Comparison of Thallium-201 Scanning in Idiopathic Dilated Cardiomyopathy and Severe Coronary Artery Disease


Summary To determine whether cardiomyopathy could be distinguished from coronary artery disease, we used thallium scanning to study 25 patients with severe left ventricular dysfunction and chronic heart failure. Ten patients had normal coronary arteries and idiopathic cardiomyopathy (ejection fraction 20 ± 5%), and 15 patients had multivessel coronary disease and left ventricular dysfunction (ejection fraction 25 ± 6%). The exercise time and maximal heart rate were similar in the two groups. Two patients with cardiomyopathy and 11 with coronary artery disease had a positive exercise ECG (p < 0.05). Thallium scans showed perfusion defects in all 25 patients. The perfusion defects were complete in nine coronary artery disease patients (60%) and in one patient (10%) with cardiomyopathy (p < 0.05). Extensive defects involving more than 40% of the left ventricular circumference, the number of segments involved, redistribution on the 4-hour scan, lung uptake and ventricular size were similar in the two groups. Perfusion defects on thallium scanning can occur in patients with idiopathic dilated cardiomyopathy and chronic heart failure. Thallium scanning cannot be reliably used in patients with chronic heart failure to distinguish coronary artery disease from cardiomyopathy unless complete defects are present.

Idiopathic dilated cardiomyopathy is often difficult to distinguish clinically from severe coronary artery disease in patients with chronic heart failure. Because the management and prognosis of these two diseases is different, precise diagnosis is important. Bulkley et al. reported that thallium scanning could distinguish ischemic and idiopathic cardiomyopathy, as perfusion deficits occurred in coronary artery disease but not in idiopathic cardiomyopathy. Perfusion defects on thallium scanning have been reported in other forms of cardiomyopathy, including sarcoidosis and hypertrophic cardiomyopathy with normal coronary arteries. Gewirtz et al. suggested that in dogs a dilated left ventricle can cause defects on thallium scans independent of changes in myocardial perfusion.

The aim of the study was to determine whether thallium scans can show perfusion defects in patients with idiopathic dilated cardiomyopathy and differentiate between idiopathic dilated cardiomyopathy and coronary artery disease in patients with chronic heart failure.

Methods

Patients

The study group consisted of 10 patients, ages 25–62 years (mean 44 years), with idiopathic dilated cardiomyopathy, defined as severe left ventricular dysfunction due to myocardial damage from an unidentified cause. These patients had symptomatic left ventricular failure (New York Heart Association functional class II–IV), predominantly global asynergy on ventriculography, left ventricular ejection fraction (LVEF) less than 35% and normal or minimally narrowed (< 50%) coronary arteries.

The study group was compared with 15 patients, ages 27–59 years (mean 49 years), with coronary artery disease and severe left ventricular dysfunction (ischemic cardiomyopathy). These patients also had symptomatic left ventricular failure (New York Heart Association class II–IV), predominantly global asynergy on ventriculography without a discrete aneurysm, LVEF less than 35%, and 70% or greater diameter narrowing in one or more coronary arteries supplying the affected myocardium.

All 25 patients underwent thallium-201 myocardial perfusion scanning. Twenty-four patients were scanned after exercise and again 4 hours later and also underwent cardiac catheterization. One patient who was bedridden with class IV dyspnea underwent thallium scanning at rest and again 4 hours later. She died 2 weeks later and her heart was examined at autopsy. Patients with recent myocardial infarction (less than 1 month), unstable angina or hemodynamically significant valvular or pericardial disease were excluded from the study. All idiopathic cardiomyopathy patients and six of the 15 coronary artery disease patients were receiving digitalis and diuretic drugs. The nine other coronary artery disease patients were receiving diuretics and three of them were also receiving calcium-antagonist drugs.

Three of the 10 patients with cardiomyopathy had a history of chest pain suggestive of myocardial ischemia. Two of the 10 patients had Q waves on the resting ECG, four had left bundle branch block and four had nonspecific ST-T wave changes. Eleven of the 15 patients with coronary artery disease had a history of myocardial infarction, two had angina pectoris, and
two had atypical chest pain. Eight of the 15 patients had Q waves on the resting ECG, three had left bundle branch block and four had nonspecific ST-T-wave changes only.

**Cardiac Catheterization**

Twenty-four of the 25 patients underwent cardiac catheterization. Left ventriculography was performed in the right anterior oblique projection, which was divided into five segments to evaluate myocardial contraction. Akinesis was defined as no systolic wall motion, hypokinesis as reduced systolic wall motion, and dyskinesis as paradoxical systolic expansion. An aneurysm was defined as a discrete, circumscribed dilatation of the left ventricle with dyskinesis and normal contraction in other segments. The LVEF was calculated from end-diastolic and end-systolic volume measurements using the length-area method developed by Kennedy and associates for the right anterior oblique projection. Coronary artery obstructions of 70% or greater of the luminal diameter were considered significant.

