

The diagnostic efficacy and safety of stress-only supine and prone myocardial perfusion imaging with a dedicated cardiac gamma camera in patients with suspected or known coronary artery disease

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Abstract

BACKGROUND: Myocardial perfusion scintigraphy remains one of the substantial noninvasive diagnostic methods in coronary artery disease. Recent technological advancement allowed to create novel semiconductor, dedicated cardiac gamma camera with better spatial resolution and higher energy resolution, resulting in the reduction of radiation burden and acquisition time. The aim of this study was to evaluate the efficacy and safety of stress-only supine and prone MPS with a cardiac gamma camera in patients with suspected or known coronary artery disease.

MATERIAL AND METHODS: A total number of 203 consecutive patients with suspected or known coronary artery disease, who underwent MPS were enrolled in the study. The patients without perfusion abnormalities on stress supine and prone MPS scans had no rest MPS, in the remaining patients two-day stress-rest imaging was performed. The group of 160 patients with one-year follow up was subjected to final analysis.

RESULTS: Stress-only protocol of myocardial perfusion imaging was performed in 72 patients, 88 patients underwent two-day stress and rest myocardial perfusion scintigraphy. In 46 out of 72 stress-only group of patients, prone study did not affect further proceedings. However, in over 1/3 of cases (26/72), prone scans resulted in abstaining from rest imaging. One year follow-up revealed no sudden cardiac deaths or myocardial infarctions in both (stress-only and stress-rest) groups. Revascularization was performed most often in the double-positive group — patients with significant ischaemia on myocardial perfusion images and chest pain or electrocardiographic changes or both during the stress test. In this double-positive group, all 11 patients had coronary angiography (two of them prior to myocardial perfusion scintigraphy), nine of them had subsequent revascularization.

CONCLUSIONS: In patients with no significant perfusion abnormalities on stress scans omitting rest study is safe with very good one-year risk prognosis of acute cardiac events and allows to limit the radiation exposure and procedure duration. Additional prone acquisitions are valuable supplements in determining the decision of safe early completion of myocardial perfusion imaging.

KEY words: myocardial perfusion scintigraphy, dedicated cardiac gamma camera

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Introduction

Myocardial perfusion scintigraphy (MPS) is one of the noninvasive cardiac stress tests, which are recommended in diagnosing

coronary artery disease (CAD) in patients with an intermediate pre-test probability of this disease. It remains also one of the substantial diagnostic tools in patients with known CAD. There are different procedure protocols regarding the radiopharmaceutical dose, the number of acquisitions or stress and rest imaging time frame. Routinely acquisitions are performed in the supine position, some centers additionally use prone or upright acquisitions to diminish the attenuation impact on imaging.

Recent technological advancement allowed to create novel semiconductor detector dedicated cardiac gamma camera with

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better spatial resolution and higher energy resolution, resulting in a reduction of radiotracer activity and acquisition time. Introduction of these types of gamma cameras into clinical practice diminished the radiation exposure and shortened the scanning duration.

Stress-only supine/prone protocol allows to electively omit the rest imaging if stress scintigrams reveal no perfusion abnormalities, which reduces the radiation exposure and shorten the procedure time.

The aim of this retrospective analysis was to assess the safety and efficacy of elective stress-only supine/prone myocardial perfusion imaging with dedicated cardiac gamma camera equipped with high-resolution cadmium zinc telluride (CZT) semiconductor detectors.

