Detection of a Biphasic Response of Hibernating Myocardium by Dobutamine-Stress Electrocardiography-Gated Technetium-99m-Tetrofosmin Single Photon Emission Computed Tomography

A Case Report

Hiroyuki Yamagishi, MD; Kaname Akioka, MD; Kumiko Hirata, MD; Yuji Sakanoue, MD; Iku Toda, MD; Minoru Yoshiyama, MD; Masakazu Teragaki, MD; Kazuhide Takeuchi, MD; Junichi Yoshikawa, MD; Hironobu Ochi, MD*

A woman with coronary artery disease underwent a new imaging technique: dobutamine-stress electrocardiography (ECG)-gated tetrofosmin-single photon emission computed tomography (SPECT). Dobutamine-stress ECG-gated tetrofosmin-SPECT with automatic left ventricular function analysis software programs detected improvement and a biphasic response of dysfunctional myocardium during dobutamine infusion, which suggested viable but hibernating myocardium. Dobutamine-stress ECG-gated tetrofosmin-SPECT with automatic left ventricular function analysis software programs has the potential to detect viable but dysfunctional myocardium with contractile reserve. (Jpn Circ J 1999; 63: 688–691)

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First Department of Internal Medicine and *Division of Nuclear Medicine, Osaka City University Medical School, Osaka, Japan
Mailing address: Hiroyuki Yamagishi, MD, First Department of Internal Medicine, Osaka City University Medical School, 1-5-7 Asahi-Machi, Abeno-Ku, Osaka 545-8586, Japan. E-mail: hiroyuki@msic.med.osaka-cu.ac.jp

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at 5 $\mu$g kg$^{-1}$ min$^{-1}$, followed by 10 $\mu$g kg$^{-1}$ min$^{-1}$, each stage lasting for 6 min. ECG-gated images were acquired at rest and during the last 192 s of each stage.

SPECT was performed with a 2-detector gamma camera (VERTEX, ADAC Laboratories, CA, USA) equipped with low-energy, general purpose collimators, with the detectors set up to form a 90-degree angle. A total of 32 equidistant projections were acquired over 180 degrees in a 64×64 matrix from the 45-degree right anterior oblique to 45-degree left posterior oblique projection. Nongated acquisition was performed with 50 s/step, 6-degree angular steps in step acquisition mode, and ECG-gated acquisition with 12 s/step, 6-degree angular steps in continuous acquisition mode, in which the camera acquired data both at each azimuth stop and while it rotated between stops. At each projection a total of 8 frames/cardiac cycle were acquired.

Transaxial slices of 4.7-mm pixel thickness were reconstructed using a Butterworth filter (order = 5.0, critical frequency = 0.35 cycles/pixel for nongated data, and order = 2.5, critical frequency = 0.22 cycles/pixel for ECG-gated data) and the filtered backprojection method (ramp filter) on a processing computer (Pegasys, ADAC Laboratories) with an automatic processing software program for SPECT (Cedars AutoSPECT)$^{10}$ An automatic left ventricular function analysis software program (Cedars Quantitative Gated SPECT)$^{8,9}$ was used for left ventricular wall motion analysis.

Her blood pressure was 178/70 mmHg at rest, 174/62 mmHg at peak exercise, 166/56 mmHg during 5 $\mu$g kg$^{-1}$ min$^{-1}$ dobutamine-stress and 166/60 mmHg during 10 $\mu$g kg$^{-1}$ min$^{-1}$ dobutamine-stress. Her heart rate was 82 beats/min at rest, 148 beats/min at peak exercise, 93 beats/min during 5 $\mu$g kg$^{-1}$ min$^{-1}$ dobutamine-stress and 110 beats/min during 10 $\mu$g kg$^{-1}$ min$^{-1}$ dobutamine-stress. ST depression was observed in leads of II, III, aVF, and V$\text{a}-$5 on ECG during exercise and during dobutamine-stress. She had no chest pain during dobutamine-stress ECG-gated SPECT.

