A comparison of $^{99m}$Tc-MIBI myocardial SPET with electron beam computed tomography in the assessment of coronary artery disease

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Abstract. We compared technetium-$^{99m}$ methoxyisobutylisonitrile (MIBI) myocardial perfusion single-photon emission tomography (SPET) (MPS) and electron beam computed tomography (EBCT) in order to assess their respective value in the detection of coronary artery disease (CAD). $^{99m}$Tc-MIBI SPET (stress-resting) and EBCT studies were performed in 51 patients with suspected CAD who underwent coronary angiography (CAG). CAG showed that of the 51 patients, 36 had coronary stenosis $\geq 50\%$ while 15 had normal results. A moderate positive rank correlation was found between coronary calcification detected by EBCT and MPS score ($r_m=0.5283$, $P<0.01$). The concordance between EBCT and MPS for the evaluation of CAD was 72.5% (37/51). The sensitivity of EBCT in detecting CAD in 51 patients was comparable to that of MPS (81% vs 94%, NS). However, the accuracy of EBCT was lower than that of MPS (78% vs 94%, $P<0.025$). As regards the detection of individual coronary artery disease, there was no significant difference in sensitivity between EBCT and MPS (65% vs 75%, NS); however, the specificity and accuracy of EBCT were lower than those of MPS (specificity: 77% vs 95%, $P<0.005$; accuracy 71% vs 85%, $P<0.005$). The sensitivity, specificity and accuracy of MPS in detecting single-vessel disease were higher than those of EBCT (specificity: 76% vs 42%, $P<0.025$; specificity: 96% vs 70%, $P<0.025$; accuracy: 93% vs 61%, $P<0.005$). However, no significant differences in the sensitivity, specificity and accuracy of MPS and EBCT were found in respect of multivessel disease. In conclusion: $^{99m}$Tc-MIBI myocardial perfusion SPET and EBCT provide different information in the assessment of CAD. The sensitivity of EBCT for the detection of CAD is comparable with that of MPS; however, the specificity and accuracy of EBCT are lower than those of MPS.

More reliable results will be obtained if both myocardial perfusion SPET and EBCT are performed.

Key words: Myocardial perfusion imaging – Single-photon emission tomography – Technetium-$^{99m}$ methoxyisobutylisonitrile – Coronary artery disease – Electron beam computed tomography


Introduction

Myocardial perfusion single-photon emission tomography (SPET) is widely accepted as a technique for the diagnosis of myocardial infarction, unstable angina and chronic coronary artery disease (CAD), for the assessment of the severity, risk and prognosis of these conditions, and for the management of CAD. SPET is considered as a major potential gatekeeper for the performance of diagnostic coronary angiography [1–4].

Calcium is deposited early in the formation of the atherosclerotic plaque. Many previous investigations have demonstrated a strong association between coronary calcification and coronary artery atherosclerosis [5]. With its lower susceptibility to coronary motion artifacts and its high contrast and spatial resolution, electron beam computed tomography (EBCT) is a sensitive and non-invasive method for the detection of coronary calcification, and may be useful for the evaluation of segmental histopathological CAD. In one study, coronary calcification was detected by EBCT in all patients with angiographically significant CAD [6]. Coronary calcification (showing the deposition of calcium in the coronary arteries), however, may not be indicative of the pathophysiological significance of the coronary artery so affected.

The purpose of this study was to compare technetium-$^{99m}$ methoxyisobutylisonitrile (MIBI) myocardial
SPET with EBCT for the diagnosis of CAD, and thus to assess their relative value.

Materials and methods

Patient population. Included in this study were 51 consecutive patients with suspected CAD who underwent coronary angiography, myocardial perfusion SPET (MPS) and EBCT within a period of 3 weeks. All patients were in a clinically stable condition at the time of the study. Twenty-eight patients had a history of previous myocardial infarction, and 23 had a history of chest pain. Thirty-six had significant CAD confirmed by qualitative coronary angiography (≥50% luminal stenosis); 14 had single-vessel disease, five had two-vessel disease and 17 had three-vessel disease. Three patients had left ventricular aneurysms documented by contrast ventriculography. The remaining 15 patients had normal coronary arteries. Patient characteristics are given in Table 1.

99mTc-MIBI myocardial perfusion SPET. 99mTc-MIBI was provided by the Department of Chemistry, Beijing Normal University. The radiochemical purity and labelling yield of 99mTc-MIBI were assessed by thin-layer-chromatography before administration to the patients; the radiochemical purity exceeded 96% in all cases.