The patient with class IV dyspnea who was bedridden did not undergo catheterization. Left ventricular contraction and LVEF were determined in this patient from a gated blood pool scan.

**Thallium-201 Scanning**

Eight patients exercised on a treadmill (standard Bruce protocol) and 16 on an upright bicycle (graded multistage protocol) until they developed disabling chest pain, breathlessness or fatigue. A modified 12-lead ECG was recorded before and during each minute of exercise and recovery, as previously reported. At peak exercise, 1.5–2.0 mCi of thallium-201 were injected intravenously, and exercise was continued for 1 minute. For the rest scan, 2 mCi of thallium-201 were injected with the patient in the upright position.

Scanning was begun 10 minutes after the administration of thallium. An Ohio Nuclear Sigma 420 camera and an all-purpose collimator were used to obtain four views: anterior, 45° left anterior oblique, and 60° left anterior oblique with the patient supine, and the left lateral with the patient in the right decubitus position. In the first view, 400,000 counts were collected. Counts in the other three views were collected for the same time as in the first view. Scanning was usually completed within 30 minutes. Scans were repeated four hours later in the same four views without further administration of thallium (4-hour redistribution scan).

**Interpretation of ECGs**

Rest and exercise ECGs were interpreted by two independent observers. The exercise ECG was defined as positive for ischemia if there was 1 mm or greater horizontal or downsloping ST-segment depression compared with baseline, lasting 0.08 second and present in three consecutive beats. The exercise ECG was considered uninterpretable in the presence of left bundle branch block. All patients with an exercise ECG negative for ischemia reached at least 80% of their predicted maximal heart rate.

**Interpretation of Thallium Scans**

Scans were randomly and independently interpreted from the original Polaroid scintiphotos by three experienced observers who were unaware of the clinical data. Each observer recorded the following data: (1) the presence, size and site of perfusion defects on the initial scan and any redistribution (defined as a decrease in size or intensity of the defect on the 4-hour scan); (2) whether the defect was complete or partial, homogeneous or nonhomogeneous; (3) the number of vascular areas with defects; (4) the number of views with uptake of thallium at the base of the heart; (5) the size of the left and right ventricular cavities (normal or enlarged); and (6) lung uptake of thallium and any change in lung uptake on the 4-hour redistribution scan. The size of perfusion defects was usually estimated as a percentage of the outer left ventricular myocardial circumference and expressed as less than 20%, 20–40% or more than 40%, corresponding to a small, moderate or large defect, respectively. A complete defect was defined as a segment of the myocardium with no thallium uptake, and a partial defect as a segment with reduced thallium uptake. A nonhomogeneous defect was defined as a segment with interspersed normal and reduced thallium uptake, and a homogeneous defect as a segment with uniformly reduced thallium uptake. Thallium defects were localized to one or more of three specific vascular areas — the left anterior descending coronary artery vascular area, the right coronary or left circumflex vascular area and the left circumflex vascular area — and to a nonspecific apical vascular area, as previously described.

The three observers were asked to interpret the thallium scans as consistent with or inconsistent with coronary artery disease. The accuracy of interpreting scans was defined as the percentage of correct interpretations.

**Postmortem Study**

The heart of the patient who died was examined at autopsy. Serial transverse sections of the coronary arteries were visually examined at 1–2-mm intervals. Gross examination of the heart was performed after fixation with formaldehyde. The heart was sectioned transversely to the long axis into 1-cm slices. Multiple blocks of myocardium were taken, stained with hematoxylin-eosin and examined histologically.

**Data Analysis**

Data were compared using the exact test of Fisher, Irwin and Yates for the $2 \times 2$ contingency table and the nonpaired $t$ test.

**Results**

**Cardiac Catheterization**

All 10 patients with cardiomyopathy had dilated left ventricles with generalized hypokinesis. Three also
showed segmental akinesis and one of them had apical dyskinesis. The mean LVEF of this group was 20 ± 5%. All 15 patients with coronary artery disease had dilated left ventricles. Nine of the 15 patients had generalized severe hypokinesis, and six had segmental akinesis in addition to moderate hypokinesis in other segments. Two of the six had segmental dyskinesis. The mean LVEF of this group was 25 ± 6% (NS).

