocardial infarction detection. Even with clinically documented myocardial infarction and a peak serum CPK of less than 300, scanning after ^{99m}Tc-glucoheptonate administration was positive in only one of four patients. Contrast ratios of infarct-to-chest background appear lower in humans than in our canine experimental models (*9*). Contrast in some scans was so low as to make interpretation of these scans quite difficult. Data processing to enhance contrast did not improve infarct identification but did improve the confidence placed in infarcts already identified on the unprocessed image. In future studies imaging may be improved by collecting a greater number of counts for each image. Absence of anatomic landmarks on the scan made definitive localization of the area of increased uptake difficult.

Technetium-99m-glucoheptonate imaging combined with electrocardiographic and serum enzyme determinations can be helpful for the more rapid diagnosis and size determination of moderate- to large-sized myocardial infarctions. In addition, areas of acute infarction can be differentiated from those of old fibrosis by comparing the increased technetium-gluconate uptake with the decreased concentration of tracers that accumulate in the myocardium in proportion of blood flow—such as ^{43}K (*3–6*). Areas of akinesis or dyskinesis on gated cardiac blood pool scans (*1*) could also be utilized to differentiate acute infarction from old fibrosis. In some cases, more accurate localization of areas of increased ^{99m}Tc-glucoheptonate accumulation could be made by performance of a cardiac blood pool scan to be superimposed on the ^{99m}Tc-glucoheptonate scan.

Because its relatively rapid blood clearance, ^{99m}Tc-glucoheptonate permits early imaging and may be a desirable tracer for the identification and measurement of moderate- to large-sized acute myocardial infarction. Infarction can be detected at an earlier

time after ischemia than the minimum waiting time of 12 hr needed with ^{99m}Tc-tetracycline (7). Controlled studies comparing the accuracy and speed of infarct identification and sizing of ^{99m}Tc-glucoheptonate, ^{99m}Tc-pyrophosphate, and ^{99m}Tc-tetracycline appear desirable. All three of these tracers have properties that are less than ideal, so the search for a simple, sensitive, and accurate agent for the scintigraphic identification of acute myocardial infarction should continue.

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