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ORIGINAL ARTICLE

Thallium-201 is comparable to technetium-99m-sestamibi for estimating cardiac function in patients with abnormal myocardial perfusion imaging

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Abstract We analyzed the left-ventricular functional data obtained by cardiac-gated single-photon emission computed tomography myocardial perfusion imaging (MPI) with thallium-201 (Tl-201) and technetium-99m-sestamibi (MIBI) protocols in different groups of patients, and compared the data between Tl-201 and MIBI. Two hundred and seventy-two patients undergoing dipyridamole stress/redistribution Tl-201 MPI and 563 patients undergoing 1-day rest/dipyridamole stress MIBI MPI were included. Higher mean stress ejection fraction (EF), rest EF, and change in EF (ΔEF) were noticed in the normal MPI groups by both Tl-201 and MIBI protocols. Higher mean EF was observed in the females with normal MPI results despite their higher mean age. Comparisons between the Tl-201 and MIBI groups suggested a significant difference in all functional parameters, except for the rest end diastolic volume/end systolic volume and ΔEF between groups with negative MPI results. For the positive MPI groups, there was no significant difference in all parameters, except for the change in end diastolic volume and change in end systolic volume after stress between both protocols. The Tl-201 provides comparable left-ventricular functional data to MIBI cardiac-gated single-photon emission computed tomography in patients with positive MPI results, and may therefore be undertaken routinely for incremental functional information that is especially valuable to this patient group.

Conflicts of interest: All authors declare no conflicts of interest.

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Introduction

Electrocardiography (ECG)-gated single-photon emission computed tomography (G-SPECT) provides quantitative assessment of the left-ventricular (LV) function and incremental information over perfusion imaging alone. With its physical property of ideal energy peak for the Anger camera, technetium-99m-sestamibi (MIBI) is the preferred agent for G-SPECT. Nevertheless, thallium-201 (Tl-201) remains the mainstay for myocardial perfusion imaging (MPI) in Taiwan despite the distinctive benefits of MIBI. We collected myocardial imaging obtained with either MIBI or Tl-201, and analyzed the LV functional data of different patient groups categorized by the result of MPI, sex, and past history of coronary artery disease (CAD) to identify factors that may influence LV ejection fraction (EF). We also analyzed the functional data to see if Tl-201 G-SPECT is comparable to MIBI G-SPECT in this application.

Methods

Patients

The study population consisted of 835 consecutive patients referred to the authors' department for MPI. It included 272 patients undergoing Tl-201 MPI from November 2009 to August 2010, and 563 patients undergoing MIBI MPI from September 2010 to November 2011. Those unable to undergo G-SPECT due to arrhythmia or other reasons during these periods were excluded.

Tl-201 protocol

For the stress imaging of the Tl-201 protocol [1], dipyridamole was infused intravenously via an injection pump at a dose rate of 0.56 mg/kg body weight over 4 minutes, and 74—129.5 MBq of Tl-201, depending on the patient's body weight, was injected via the same intravenous route 3—4 minutes after completing infusing dipyridamole upon the expected maximal effect of vasodilation. The myocardial imaging was commenced 5—10 minutes later. For the rest imaging, acquisition of redistribution images was undertaken at about 4 hours after the Tl-201 injection without any additional medication or tracer injection.

MIBI protocol

For the MIBI protocol [1], the rest imaging was carried out first, and the images were acquired at least 30 minutes after the injection of 222—370 MBq of MIBI, depending on the patient's body weight. Right after the rest imaging, the patient had pharmacological stress by dipyridamole stress, and three times the dose (666—1110 MBq) of MIBI for resting imaging was injected 3—4 minutes as in the Tl-201 protocol. The stress imaging was undertaken at least 30 minutes after the tracer injection.

Imaging

The G-SPECT was carried out with a dual-head gamma camera, the GE Infinia (GE Medical Systems, Waukesha, WI, USA), with the camera heads angled at 90° and orbiting a 180° half-circle from 45° right anterior oblique to 45° left posterior oblique over the patient's chest. Low-energy high-resolution collimators were used with a 15% symmetric energy window centered at 70 keV and a 10% symmetric energy window centered at 167 keV for Tl-201, as well as with a 10% symmetric energy window centered at 140 keV for MIBI. Data were recorded in 64 $\times$ 64 matrices with a pixel size of 8.84 mm. The SPECT was carried out in step-and-shoot mode for 30 projections with 40 seconds per step for the rest imaging and 35 seconds per step for the stress imaging in the Tl-201 protocol, as well as with 40 seconds per step for the rest imaging and 25 seconds per step for the stress imaging in the MIBI protocol. Both the stress and rest images were acquired in ECG-gated mode at eight frames per cycle synchronized with a camera-dedicated ECG.

Image reconstruction and interpretation

Transaxial tomograms were reconstructed by two experienced technologists with the EC Toolbox of the GE proprietary eNTEGRA application software (GE Medical Systems). A Butterworth filter with a critical frequency of 0.52 and a power of 5, and a ramp filter were used for back projection. The reconstruction procedures include placing and resizing an ovoid region of interest to adequately encompass the heart, adjusting the orientation and limit lines to dichotomize the heart within the chosen slicing limits in the vertical and horizontal axes, and properly masking the extracardiac background to enhance the quality of the image display. The remaining processes and image display were finished automatically by the program. For the calculation of the functional parameters, for each one of the eight gate images, a circular region of interest was placed and resized around the heart in its short axis, and two vertical lines were properly adjusted to determine the extent of the cardiac chamber in its vertical axis. The program then automatically calculated the data and displayed the ECG-gated images in cine mode accompanied by the functional parameters, including EF, end systolic volume (ESV), and end diastolic volume (EDV).

The images were interpreted visually with the aid of semiquantitative tools of the EC Toolbox, including the extent of perfusion defects and summed stress/rest scores, and the functional images without any knowledge of the functional data by two nuclear-medicine physicians with $>$ 30 years' experience in nuclear cardiology.

Data analysis

The functional parameters of the mean stress EF, mean rest EF, and mean percentage change in EF (ΔEF) were compared between the paired patient groups. The patients were first divided into two groups: one with normal MPI results and the other with positive MPI results. We first compared the functional data between the two groups, and