

Usefulness of myocardial perfusion SPECT in patients with left bundle branch block and previous myocardial infarction

J Candell-Riera, G Oller-Martínez, O Pereztol-Valdés, J Castell-Conesa, S Aguadé-Bruix, M Soler-Peter, M Simó, C Santana-Boado, J Soler-Soler

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Background: The diagnostic value of myocardial perfusion scintigraphy in patients with left bundle branch block (LBBB) and previous acute myocardial infarction has not been evaluated.

Objective: To determine the utility of single photon emission computed tomography (SPECT) in patients with LBBB and previous acute myocardial infarction.

Methods: Seventy two consecutive patients with permanent LBBB and previous acute myocardial infarction were studied with stress-rest SPECT using ^{99m}Tc compounds. The same stress procedures were followed in all patients: (1) exercise alone when it was sufficient; (2) exercise plus simultaneous administration of dipyridamole if exercise was insufficient.

Results: In 26 of 28 patients (93%) who had a Q wave acute myocardial infarct before the development of LBBB, there was concordance between abnormal Q waves and rest SPECT in the localisation of myocardial necrosis ($\kappa = 0.836$; $p = 0.0001$). In 48 patients who had coronary angiography, the positive predictive value of exercise (+dipyridamole) myocardial SPECT for the diagnosis of left anterior descending coronary artery stenosis was 93%, for left circumflex coronary artery stenosis, 96%, and for right coronary artery stenosis, 89%. Specificity values were 83%, 91%, and 69%, respectively. However, sensitivity (69%, 64%, and 89%) and negative predictive values (48%, 46%, and 82%) were suboptimal.

Conclusions: Rest myocardial perfusion SPECT with technetium compounds is useful for localising healed myocardial infarction in patients with LBBB, and exercise (+dipyridamole) SPECT has a high positive predictive value and specificity for the diagnosis of coronary stenosis in these patients.

See end of article for authors' affiliations

Correspondence to:
Dr J Candell-Riera, Servei de Cardiologia, Hospital Universitari Vall d'Hebron, P Vall d'Hebron 119-129, 08035 Barcelona, Spain; jcandell@hg.vhebron.es

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Cumulative results indicate that the specificity of exercise perfusion scintigraphy with ^{201}Tl for the diagnosis of significant stenosis of the left anterior descending coronary artery is low in patients with left bundle branch block (LBBB), ranging between 0–87%.^{1–27} Inclusion of patients with exercise induced LBBB, different methodology (planar v tomographic), and different interpretation criteria (angiographic: 50% v 70% left anterior descending stenosis; scintigraphic: septal v anteroseptal defects; reversible defects v fixed defects) may explain this variability. Althoeffer and colleagues suggested that ^{99m}Tc compounds might be more specific than ^{201}Tl in the evaluation of coronary artery disease in these patients because of the apparent rarity of false positive septal findings.²¹ Good results have been reported using exercise (+dipyridamole) SPECT with technetium compounds both in patients without LBBB and in patients with LBBB and without previous acute myocardial infarction. This prompted us to analyse the same methodology in patients with LBBB plus previous myocardial infarction in order to determine the diagnostic value of this technique.^{28–30}

METHODS

Patients

During the last four years, myocardial SPECT was undertaken in 3258 patients, 72 of whom (mean (SD) age, 65 (13) years, 18 women) had LBBB and previous acute myocardial infarction and were able to exercise. Twenty eight of these had had Q wave acute myocardial infarction when LBBB was not present on their ECG. The electrocardiographic localisation of the abnormal Q waves was eight anterior, 19 inferior, and one lateral. Concordance between rest SPECT and abnormal Q

waves for myocardial infarct localisation was evaluated in this group. Forty eight patients had coronary angiography within less than three months of the scintigraphic study, for clinical purposes. The diagnostic accuracy of SPECT for detecting coronary stenoses of > 50% was studied in this group.

Myocardial SPECT

All patients received an intravenous dose of ^{99m}Tc -tetrofosmin (8 mCi) 30–60 seconds before the end of exercise. Stress images were acquired 15–30 minutes after the administration of the radiopharmaceutical. A 24 mCi dose of ^{99m}Tc -tetrofosmin was given immediately after stress images had been obtained. Rest images were acquired 15–30 minutes after the administration of the radiopharmaceutical.

Images were acquired using an Elscint SP4 scintillation camera, equipped with a high resolution collimator, a semicircular orbit of 180° starting at 30° right anterior oblique position, and with detections every 3°. Reconstruction was done (Butterworth filter, order 5, section frequency 0.4) and short axis, horizontal long axis, and vertical long axis were obtained according to the current recommendations.

