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# ECG-gated thallium-201 myocardial SPECT in patients with old myocardial infarction compared with ECG-gated blood pool SPECT

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We evaluated one of the merits of ECG-gated thallium-201 single photon emission computed tomography (g-Tl SPECT), i.e., the ability to appreciate left ventricular (LV) wall motion. LV wall motion assessed by g-Tl SPECT and by ECG-gated Blood Pool SPECT (g-BP SPECT) was classified into three grades and compared segment by segment. Tl-201 uptake by g-Tl SPECT was also classified into three grades and compared with those of wall motion in g-BP SPECT.

Fifty patients with prior myocardial infarction were injected intravenously at rest with 111 to 185 MBq (3 to 5 mCi) of Tl-201. The left ventricular regions were divided into anterior, septal, inferior and lateral segments (50 patients×4 segments=200 segments in total). The grades of wall motion and Tl-201 uptake detected by g-Tl SPECT correlated well with those of wall motion in g-BP SPECT (94.5% and 85%, respectively).

With g-Tl SPECT it was possible to evaluate left ventricular wall motion, providing clear perfusion images.

**Key words:** thallium-201, technetium-99m red blood cells, ECG-gated, SPECT, myocardial infarction

## INTRODUCTION

ECG-GATED THALLIUM-201 single photon emission computed tomography (g-Tl SPECT) has not been widely used as a routine examination procedure because of its long data acquisition time. However, g-Tl SPECT has three major merits: (1) clearer perfusion images [end-diastolic (ED) and end-systolic (ES) images], (2) left ventricular (LV) wall motion[1] and (3) systolic thickening of the LV wall as increased pixel counts in ES images compared with pixel counts in ED images.[2] How well can g-Tl SPECT appreciate the LV wall motion? Is the wall motion in the infarcted region always abnormal? This study was performed mainly to evaluate one of the merits of g-Tl SPECT, namely assessment of LV wall motion, comparing the grades of wall motion and Tl-201 uptake assessed by g-Tl SPECT with those of wall motion in ECG-gated Blood Pool SPECT (g-BP SPECT).[3,4]

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## MATERIALS AND METHODS

*Patients*

Materials were 50 patients with old myocardial infarction whose strokes occurred at least two months prior to the SPECT studies. A diagnosis of myocardial infarction was made on the basis of ECG changes in the acute phase and significantly in-

creased myocardial enzymes (CPK and LDH). Of these, 14 cases were also confirmed by positive $^{99m}$Tc-pyrophosphate scintigraphy (hot scan).[5,6] The g-Tl SPECT and g-BP SPECT were performed within a week. There were 41 males and 9 females. Ages ranged from 35 to 85 years with a mean of 62.1 years.

*ECG-gated Tl-201 myocardial SPECT*

Ten minutes after intravenous injection of 111 to 185 MBq (3 to 5 mCi) of Tl-201 chloride, patients lay on the imaging table in the supine position with their left hands and forearms raised over their heads. The projection data were acquired through 180 degrees from 45 degrees RAO to 45 degrees LPO in 24 steps (80 to 100 beats per step) with a rotating gamma camera (Hitachi Gamma-View-T, Japan) equipped with a low energy high resolution collimator and interfaced to a computer (Hitachi HARP system). The acquisition required 30 to 40 minutes. An R-R interval was divided into about 20 fractions. The first three fractions were added for the reconstruction of ED images and three ES fractions as defined by planar Tc-99m MUGA studies were added for the reconstruction of ES images. After 9-point spstial smoothing, both ED and ES contiguous transverse images were reconstructed by filtered backprojection with Chesler filter. These were reformatted to short and long axial images perpendicular to the cardiac axes. The image size was a $64 \times 64$ matrix and the slice thickness was 6 mm. Attenuation correction was not performed.

*ECG-gated Blood Pool SPECT*

The patients were injected with 740 to 1,110 MBq (20 to 30 mCi) of Tc-99m pertechnetate to label red blood cells *in vivo* in the presence of stannous pyrophosphate. After the planar blood pool studies (first-pass and MUGA), projection data were acquired in the same way as with the g-Tl SPECT except that fifty beats per step were used. The data acquisition required 20 to 25 minutes. The ED and ES images were also processed in the same way as with the g-Tl SPECT.

