

Increased redistribution of ^{99m}Tc -MIBI under the action of nitrate administration — a good tool for detection of myocardial vitality in patients with severe CAD

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Abstract

BACKGROUND: The purpose of the study was to investigate and assess patients with severe, coronarographically documented coronary artery disease (CAD), previous myocardial infarction and left ventricular dysfunction, using radionuclide method for myocardial perfusion scintigraphy with ^{99m}Tc -MIBI and nitrate administration for detection of viable myocardium.

MATERIAL AND METHODS: We investigated 56 patients (37 male, 19 female, mean age 58 ± 8 years) with CAD and previous myocardial infarction, mean EF $38\% \pm 12$; divided into 2 groups: Group I — 28 patients, investigated at rest, i.v. injected 370 MBq ^{99m}Tc -MIBI, scintigraphy performed at 30 min and 4th hour; Group II — 28 patients, investigated at rest, i.v. injected 370 MBq ^{99m}Tc -MIBI, scintigraphy performed at 30 min, immediately after that administration of 20 mg Isosorbidinitrate

per os and delayed scintigraphy at 2nd and 4th hour. Myocardial SPECT imaging using Siemens Diacam with semiquantitative analysis of acquisition data was performed.

RESULTS: The results established significant but low tracer redistribution in Gr. I, mean redistribution $17.5\% \pm 5.6$. After nitrate administration (Gr. II) we detected increased tracer redistribution, mean $30.4\% \pm 7.8$. The redistribution is higher at the 4th hour, compared to that obtained at 2nd hour after injection. Comparison of the results before and after PTCA showed sensitivity and specificity 93% and 67% respectively.

CONCLUSION: It is concluded that after nitrate administration ^{99m}Tc -MIBI redistribution enhances noticeably and may play a feasible role in detection of viable myocardium in patients with severe CAD.

Key words: ^{99m}Tc -MIBI myocardial scintigraphy, myocardial vitality, nitrate administration

Introduction

Assessment of myocardial vitality is important for the diagnosis, staging and management of patients with severe coronary artery disease (CAD) concerning the benefit from coronary bypass graft (CABG) or percutaneous transluminal coronary angioplasty (PTCA). The myocardial vitality detection, obtained with ^{99m}Tc -MIBI under rest condition, established discordant results. In most studies, MIBI has been shown to substantially underestimate the amount of viable myocardium. Some authors [1–4] reported that ^{99m}Tc -MIBI undergoes low but significant redistribution, which may be used in the detection of myocardial vitality. These publications allow Maurea et al. [5, 6] to employ rest-redistribution technique using ^{99m}Tc -MIBI for recognition of viable myocardium.

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Other authors apply nitrates in 2-day protocol for detection of viable myocardium [7–9].

The aim of this study is to investigate and assess patients with severe, coronarographically documented CAD and left ventricular dysfunction, using radionuclide method with ^{99m}Tc -MIBI in 1-day protocol and single tracer injection, registering enhanced redistribution of the tracer under the action of nitrate administration as a tool for myocardial vitality detection.

Material and methods

Study population

We investigated 56 patients (37 males, 19 females with mean age 58 ± 8 years), with coronarographically documented CAD: 1-vessel disease 18, 2-vessel disease 26, 3-vessel disease 12. At least one area of wall motion abnormality was present in all cases and mean left ventricular ejection fraction (LVEF) was $38\% \pm 12\%$ assessed echocardiographically. All patients had previously had clinically documented myocardial infarction.

The patients were advised to withdraw cardiac medications at least 24 hours before imaging and had overnight fast.

Study protocol

All the patients were divided randomly into 2 groups. Data of the first group were used to validate the literature data for ^{99m}Tc -MIBI redistribution, while data of the second group were used to verify the feasibility of the method for clinical purposes: I group ($n = 28$) — 1-vessel disease 8 patients, 2-vessel disease 14, 3-vessel disease 6; mean LVEF $38\% \pm 5\%$ were investigated at rest, applying 370 MBq ^{99m}Tc -MIBI (kit Polatom) i.v. Early scintigraphy was performed 30 min later and delayed scintigraphy was obtained 4 hours post injection for tracer redistribution registration. II group ($n = 28$) — 1-vessel disease 10 patients, 2-vessel disease 12, 3-vessel disease 6, mean LVEF $39\% \pm 6\%$ patients were investigated at rest, applying 370 MBq ^{99m}Tc -MIBI i.v. Early scintigraphy was performed 30 min later. Right after that each patient received 20 mg. Isosorbiddinitrate per os. Delayed scintigraphies were fulfilled 2 hours and 4 hours after injection. All of the patients underwent PTCA and were investigated again 2 months after that.