Myocardial uptake was assessed by consensus between three experienced observers who were unaware of the results of the ECG and coronary angiography. Five regions were evaluated: anterior, apical, septal, inferior, and lateral. Anterior, septal, and apical regions were attributed to the left anterior descending coronary artery, the lateral region to the circumflex coronary artery, and the inferior region to the right coronary artery. The uptake in each of these regions was assessed as normal, equivocal, mild defect, moderate defect, or severe defect (similar to the background uptake). In order to analyse concordance between abnormal Q waves and SPECT

Table 1 Clinical characteristics and results of exercise testing in patients with and without catheterisation

	With catheterisation (n=48)	Without catheterisation (n=24)	p Value
Age (years)	66 (7)	70 (6)	
Women	11 (23%)	7 (29%)	0.769
Treatment			
β Blockers	15 (31%)	10 (42%)	0.381
Nitrates	36 (75%)	13 (54%)	0.073
Calcium channel blockers	22 (46%)	8 (33%)	0.310
Triple therapy	14 (29%)	1 (4.2%)	0.013
Stress test			
Duration (min)	5.61 (2.0)	5.67 (2.0)	0.900
Watts	50 (37)	45.6 (40)	0.654
METs	4.5 (1.6)	4.7 (2)	0.672
Peak HR (beats/min)	102 (20)	106 (25)	0.500
% predicted HR	68 (17)	69 (21)	0.840
SBP (mm Hg)	154 (27)	164 (33)	0.204
HR × SBP	15 730 (459)	17 614 (614)	0.0001
Angina	20 (41.6%)	1 (4.2 %)	0.001
+ Dipyridamole	22 (45.8%)	5 (20.8%)	0.182

Values are mean (SD) or n (%).
HR, heart rate; SBP, systolic blood pressure.

for the location of previous acute myocardial infarction, the defect at rest was considered to be the site of previous necrosis.

Stress test

The same stress procedures were followed in all patients: (1) exercise alone when this was sufficient (peak heart rate > 80% of the predicted heart rate, > 5 METs, with or without angina); (2) exercise plus dipyridamole if exercise was insufficient (peak heart rate < 80%, < 5 METs, no angina).²⁸

Forty five patients did a symptom limited exercise stress test on a bicycle ergometer, with an initial 50 W load and successive 25 W increments every three minutes until exhaustion, symptoms, or > 2 mm ST segment depression developed. In 27 patients whose peak heart rate was below 80% of the predicted value for their age (220 beats/min minus age in years) and whose oxygen consumption was below 5 METs without angina, intravenous dipyridamole (0.14 mg/kg/min over four minutes) was given while they were still exercising at the maximum tolerated load. Exercise continued until two minutes after the end of the dipyridamole infusion. The administration of dipyridamole was indicated when the first level of exercise was not optimally tolerated by the patient (50 W for a 70 kg adult represents an oxygen consumption level of 4.3 METs). The drug infusion was interrupted if the patient developed angina or > 1 mm ST segment depression.

Catheterisation

Forty eight patients (64%) underwent cardiac catheterisation. The procedure was done using the usual Seldinger technique within three months of the myocardial SPECT study. There were at least four projections (orthogonal 2 × 2) for the left anterior descending coronary artery and two projections (orthogonal) for the right coronary artery. Coronary stenoses were evaluated by two experienced angiographers, and coronary artery disease was considered present if there was > 50% lumen diameter stenosis.

Statistical analysis

The χ^2 test was used to assess the association between categorical variables. The t test for independent samples was used to compare the distribution of continuous variables between two groups. One way analysis of variance was used to compare their distribution between more than two groups of patients. The degree of association between the location of the infarct by ECG and by SPECT was evaluated by a κ coefficient.

Receiver operating curves (<http://www.medcal.be/index.html>) were used to identify the best possible trade off between sensitivity and specificity. According to the results of these curves, sensitivity, specificity, positive and negative predictive values, and global value, with their 95% confidence intervals, were determined using standard criteria. All analysis were undertaken using the SPSS v 7.5 for Windows statistical package.^{31 32}

RESULTS

The patients' baseline characteristics, treatment, numbers to whom dipyridamole was given, and the ergometric indices of those who did and did not have catheterisation are summarised in table 1. Patients who had catheterisation more often had triple therapy, achieved a lower peak heart rate × systolic blood pressure product during stress test, and were more often symptomatic. One vessel disease was present in seven patients, two vessel disease in 22, and three vessel disease in 19. The distribution of the affected vessels was left anterior descending coronary artery in 37 patients, circumflex coronary artery in 35, and right coronary artery in 36.