*Analysis*

In the 50 patients, each LV SPECT image was divided into four segments, i.e., anterior, septal, inferior and lateral walls, which made a total of 200 segments (50 pts $\times$ 4 seg). The anterior and inferior walls were evaluated with a vertical long axis and a short axis. The septal and lateral walls were evaluated with a horizontal long axis and a short axis. In the short axis, three slices (near the apex, in the middle and near the base) were evaluated. The ED and ES images were superimposed with a cut off level of 50% (30% in OMI regions with very low counts) of the maximum pixel counts for the edge detection of the LV wall on the screen.

(1) One radiologist and one cardiologist classified the wall motion visually into three grades: normal, hypokinesis and akinesis (including dyskinesis). Then the grades of wall motion obtained by g-Tl SPECT and g-BP SPECT were compared segment by segment.

(2) The intensity in the ED images in g-Tl SPECT was classified into three groups: normal ($>70\%$ of maximum pixel counts), low (50 to 70%) and deficient ($<50\%$). The grades of Tl-201 uptake were then compared with those of the wall motion derived from the g-BP SPECT, analyzing all three of the cardiac axes.

(3) The grades of Tl-201 uptake in the 91 segments with infarct defined by low or deficient Tl-201 uptake in ED images in the g-Tl SPECT were compared with those of wall motion in the g-BP SPECT.

## RESULTS

(1) Table 1 summarizes the relationship between the grades of wall motion derived from the g-Tl SPECT and those from the g-BP SPECT. In the anterior and lateral walls, they were completely concordant. The overall concordance rate in the 200 segments was 94.5%.

(2) Table 2 summarizes the relationship between the grades of Tl-201 uptake assessed by g-Tl SPECT images and those of wall motion from the g-BP SPECT images. The concordance rate was 85%.

(3) In the 91 infarcted segments, wall motion was observed in 35 (38.5%) segments, i.e., in 20 (22.0%) segments wall motion was hypokinetic and in 15 (16.5%) wall motion was normal. (see Table 3)

**Table 1** Comparative results for the left ventricular wall motion, assessed by ECG-gated Tl-201 myocardial SPECT (g-Tl SPECT) and ECG-gated Blood Pool SPECT (g-BP SPECT)

| Tl\BP | Anterior | | | Septal | | | Lateral | | | Inferior | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nl | Hypo | A | Nl | Hypo | A | Nl | Hypo | A | Nl | Hypo | A |
| Normal | 26 | | | 31 | | | 40 | | | 15 | 1 | |
| Hypo | | 4 | | | 7 | 1 | | 5 | | 3 | 7 | 1 |
| A | | | 20 | | 3 | 8 | | | 5 | 2 | | 21 |