Imaging and processing

Myocardial SPECT imaging was performed using single head Siemens Diacam gamma camera with high resolution low-energy collimator. A 180° elliptical body counter acquisition beginning at the 45° RAO was performed in 32 frames of 30 s each. Transaxial slices were automatically reoriented by a computer program to obtain oblique angle tomograms parallel to the long and short axes of LV. Polar maps were generated in division of LV into 9 regions: anterior, anterosseptal, septal, inferoseptal, inferior, inferolateral, lateral, anterolateral and apical region. Each region except the apical, was further subdivided in proximal and distal segments. Segmental ^{99m}Tc -MIBI activity was analysed semi-quantitatively (Siemens Quantitative Heart Application): in each tomographic study the point with the maximal tracer activity was used as the 100% reference. Tracer uptake in all myocardial segments was then expressed as a percentage of the activity measured in the reference point. For the purpose of the present study, the scintigraphic results were made and compared in the early and delayed scintigraphies. Segments with reduced tracer activity were defined as

hypoperfused. Segments with increased activity on the delayed scintigraphy of more than 10% [6] were considered reversible (viable) — completely reversible (reaching normal perfusion) and partially reversible (improving the perfusion with more than 10% but not yet normal) and these without increasing of activity (less than 10%) — fixed or nonviable. The results were compared with those after PTCA.

Statistical analysis

All data are expressed as mean values \pm standard deviation. Student's *t* test was used and a *P* value of less than 0.05 was considered significant. For the purpose of the present study, scintigraphic (sc.) results were considered true viable if hypoperfused reversible segments showed improved perfusion after PTCA.

Results

Group I: A total of 404 myocardial segments were analysed, from which 235 were normally perfused and 169 — hypoperfused on the early scintigraphy (sc.). On the delayed scintigraphic (sc.) 35 (21%) segments showed complete reversibility, 88 (52%) were partial reversible and 46 (27%) — fixed. Mean redistribution in the reversible segments was $17.5\% \pm 5.6$; $p < 0.001$ and in fixed defects respectively $2.3\% \pm 2.4$; $p > 0.05$.

Group II: On the early sc. we estimated 404 myocardial segments, from which 223 were normal and 181 were hypoperfused. On the delayed sc. 2 hours later 38 (21%) segments showed complete reversibility, 62 (34%) were partially reversible and 81 (45%) were fixed. Mean tracer redistribution was $27.8\% \pm 8.1$. On the delayed sc. 4 hours after tracer injection we obtained complete reversibility in 72 (40%) hypoperfused segments, partial reversibility in 71 (39%) and 38 (21%) fixed defects. From 81 fixed defects established at the 2nd hour, 41 (51%) showed increased tracer activity at the 4th hour and were considered as reversible. Mean tracer redistribution in the reversible segments was $30.4\% \pm 7.8$; $p < 0.001$ and in the fixed defects $2.3\% \pm 2.4$; $p > 0.05$.

A total of 43 hypoperfused segments were registered in vascular territories with significant but noncritical stenosis, assessed coronarographically. Mean tracer activity in these segments was $52.7\% \pm 5$. A total of 37 (86%) hypoperfused segments were reversible/viable after nitrate administration and 6 (14%) were fixed. A total of 138 hypoperfused segments were registered in vascular territories with critical stenosis or occlusion. Mean tracer activity was $38\% \pm 12$. A total of 106 (77%) segments were reversible and 32 (23%) — fixed (Fig. 1, 2).

After undergoing PTCA we detected significantly improved perfusion in 129 reversible hypoperfused segments — true viable segments, lack of improvement in 14 reversible segments — false positive results; without change in perfusion in 29 fixed defects — true negative and in 9 of fixed defects improved perfusion was observed — false negative results according to the scintigraphy. Systolic function assessed echocardiographically indicated LVEF laying in the range 44–72%, mean $56\% \pm 7\%$.