Eight patients (11%) had a normal SPECT. Localisation of necrosis in rest SPECT images was inferior in 47 patients (65%), anterior in 14 (19%), and lateral in three (4%). In 26 of the 28 patients (92.8%) who had a Q wave acute myocardial infarct before the development of LBBB there was concordance between abnormal Q waves and SPECT in the localisation of the infarct ($\kappa = 0.836$, $p < 0.0001$). Only one patient with previous inferior infarction with abnormal Q waves in the inferior leads had a septal perfusion defect at rest.

According to the results of the receiver operating curves, SPECT was considered positive for left anterior descending, circumflex, and right coronary artery stenoses of > 50% whenever a mild, moderate, or severe defect appeared during stress, irrespective of reversibility at rest in anterior-septal-apical, lateral, and inferior regions, respectively (fig 1). Sensitivity, specificity, and positive and negative likelihood ratios (and their 95% confidence intervals) of SPECT for the diagnosis of stenosis of each coronary artery are summarised in table 2. The best sensitivity was observed for the right coronary artery (94.2%) and the best specificity for the circumflex artery (91.6%), although the specificity of left anterior descending coronary artery was also high, at 83.3%. Positive predictive value was high for the three arteries (92.5% for the

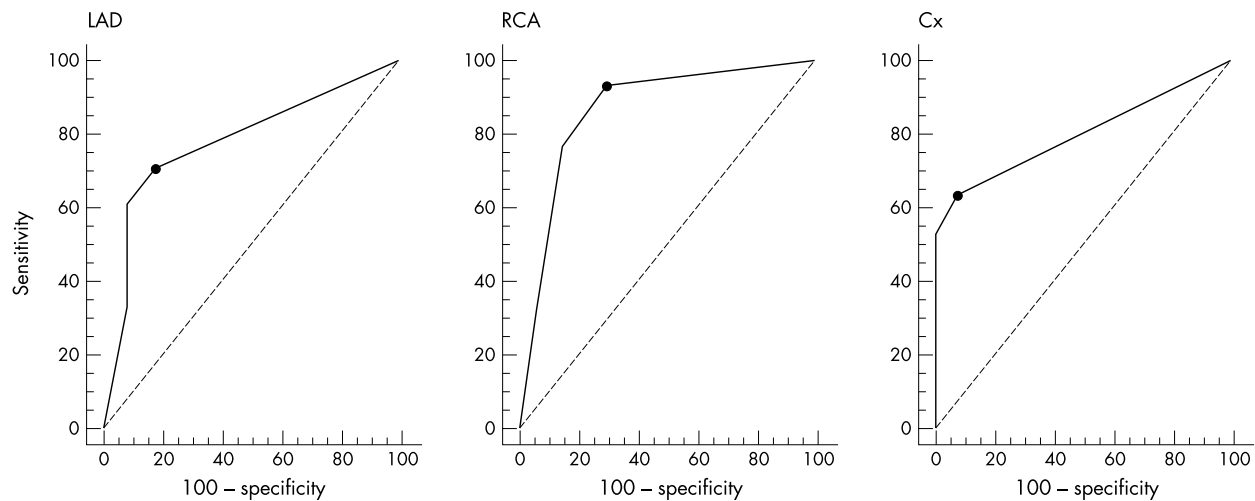


Figure 1 Identification of the best possible trade off (black point) between sensitivity and specificity of myocardial perfusion SPECT for the diagnosis of > 50% stenosis of the left anterior descending coronary artery (LAD), the right coronary artery (RCA), and the left circumflex coronary artery (Cx) by means of receiver operating curves.

left anterior descending artery, 95.8% for the circumflex artery, and 89.2% for the right coronary artery), but negative predictive value was low for the left anterior descending artery and the circumflex artery (47.6% and 45.8%, respectively).

DISCUSSION

The value of myocardial perfusion SPECT in patients with LBBB and previous acute myocardial infarction has not been evaluated before. In this study we assessed the concordance between rest myocardial SPECT and the ECG in localising necrosis in patients who had had acute myocardial infarction before developing LBBB; and we assessed the accuracy of SPECT in the diagnosis of coronary artery stenosis in patients with LBBB and previous infarction.

Although some reports have suggested that atypical characteristics of the QRS complex such as Q or S waves in V6 during LBBB support the diagnosis of myocardial infarction, the diagnostic accuracy of the ECG is very low and location of necrosis in patients with LBBB is impossible in the majority of cases.^{33 34} The left bundle branch has a dual blood supply in 50% of patients (atrioventricular nodal artery from the right coronary artery and septal branch from the left anterior descending coronary artery), but Lie and colleagues reported a high incidence of LBBB in patients with inferior wall infarction, suggesting that frequently the main arterial system of the left bundle was supplied by the right coronary artery. In our series an inferior localisation of necrosis was also clearly predominant: 67% (18/27) in patients with acute myocardial infarction before the development of LBBB, and 65% (47/72) in rest SPECT images.^{35 36} The concordance between the ECG location and the SPECT location of necrosis in patients who had had acute myocardial infarction before LBBB was of 92.8% ($\kappa = 0.836$, $p = 0.0001$), indicating good accuracy of SPECT for localising necrosis in patients with LBBB. Only one

patient with previous inferior infarction had a septal perfusion defect at rest. Thus in our series the presence of false anteroseptal defects in patients with LBBB and without anterior infarction was very infrequent.