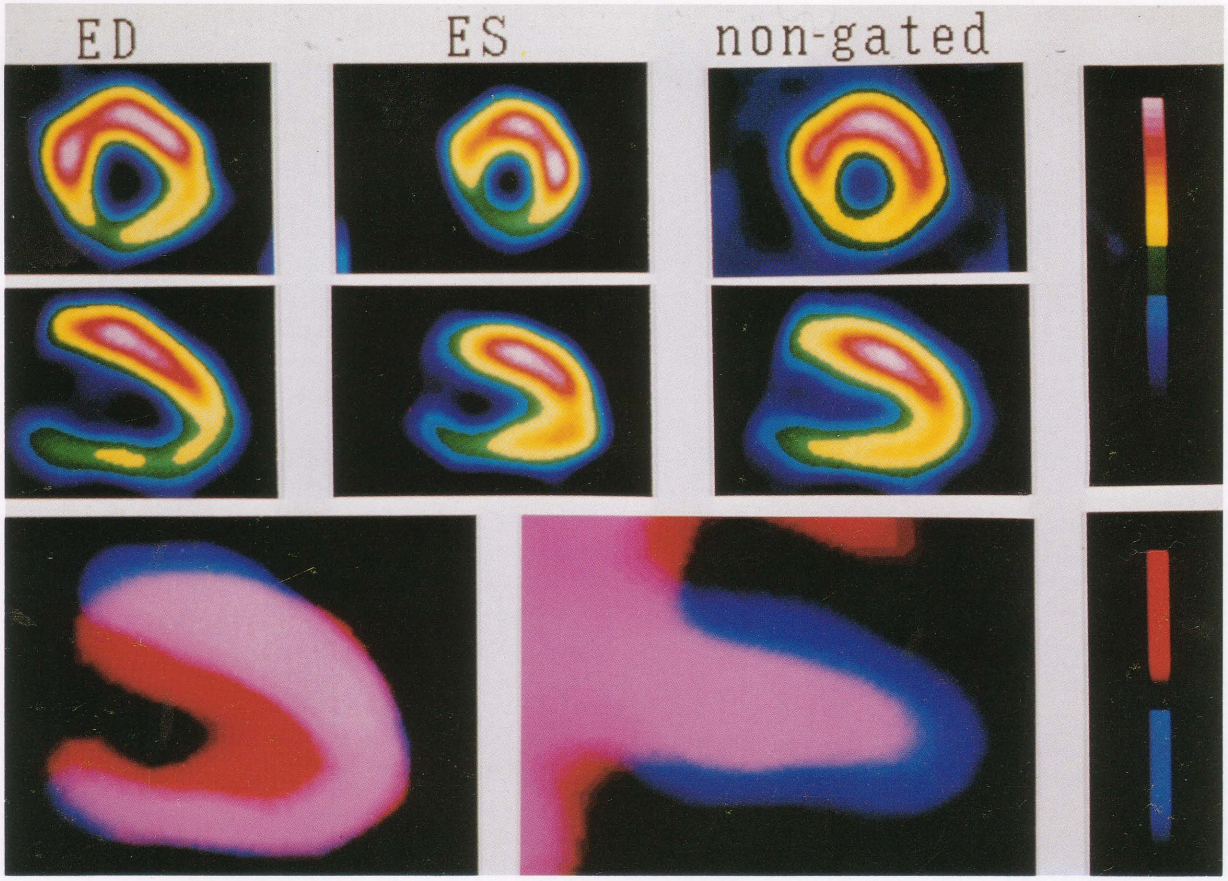


**Fig. 1** Inferior old myocardial infarction in a 62-year-old male is demonstrated. ECG-gated Tl-201 myocardial SPECT depicts markedly reduced perfusion in the inferior wall (top and middle rows, left and center). The ED vertical long axial slice shows the whole inferior wall to have relatively low counts (middle row, left), whereas the ES slice shows it to have relatively higher counts near the apex, indicating better systolic thickening than near the base (middle row, center). The display of the superimposed ED and ES images depicts hypokinesis in the high inferior wall (bottom row, left). The ECG-gated Blood Pool SPECT shows the wall motion of the high inferior wall to be nearly normal (bottom row, right).

**Table 2** Comparative Tl-201 uptake assessed by g-Tl SPECT and wall motion by g-BP SPECT

| Tl\BP | Anterior | | | Septal | | | Lateral | | | Inferior | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nl | Hypo | A | Nl | Hypo | A | Nl | Hypo | A | Nl | Hypo | A |
| Normal | 18 | 1 | | 30 | 1 | 1 | 41 | 2 | | 14 | 1 | |
| Low | 7 | 3 | | 1 | 5 | | | 1 | | 3 | 5 | 3 |
| Defect | 1 | | 20 | | 3 | 9 | | 1 | 5 | 3 | 2 | 19 |

**Table 3** Comparative Tl-201 uptake by g-Tl SPECT and wall motion by g-BP SPECT in 91 infarcted segments

| | Wall motion by ECG-gated blood pool SPECT | | |
|---|---|---|---|
| Tl uptake | Normal | Hypokinesis | Akinesis |
| Low | 11 (12.1%) | 14 (15.4%) | 3 ( 3.3%) |
| Defect | 4 ( 4.4%) | 6 ( 6.5%) | 53 (58.2%) |

## CASE REPORT

A sixty-two-year-old male with an inferior wall old myocardial infarction is represented in Fig. 1. Although the vertical long axial ED image demonstrates uniformly decreased perfusion throughout the entire inferior wall, better wall motion and systolic thickening near the apex than near the base can be seen in the ES image. The g-Tl SPECT provides: (1) clear ED and ES perfusion images, (2) information about

wall motion, and (3) information about systolic thickening.