Discussion

The role of ^{99m}Tc -MIBI in the evaluation of myocardial vitality has been the subject of some debate [10–13]. The findings have been confirmed that rest injection of ^{99m}Tc -MIBI underestimates viable

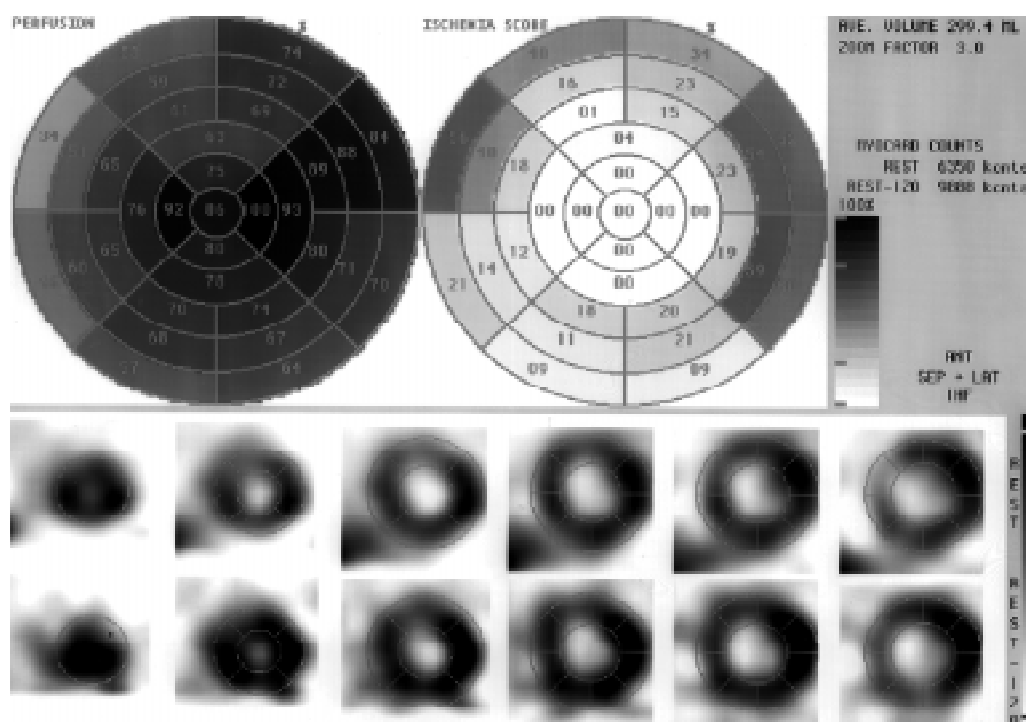


Figure 1. Patient with 80% stenosis of LAD, 50% stenosis of RCA. Hypoperfusion of anterior, septal and inferior segments; reversible on the delayed scintigraphy. After PTCA — viable myocardium.