Exercise test and resting SPET was performed with a 2-day protocol. All patients underwent a submaximal exercise test according to the Bruce protocol, described previously [7]. Briefly, a standardized multistage exercise protocol was performed with the patient seated on the ergometric bed in the erect position with continuous monitoring of ECG, heart rate, blood pressure and symptoms. At peak exercise, 740 MBq (20 mCi) 99mTc-MIBI was injected intravenously 1 min before the end of exercise. Criteria for interrupting the exercise test were failure to achieve 85% of age-predicted maximal heart rate, severe chest pain, development of marked ST segment depression, decrease in systolic blood pressure >20 mmHg, systolic blood pressure >220 mmHg or diastolic blood pressure >120 mmHg, and severe ventricular arrhythmia. Tomographic images were acquired 60 min later.

SPET acquisition was performed with a multi SPET gamma camera (Siemens multi SPECT 3) equipped with low-energy, all-purpose, parallel-hole collimators and connected to a dedicated computer system (Siemens ICON). Sixty projections (100 kcounts/projection) were acquired over 360° with a 64x64 matrix and a zoom of 1.45. The field of view of the detector was 40.6x30.5 cm². A 20% symmetric energy window centered on the 140-keV peak was used. Each projection image was corrected for non-uniformity. The images were reconstructed with a filtered back-projection method. A Butterworth filter was used for reconstruction (cut-off frequency 0.45, order 7). MPS was analysed by two experienced nuclear medicine physicians, who were unaware of the EBCT and angiographic findings. In each case of disagreement, a decision was reached by consensus. Twenty-one segments were determined on the left ventricular wall. As a first step, three short-axis slices - one apical, one medial and one basal - were chosen with the help of the long-axis slices. Then, on each of these short-axis slices, the anterior, septal and lateral walls were divided into two segments and the inferior wall was considered as one segment. This gave seven segments for the whole ring and a total of 21 segments for all three slices. Each segment was scored with a four-point scoring system: 0=normal 99mTc-MIBI uptake; 1=moderate reduction of 99mTc-MIBI uptake; 2=severe reduction of 99mTc-MIBI uptake; 3=absence of 99mTc-MIBI uptake. If two or more continuous slices had a score greater than 1, the study was considered abnormal. A single segment with a score of 2 or 3 was defined as abnormal, too. The anterior, anteroseptal wall of the left ventricle was considered to belong to the territory of the left anterior descending artery, the lateral wall of the left ventricle to that of the left circumflex artery, and the inferior and posteroseptal wall of the left ventricle to that of the right coronary artery.

Electron beam computed tomography. An EBCT scanner system (Imatron C-150) was used to obtain contiguous 3-mm-thick transverse images with ECG triggering (at 80% of the R-R interval), commencing at the root of the aorta cephalad to the coronary sinuses and proceeding caudally through the entire coronary artery tree. Scan acquisition time was 100 ms. The field of view was 26 cm² and the reconstruction matrix was 512x512. One pixel was equal to 0.258 mm². No contrast-enhancing agent was used.

Each image was analysed by an experienced radiological physician who placed a region of interest around each focus of coronary artery calcification. Coronary artery calcification was defined as an area >1 mm² with a CT number >130 Hounsfield units (HU) within the borders of a coronary artery. Image processing software provided measurements of the the calcification area within each region of interest and the calcification area was calculated as the total area within all regions of interest.

Coronary angiography. Catheterization was performed by the Judkins’ technique with a minimum of five views of the left coronary system and two views of the right coronary system. All coronary angiograms were visually assessed, in terms of percent diameter narrowing, by two cardiologists. Significant disease was defined as ≥50% diameter narrowing in one or more major coronary artery branches.

Statistics. Results were expressed as the mean ±1 SD and categorical data as percentages. The chi square test was used to determine the difference between the percentages for two groups. Spearman’s rank correlation or linear correlation was used to analyse whether there was a correlation between two variants. A P value <0.05 was considered statistically significant.

Table 1. Clinical data and angiographic results in the 51 patients

<table>
<thead>
<tr>
<th>Age</th>
<th>Gender</th>
<th>Clinical diagnosis</th>
</tr>
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<tbody>
<tr>
<td>≤45 years</td>
<td>11 (22%)</td>
<td>Coronary artery disease</td>
</tr>
<tr>
<td>&gt;45 years</td>
<td>40 (78%)</td>
<td>Previous myocardial infarction</td>
</tr>
<tr>
<td>Female</td>
<td>3 (6%)</td>
<td>Left ventricular aneurysm</td>
</tr>
<tr>
<td>Male</td>
<td>48 (94%)</td>
<td>Single-vessel disease</td>
</tr>
<tr>
<td>Non-coronary artery disease</td>
<td>15 (29%)</td>
<td>Two-vessel disease</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Three-vessel disease</td>
</tr>
</tbody>
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a Mean age (±SD)=53±8.9 years