## DISCUSSION

Long data acquisition time has been inherent in ECG-gated SPECT imaging. Before the development of SPECT, Budinger et al[7] obtained three dimensional ECG-gated myocardial imaging by rotating the patient. That required two hours of acquisition with inadequate radionuclide counts and resolution. Even since more clinically oriented SPECT systems were developed with modest reducing time, no studies evaluating the usefulness of g-Tl SPECT in comparison with g-BP SPECT in wall motion have been reported, probably because of its still relatively long data acquisition time (about one hour). We have found that this acquisition time can be reduced to 30 to 40 minutes by increasing the Tl-201 dose to (111 MBq to) 185 MBq [(3 mCi to) 5 mCi] and by acquiring fewer steps (24 steps). The patient raised his left hand and forearm over the head and maintained that position so that the camera could obtain the minimum radius of the orbit to get more counts and better resolution. Adding three frames out of 20 fractions of the R-R interval for ED and ES projection data allowed higher and enough counts to make g-Tl SPECT images clearer than the non-gated images. Although a single head camera was used in this study, a multi-headed r-camera would shorten the acquisition time significantly. Moreover, the problem of the long data acquisition time is most likely to be overcome by the new technetium-99m labeled radiopharmaceuticals.[8–10]

The comparative study of wall motion by g-Tl SPECT and g-BP SPECT demonstrated that g-Tl SPECT had essentially the same ability to evaluate the local LV wall motion as the g-BP SPECT technique as shown by the excellent concordance (94.5%). (see Table 1)

Although the ED and ES images had enough pixel counts to evaluate the wall motion in most cases, in 8 out of 11 discordant segments, wall motion was underestimated compared with that of g-BP SPECT, and this might be attributed in part to the markedly reduced count rates in infarcted regions.

The comparative study of the grades of Tl-201 uptake assessed by the g-Tl SPECT and those of wall motion assessed by the g-BP SPECT in 91 infarcted segments revealed some wall motion in 35 lesions (38.5%). Especially in 15 (16.5%) segments i.e., in 11 (12.1%) segments with low Tl-201 uptake and 4 (4.4%) with deficient, wall motion was considered as normal, where g-BP SPECT could not detect any abnormality resulting from the infarction. The wall motion approach in the blood pool study was therefore inadequate to detect myocardial infarction, but this may be acceptable for the evaluation or follow up of LV function in the region of known prior myocardial infarction. However, it is important to be aware of this incidence when interpreting wall motion and viability in the infarcted regions.

For the evaluation of ischemia, Tl-201 stress-redistribution myocardial scintigraphy[11–15] was useful, while for the assessment of viability, the rest T-201 study was more suitable, because lesions with persistent defects in the delayed images 2 to 5 hours after the injection might be viable and reversible.[16–20] Therefore, if the rest Tl-201 study is indicated for patients who have persistent defects or minimal redistribution in a delayed study, or who cannot undergo a stress study, the g-Tl SPECT would prove quite useful.

Another advantage which is characteristic of g-Tl SPECT is that g-Tl SPECT can evaluate LV systolic thickening (not only wall motion) as increased pixel counts in ES images.[2] For example a deficient perfusion area with no increased pixel counts indicates no function and probably a scar. On the other hand, a decreased perfusion area with increased pixel counts indicates functioning and viability. A decreased perfusion area but not an absolute defect with minimal (absent or inadequate) increased pixel counts may indicate a "hibernating myocardium.[21]"

We conclude that the Tl-201 ECG-gated myocardia SPECT is a useful diagnostic strategy that could evaluate wall motion, providing clear perfusion images.


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