The coronary arteries were normal in nine of the 10 cardiomyopathy patients. One patient had a 50% left circumflex lesion and a 30% right coronary artery lesion. All 15 patients with coronary artery disease had either three-vessel disease (13 patients) or two-vessel disease (two patients) and had at least one totally occluded coronary artery.

Exercise Stress Testing

The exercise test results are shown in table 1. The exercise time and the mean maximal heart rate were similar in the cardiomyopathy and coronary artery disease patients. In all patients with cardiomyopathy and in 11 of the 15 patients with coronary artery disease, exercise was limited by dyspnea with or without leg fatigue. The other four patients with coronary artery disease developed angina with dyspnea. Eleven patients with coronary artery disease and two with cardiomyopathy had a positive exercise ECG (p < 0.05). The incidence of exercise ECGs that were negative or uninterpretable because of left bundle branch block was similar in the two groups.

Thallium-201 Scanning

The thallium scan results are shown in table 2. All 25 patients showed perfusion defects on the initial thallium scan. Thallium scans demonstrating perfusion defects in a patient with cardiomyopathy are shown in figure 1. All patients with cardiomyopathy had apical defects, which usually extended into the anteroseptal or inferoposterior segments, or both. Extensive defects involving 40% or more of the left ventricular circumference occurred in five cardiomyopathy patients (50%) and in 10 coronary artery disease patients (67%) (NS). The mean number of segments with defects in the four views of the thallium scan was 6.3 ± 2.5 (mean ± SD) for cardiomyopathy patients and 7.3 ± 1.3 for coronary artery disease patients (NS). Redistribution on the 4-hour scan (figs. 2 and 3) occurred in four cardiomyopathy patients (40%) and in 10 coronary artery disease patients (67%) (NS), whereas only constant defects were present in six cardiomyopathy (60%) and five coronary artery disease patients (33%). Complete perfusion defects (fig. 3) occurred in nine coronary artery disease patients (60%) and only one cardiomyopathy patient (10%) (p < 0.05); partial defects occurred in six coronary disease (60%) and nine cardiomyopathy patients (90%). Nonhomogeneous defects (figs. 1 and 4) occurred in seven cardiomyopathy patients (70%) and seven coronary artery disease patients (47%) (NS), whereas only homogeneous defects occurred in three cardiomyopathy (30%) and eight coronary artery disease patients (53%). Uptake of thallium at the base of the heart, left ventricular enlargement, right ventricular enlargement, lung uptake and improvement in lung uptake on the 4-hour redistribution scan occurred similarly in both groups of patients (table 2).

<table>
<thead>
<tr>
<th>Table 1. Exercise Test Results</th>
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<tbody>
<tr>
<td>Cardio-myopathy</td>
</tr>
<tr>
<td>(n = 9)</td>
</tr>
<tr>
<td>Exercise time (min)</td>
</tr>
<tr>
<td>(beats/min)</td>
</tr>
<tr>
<td>Dyspnea and fatigue</td>
</tr>
<tr>
<td>Dyspnea and chest pain</td>
</tr>
<tr>
<td>Positive exercise ECG</td>
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<tr>
<td>Left bundle branch block</td>
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<tr>
<td>Negative exercise ECG</td>
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*p < 0.05.

<table>
<thead>
<tr>
<th>Table 2. Thallium Scan Results</th>
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<tr>
<td></td>
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<tr>
<td>Perfusion defects</td>
</tr>
<tr>
<td>Defect size (% LV circumference)</td>
</tr>
<tr>
<td>&lt; 20</td>
</tr>
<tr>
<td>20–40</td>
</tr>
<tr>
<td>&gt; 40</td>
</tr>
<tr>
<td>Mean number of segments with defects</td>
</tr>
<tr>
<td>Defects in multiple specific vascular areas</td>
</tr>
<tr>
<td>Redistribution on 4-hour scan</td>
</tr>
<tr>
<td>Constant defects</td>
</tr>
<tr>
<td>Complete defects</td>
</tr>
<tr>
<td>Partial defects</td>
</tr>
<tr>
<td>Nonhomogeneous defects</td>
</tr>
<tr>
<td>Homogeneous defects</td>
</tr>
<tr>
<td>Uptake at base of left ventricle (&gt; 2 views)</td>
</tr>
<tr>
<td>LV enlargement</td>
</tr>
<tr>
<td>RV enlargement</td>
</tr>
<tr>
<td>Lung uptake</td>
</tr>
<tr>
<td>Improvement in lung uptake on 4-hour scan</td>
</tr>
</tbody>
</table>

*p < 0.05.