Nongated myocardial perfusion SPECT images are shown in Fig 1. A reversible defect was observed at the apex. Left ventricular functional images of dobutamine-stress ECG-gated SPECT are shown in Fig 2. At rest (left), the antero-apical wall was hypokinetic and septo-apical wall was akinetic. During 5 $\mu$g kg$^{-1}$ min$^{-1}$ dobutamine-stress (middle), the wall motion abnormality improved; the antero-apical wall became normokinetic and the septo-apical wall became hypokinetic. However, during 10 $\mu$g kg$^{-1}$ min$^{-1}$ dobutamine-stress (right), the wall motion of the apex worsened again; the antero-apical wall became hypokinetic and septo-apical wall became akinetic.

Left ventriculography with contrast medium revealed hypokinesis at the apex and akinesis in the septum (Fig 3), whereas coronary arteriography revealed 90% stenosis of the proximal portion of the left anterior descending artery (Fig 4).
In this patient, the results of assessment of left ventricular wall motion at rest obtained with ECG-gated SPECT and left ventriculography with contrast medium were concordant. Moreover, dobutamine-stress ECG-gated SPECT was able to detect a biphasic response to dobutamine in the dysfunctional myocardium, which appeared to indicate ischemic and hibernating myocardium. Myocardial ischemia was also detected by the exercise-induced perfusion abnormality.

**Discussion**

We have performed dobutamine-stress ECG-gated SPECT in 23 patients with left ventricular dysfunction. In these patients, the concordant rate of assessment of wall motion between left ventriculography and ECG-gated SPECT was 74% (unpublished data). The typical biphasic response of dysfunctional myocardium was observed in only the present case.

Hibernating myocardium contracts in response to a low dose of intravenous dobutamine (5–10 \( \mu \text{g kg}^{-1} \text{min}^{-1} \)), but its function may deteriorate after the infusion of a high dose of dobutamine, because flow reserve is reduced and cannot meet the increased metabolic demand, resulting in ischemia with a further reduction in contraction. Senior et al reported that the detection of myocardial ischemia was significantly enhanced by utilizing the biphasic response, in addition to the worsening response, during serial dobutamine-stress echocardiography in patients with wall motion abnormality. Afridi et al reported that a biphasic response in dobutamine-stress echocardiography was observed in 28% of myocardial segments in patients with stable coronary artery disease, and that about 20% of segments exhibiting biphasic responses demonstrated deterioration of wall motion during \( \leq 10 \mu \text{g kg}^{-1} \text{min}^{-1} \) dobutamine infusion. They also reported that the prediction of recovery of function with dobutamine echocardiography depended on the type of wall motion response observed during dobutamine, the best being for a biphasic response and worst for sustained improvement.

The use of \(^{201}\text{TI}\) or \(^{99m}\text{Tc}\)-tetrofosmin to assess viability provides a sensitive but nonspecific method for predicting recovery of function after revascularization, whereas contractile reserve in response to dobutamine to assess viability provides a specific but insensitive predictor of recovery of function. It is conceivable that patients with reduced left ventricular function have more profound and possibly irreversible ultrastructural changes in areas of myocardial hibernation, such as loss of contractile protein, and that this leads to the reduced specificity of radionuclide techniques. Both \(^{99m}\text{Tc}\)-sestamibi and \(^{99m}\text{Tc}\)-tetrofosmin have been used successfully for the detection and assessment of coronary artery stenosis. However, neither of these \(^{99m}\text{Tc}\)-labeled traces, redistributes significantly after injection.
and this is a theoretical disadvantage in the assessment of viability in myocardium that might be underperfused at rest. Some studies suggest that $^{201}$Tl is superior to $^{99m}$Tc-labeled traces for the detection of viable myocardium.$^{18}$

The new method we used, dobutamine-stress ECG-gated tetrofosmin-SPECT, can detect improvement and a biphasic response of dysfunctional myocardium during dobutamine infusion. Dobutamine-stress ECG-gated tetrofosmin-SPECT with automatic left ventricular function analysis software programs has the potential to detect viable but dysfunctional myocardium with contractile reserve.

References