Exercise induced ECG changes are recognised as non-invasive indicators of myocardial ischaemia, but the specificity of the exercise ECG is dependent upon the normality of the resting ECG. Thus exercise induced ECG changes do not facilitate detection of ischaemia in patients with LBBB.³⁷ Exercise myocardial perfusion SPECT has been proposed for these patients, but anteroseptal false positive perfusion defects can occur. The demonstration of residual ischaemia in patients with previous acute myocardial infarction—whether at a distance or in the same region of the infarct—is of considerable prognostic value, but the value of myocardial perfusion SPECT for diagnosing significant coronary stenosis in patients with LBBB and previous acute myocardial infarction has not been reported before.

Because some investigators have found improved specificity with technetium compounds and the use of dipyridamole in patients with LBBB, in our study we analysed the accuracy of exercise (+dipyridamole) perfusion SPECT in patients with LBBB and previous myocardial necrosis in the diagnosis of coronary artery stenosis.^{13 18 20-24}

In our series, positive predictive values of exercise (+dipyridamole) SPECT perfusion scintigraphy were 93% for left anterior descending coronary artery stenosis of > 50%, 96% for circumflex coronary artery stenosis, and 89% for right coronary artery stenosis; specificity values were 83%, 92%, and 69%, respectively. The high specificity for the left anterior descending artery—in contrast to that reported in patients with LBBB but without previous acute myocardial infarction—could be explained by the fact that inferior acute myocardial infarction and LBBB together would probably result in a severe defect in

Table 2 Results of exercise (+dipyridamole) SPECT in patients with left bundle branch block and previous acute myocardial infarction

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	GV (%)
LAD	69.4 (53.1 to 82.7)	83.3 (54.9 to 97.1)	92.5 (77.6 to 98.7)	47.6 (27.3 to 68.5)	72.9 (52.1 to 84.0)
Cx	63.8 (47.4 to 78.2)	91.6 (65.2 to 99.6)	95.8 (81.1 to 99.8)	45.8 (26.9 to 65.6)	70.8 (56.8 to 82.3)
RCA	94.2 (82.3 to 99.0)	69.2 (41.3 to 89.4)	89.2 (75.9 to 96.4)	81.8 (51.7 to 96.8)	87.5 (51.7 to 96.8)

Values in parentheses are 95% confidence intervals.

Cx, circumflex coronary artery; GV, global value; LAD, left anterior descending coronary artery; NPV, negative predictive value; PPV, positive predictive value; RCA, right coronary artery; SBP, systolic blood pressure.

the inferior region on SPECT, and fewer septal false positives from the bundle branch block.

However, the sensitivity and negative predictive value of exercise (+dipyridamole) myocardial perfusion SPECT were suboptimal for the left anterior descending artery (69% and 48%, respectively) and the circumflex artery (64% and 46%). Several factors could explain these results:

- the low peak oxygen consumption (4.5 METs) and low myocardial oxygen consumption (68% of predicted heart rate and peak heart rate \times maximum systolic blood pressure product of 15 730) in symptomatic medically treated patients (41% had angina during stress)
- dipyridamole and tetrofosmin may underestimate the presence of coronary artery disease because of the rapid rate of the tetrofosmin extraction fraction during high flow states
- the low capacity of myocardial perfusion SPECT to detect not only the most severe stenoses but all coronary stenoses
- the low capacity of myocardial perfusion SPECT to detect ischaemia at a distance in the presence of necrosis in a particular region; low sensitivity of myocardial scintigraphy for diagnosing multivessel disease in patients with previous acute myocardial infarction has also been reported in previous studies of patients without LBBB.³⁸⁻⁴⁰

We conclude that resting myocardial perfusion SPECT with technetium compounds is useful for localising healed myocardial necrosis in patients with LBBB, and that exercise (+dipyridamole) SPECT has a high positive predictive value and specificity for the diagnosis of coronary stenosis in patients with LBBB and previous acute myocardial infarction.

Authors' affiliations

J Candell-Riera, G Oller-Martínez, C Santana-Boado, J Soler-Soler, Department of Cardiology, Hospital Universitari Vall d'Hebron, Barcelona, Spain
O Pereztol-Valdés, J Castell-Conesa, S Aguadé-Bruix, M Soler-Peter, M Simó, Department of Nuclear Medicine, Hospital Universitari Vall d'Hebron

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