Abbreviations: LV = left ventricular; RV = right ventricular.
artery disease, even in the presence of nonhomogeneity of thallium uptake. Although he interpreted all the coronary artery disease scans correctly, he interpreted seven of the 10 cardiomyopathy scans as consistent with coronary disease. In contrast, observer 3 interpreted nonhomogeneity of thallium uptake as a sign of cardiomyopathy and as inconsistent with coronary artery disease even in the presence of redistribution on the 4-hour scan. He correctly interpreted eight of the 10 cardiomyopathy scans as inconsistent with coronary artery disease, but interpreted only 10 of the 15 coronary disease scans as consistent. The results for observer 2 were intermediate between those of the other two observers.

The consensus of the three observers correctly identified 20 of the 25 scans as consistent or inconsistent with coronary artery disease. The accuracy of thallium scanning for separating patients with coronary artery disease and cardiomyopathy was therefore 80%.

Correlation of Scan Results and Postmortem

One patient (age 29 years) with cardiomyopathy died 2 weeks after thallium scanning. The heart weighed 570 g. All four chambers were dilated and the left ventricle was hypertrophied. There were no areas of necrosis or fibrosis by gross examination. Histologic examination showed only small areas of interstitial fibrosis. The coronary arteries were widely patent.

The thallium scan in this patient (fig. 5) showed dilatation of the left ventricle and reduced thallium uptake in the anteroseptal and apical segments compared with the posterolateral segments. Autopsy failed to show fibrosis or necrosis in the anteroseptal wall, but a transverse section of the heart (fig. 6) clearly showed that the anteroseptal wall was thinner than the posterolateral wall. This difference in the thickness of the left ventricular walls could explain the relative difference of thallium uptake in the anteroseptal and posterolateral segments.

Discussion

All patients with idiopathic dilated cardiomyopathy in this study showed perfusion defects on thallium scans that were similar to those in patients with coronary artery disease. There was no significant difference in the incidence of the mean number of segments involved, the percent of left ventricular circumference involved, and the number of vascular areas involved in

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**Figure 1.** The exercise (Ex) and 4-hour redistribution (R) thallium scans in a 27-year-old man with idiopathic dilated cardiomyopathy and an ejection fraction of 18%. Extensive perfusion defects on the exercise scan, represented by the bars in the diagram below, in the inferior (INF), septal (SEPT), anteroseptal (ANT SEPT), anterior (ANT) and apical (AP) segments persisted on the redistribution scan. The anterolateral (ANT LAT) and posterior (POST) segments are nonhomogeneous; normal thallium uptake is interspersed with reduced thallium uptake. LAO = left anterior oblique; AP AN = apical segment in anterior view; AP 40 = apical segment in 40° LAO view; LAT = lateral segment, AP 60 = apical segment in 60° LAO view; POST INF = posterior inferior segment; AP LL = apical segment in left lateral view.

**Figure 2.** The exercise (Ex) and 4-hour redistribution (R) thallium scans in a 62-year-old man with cardiomyopathy and an ejection fraction of 20%. A constant perfusion defect is present on the exercise scan, as illustrated by the bars in the diagram on the right, in the anterolateral (ANT LAT) and apical (APEX) segments in the anterior view. A second perfusion defect in the septal (SEPT) segment in the 40° left anterior oblique (LAO) view partially improves on the 4-hour redistribution scan. Abbreviations as in figure 1.
the cardiomyopathy and coronary artery disease patients. Reversible perfusion defects with redistribution on the 4-hour scan, usually a reliable sign of myocardial ischemia and coronary artery disease, were also found in patients with cardiomyopathy. Only complete perfusion defects with no thallium uptake were more common in the coronary artery disease patients, and could reliably separate the two groups. Conversely,

**Figure 3.** The exercise (Ex) and 4-hour redistribution (R) scans in a 50-year-old man with coronary artery disease and an ejection fraction of 15%. Transmural perfusion defects are seen on the exercise scan, as illustrated by the bars in the diagram (D) on the right, in the inferior (INF), septal (SEPT), anteroseptal (ANT SEPT), posteroinferior (POST INF) and apical (AP) segments. Significant redistribution is present on the 4-hour scan. Computer enhancement was used for illustrative purposes only. Abbreviations as in figure 1.

**Figure 4.** The exercise (Ex) and 4-hour redistribution (R) scans in a 27-year-old diabetic man with cardiac failure who was found to have coronary artery disease and an ejection fraction of 23%. Small perfusion defects on the exercise scan, illustrated by the bars in the diagram below, in the anteroapical (AP ANT), septal (SEPT), lateral (LAT), anteroseptal (ANT SEPT) and anterior (ANT) segments are interspersed with areas of normal thallium uptake. There is significant improvement in the defects on the 4-hour scan. Abbreviations as in figure 1.