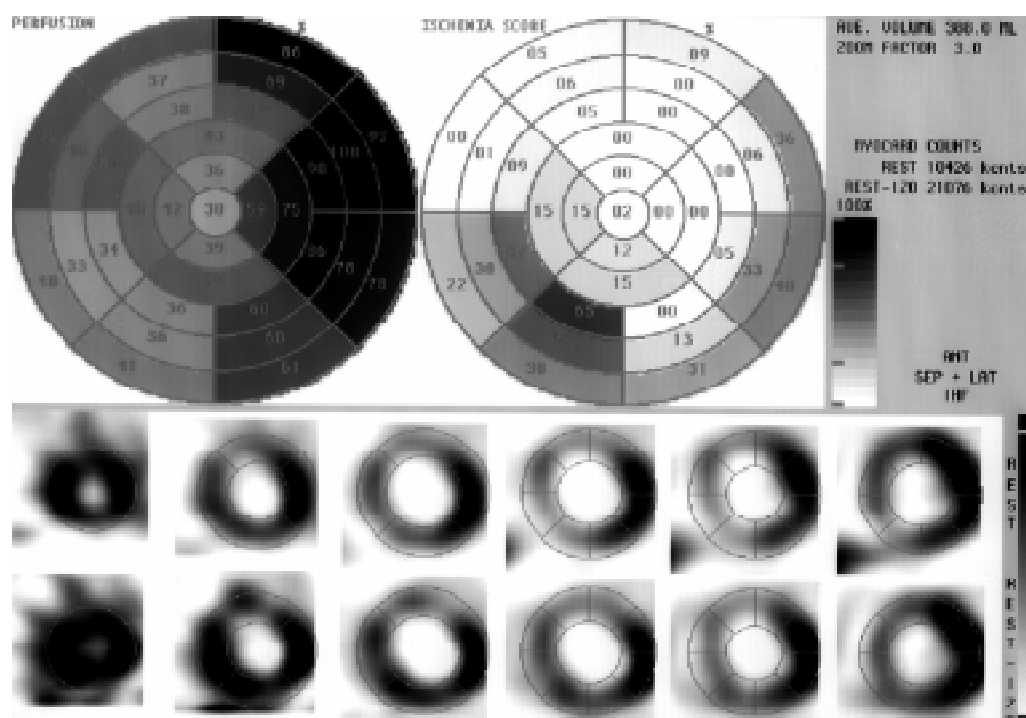


Figure 2. Patient with occlusion of LAD, 80% stenosis of RCA and 55% stenosis of LCx. Reversible hypoperfusion of inferoapical, inferoseptal and inferior segments and fixed defect in the anteroapical and anteroapical area. After PTCA — improved perfusion in the reversible hypoperfused segments and lack of improvement in the fixed defect.

tissue in about 30–50% of segments. On the other hand Bonow et al. [10] reported that only 3–6% of segments with MIBI uptake < 30% were assessed as viable by PET imaging and 92% of seg-

ments with MIBI uptake > 70% showed viable tissue on PET while Claeys et al. [13] conclude that the mean tracer activity up to 50% accurately separates viable from nonviable myocardium. The data

Table 1. Comparison of the results obtained in Group I and II

Groups	Reversible segments	Compl. revers. segments	Fixed defects	Mean redistribution
Group I	73%	21%	27%	17.5% \pm 5.6
Group II— 2 h	55%	21%	45%	27.8% \pm 8.1
Group II— 4 h	79%	40%	21%	30.4% \pm 7.8

are different and contradictory. In order to improve the results Maurea et al. [5] employ rest-redistribution MIBI sc. as well as [7–9] performed baseline-nitrate MIBI perfusion myocardial sc. for recognition of viable myocardium.

The publications of Lie et al. [1] and Richter et al. [3], who registered a significant MIBI redistribution and the mechanism of nitrate action which dilates stenosed coronal vessels and improves the perfusion in the ischemic area, encouraged us to apply a method for registration of the enhanced MIBI redistribution under the action of nitrate administration using 1-day protocol and single tracer injection.

The results of Group I confirmed the literature data for MIBI redistribution. We detected low but significant tracer redistribution — mean value $17.5\% \pm 6.0$; $p < 0.001$.

The analysis of results in Group II showed increased redistribution under the action of nitrates- mean redistribution at 2nd hour $27.8\% \pm 8.1$ and redistribution at 4th hour $30.4\% \pm 7.8$; $p < 0.001$. The comparison of the values of redistribution in Group I ($17.5\% \pm 6.0$) and Group II (30.4 ± 7.8) revealed significant difference — $p < 0.001$. The comparison of results, obtained on the delayed sc. at the 2nd and 4th hour after tracer application demonstrates higher redistribution at the 4th hour. From a total of 81 fixed defects as defined at the 2nd hour, 43 (53%) improved their activity at the 4th hour and were accepted as reversible. The data suggest the preferable time for investigation at 4th hour. The comparison of the results in the two groups can be seen in Table 1.

The comparison of the results obtained before and after PTCA confirmed that the enhanced MIBI redistribution under the action of nitrate administration is a good tool for myocardial vitality detection. The segments showing tracer activity $> 50\%$ may be accepted as viable, but when the tracer activity is lower, the determination of viable myocardium is difficult or even impossible. The nitrate administration suggests the possibility for distinguishing the viable from non-viable tissues when the myocardial perfusion is less than 50%.

The sensitivity and specificity of the method for myocardial vitality detection are 93% and 67% respectively. The following formulas were used for calculation of sensitivity = $TP/(TP + FP)$ and specificity = $TN/(TN + FP)$ where T — true, F — false, P — positive, N — negative. As a standard we used the scintigraphic results after PTCA (perfusion improvement or lack of improvement in hypoperfused segments) and increase of LVEF obtained echocardiographically: TP 129, FP 14, TN 29, FN 9.

Conclusion

We concluded that ^{99m}Tc -MIBI undergoes significant but low redistribution 4 hours after tracer injection. After nitrate administration the redistribution enhances noticeably and is a good tool for identification of hypoperfused but still viable myocardium in patients with severe CAD.

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