**Table 3. Interpretation of Thallium Scans**

<table>
<thead>
<tr>
<th>Cardiomyopathy</th>
<th>Consistent with CAD</th>
<th>Inconsistent with CAD</th>
<th>Coronary artery disease</th>
<th>Consistent with CAD</th>
<th>Inconsistent with CAD</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observer 1</td>
<td>7 (70%)</td>
<td>3 (30%)</td>
<td>15 (100%)</td>
<td>0 (0%)</td>
<td>72%</td>
<td></td>
</tr>
<tr>
<td>Observer 2</td>
<td>6 (60%)</td>
<td>4 (40%)</td>
<td>13 (87%)</td>
<td>2 (13%)</td>
<td>68%</td>
<td></td>
</tr>
<tr>
<td>Observer 3</td>
<td>2 (20%)</td>
<td>8 (80%)</td>
<td>10 (67%)</td>
<td>5 (33%)</td>
<td>72%</td>
<td></td>
</tr>
<tr>
<td>Consensus</td>
<td>4 (40%)</td>
<td>6 (60%)</td>
<td>14 (93%)</td>
<td>1 (7%)</td>
<td>80%</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: CAD = coronary artery disease; accuracy = percentage of correct interpretations.
partial defects, although more common in cardiomyopathy, occurred in both groups and did not reliably predict patients with cardiomyopathy. Despite our expectation that nonhomogeneous defects would be a feature of cardiomyopathy, they occurred in both groups of patients and did not separate the two groups. Thallium uptake at the base of the left ventricle, which others have reported as a reliable sign of three-vessel or left main coronary artery disease, also occurred in our patients with cardiomyopathy.

Bulkley et al. who conducted the only other study of thallium scanning in dilated cardiomyopathy, reported that perfusion defects were uncommon in cardiomyopathy. They defined a perfusion defect as a segment with no thallium uptake, whereas we defined a perfusion defect as a relative reduction of thallium uptake, which could be either complete (no thallium uptake) or partial (reduced thallium uptake). Complete perfusion defects in our study, as in the previous study, differentiated coronary artery disease from cardiomyopathy, but partial defects occurred in both groups. Partial perfusion defects frequently occur in patients with coronary artery disease and must be included in the definition of a perfusion defect.

Constant perfusion defects seen on thallium scans of patients with idiopathic dilated cardiomyopathy may represent areas of myocardial fibrosis and scarring often found in patients with cardiomyopathy. In the patient who died, no localized fibrosis or scarring was found at autopsy. On thallium scans, the perfusion defect occurred in the anteroseptal wall (fig. 5), which was disproportionally thinner than the posterolateral wall (fig. 6). Disproportional dilatation of the ventricle may lead to a relative difference in the density of radioactivity per unit area of myocardium despite a similar myocardial tracer distribution per unit mass of tissue. In the above example, uptake of thallium in the thinner anteroseptal myocardium was normal, but spread over a larger area, which resulted in a relative perfusion defect when compared with the thicker posterolateral wall. Changes in left ventricular geometry occur in patients with idiopathic dilated cardiomyopathy and may account for constant perfusion defects on thallium scans.

In contrast to constant defects, thallium defects that show redistribution on the 4-hour scan suggest reversible myocardial ischemia. In our patients with cardiomyopathy, reversible defects could not be explained by regional differences in coronary blood flow. Thallium uptake by myocardial cells also depends on factors other than coronary blood flow. In cardiomyopathy, the myocardial cell membrane in some areas of the heart may be abnormal, which results in different rates of thallium uptake. Reversible defects may also result from a change in left ventricular geometry between the time of the exercise and redistribution scans. Reversible thallium defects in the absence of significant coronary artery disease have been associated with exercise-induced spasm, mitral valve prolapse and aortic stenosis, all of which were excluded in our patients with cardiomyopathy. Reversible defects may be due to significant coronary
artery disease that was underestimated at angiography, to myocardial ischemia with normal coronary arteries and to artifacts.

Clinical Implications

In patients who have symptoms of congestive failure and cardiomegaly, coronary artery disease with left ventricular dysfunction should be distinguished from idiopathic dilated cardiomyopathy because patients with coronary artery disease may require surgery. Clinical differentiation is difficult. Thallium scanning is the preferred noninvasive test for separating these two groups. Our data indicate that coronary artery disease is present only if complete perfusion defects are seen. When partial defects, whether reversible or constant, are present in patients with chronic heart failure, idiopathic dilated cardiomyopathy cannot be reliably distinguished from coronary artery disease.

References

Comparison of thallium-201 scanning in idiopathic dilated cardiomyopathy and severe coronary artery disease.
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