Material and methods

Two hundred and three consecutive patients with suspected or known CAD who underwent MPS with supine and prone imaging were evaluated. Imaging was performed on Discovery NM 530c gamma camera with CZT semiconductor detectors, acquisition time duration was 5 minutes. The patients were injected with [99mTc] sestamibi, radiopharmaceutical activity was 296–925 MBq (8–25 mCi), depending on body mass index however the majority of patients received 296–370 MBq (8–10 mCi) of [99mTc] sestamibi. The stress test was performed on treadmill according to Bruce or modified Bruce protocol, radiopharmaceutical was injected approximately one minute before finishing the exercise. In case of assumably non-diagnostic exercise test (according to criteria of European Society of Cardiology) or contradictions to exercise on a treadmill, the pharmacological test was performed with either dipyridamole (0.14 mg/kg/min within 4 minutes) or regadenoson (0.4 mg bolus independent of body weight) intravenous injection. The myocardial perfusion scans were acquired approximately one hour post radiotracer injection, the sequence of supine and prone scans was facultative (supine scans were electrocardiographically gated). The myocardial perfusion images were reconstructed with dedicated QPS-QGS software.

Each stress MPS in supine and prone position was assessed by 3 independent experienced physicians and assigned to one of three groups: 1 — no rest MPS needed, 2 — the question of referring clinician probably can be answered with the stress-only examination, but for accurate myocardial perfusion assessment rest imaging should be performed, 3 — rest MPS is definitely required. In case of discrepancy between interpreters, for further clinical proceedings, the consensus was established. If no perfusion defects were visible (defects visible on only supine or prone images were considered as false positive), the stress-only protocol was applied. One year follow-up data were obtained for 160 patients, who were taken under further analysis.

The mean age in the investigated group was 64 years (39–87), over half of the patients were women (86/160). The most frequent risk factors of CAD were hypertension and dyslipidaemia. Forty-eight patients had prior invasive interventions — percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG), 34 of them had a history of myocardial infarction prior to the study (Table 1). The majority of the patients underwent exercise test on treadmill, 18 had pharmacological stress test.

Table 1. Characteristics of study cohorts

	Stress-only	Stress-rest
Hypertension	52	58
Diabetes mellitus	14	32
Smoking	15	21
Dyslipidemia	43	44
Acute coronary syndromes	6	27
Percutaneous coronary interventions	12	33
Coronary artery bypass-grafting	0	3

Results

Stress-only protocol of myocardial perfusion imaging was performed in 72 patients, 88 underwent two-day stress and rest myocardial perfusion imaging. The vast majority of images were of good and very good quality. If any of the scans had no diagnostic value, those examinations were excluded from the study (Figure 1).

The decision whether to omit rest study was made after reviewing both supine and prone images. In 46 out of 72 patients of stress-only group, prone study did not affect further proceedings. However, in over 1/3 of cases (26/72), prone images were decisive whether or not to perform rest study. All of these 26 patients with MPS defects on supine images presented normal perfusion on prone scans and negative follow-up. Detailed results of supine MPS scans in patients concerning the number of abnormal segments are summarized in Figure 2.

In the whole cohort, the agreement between 3 independent physicians in 3-point scale assessment was good with 81% concordance. However, in the stress-only group the agreement was significantly higher with 94% concordance, compared to 70% in the stress-rest group.

One year follow-up revealed no sudden cardiac deaths or myocardial infarctions in both (stress-only and stress-rest) groups. In the stress-only group, despite negative MPS results, 5 out of 72 patients underwent subsequent coronary angiography as the result of clinical outcomes discrepancy. Two of them confirmed the absence of stenoses, another 3 coronary angiograms showed borderline lesions. One patient with 50% stenosis in the left anterior descending artery and normal fractional flow reserve (FFR = 0.88) underwent PCI.

Fifteen patients in stress-only group with obviously negative MPS had a positive exercise stress test due to either chest pain or ischaemic electrocardiographic (ECG) changes or both. No cardiac incidents and interventions occurred during one-year observation in this group.

In the stress-rest group, 27 out of 88 patients had negative MPS (no reversible perfusion abnormalities) — one of them underwent subsequent coronarography, no stenosis was found. In the remaining patients (positive MPS) most of them (34/61) had mild reversible perfusion abnormalities and 27 had significant ischaemia (more than 2 segments of reversible perfusion abnormalities). Thirty-four patients were then subjected to coronary angiography and 6 patients had invasive diagnostics before MPS.

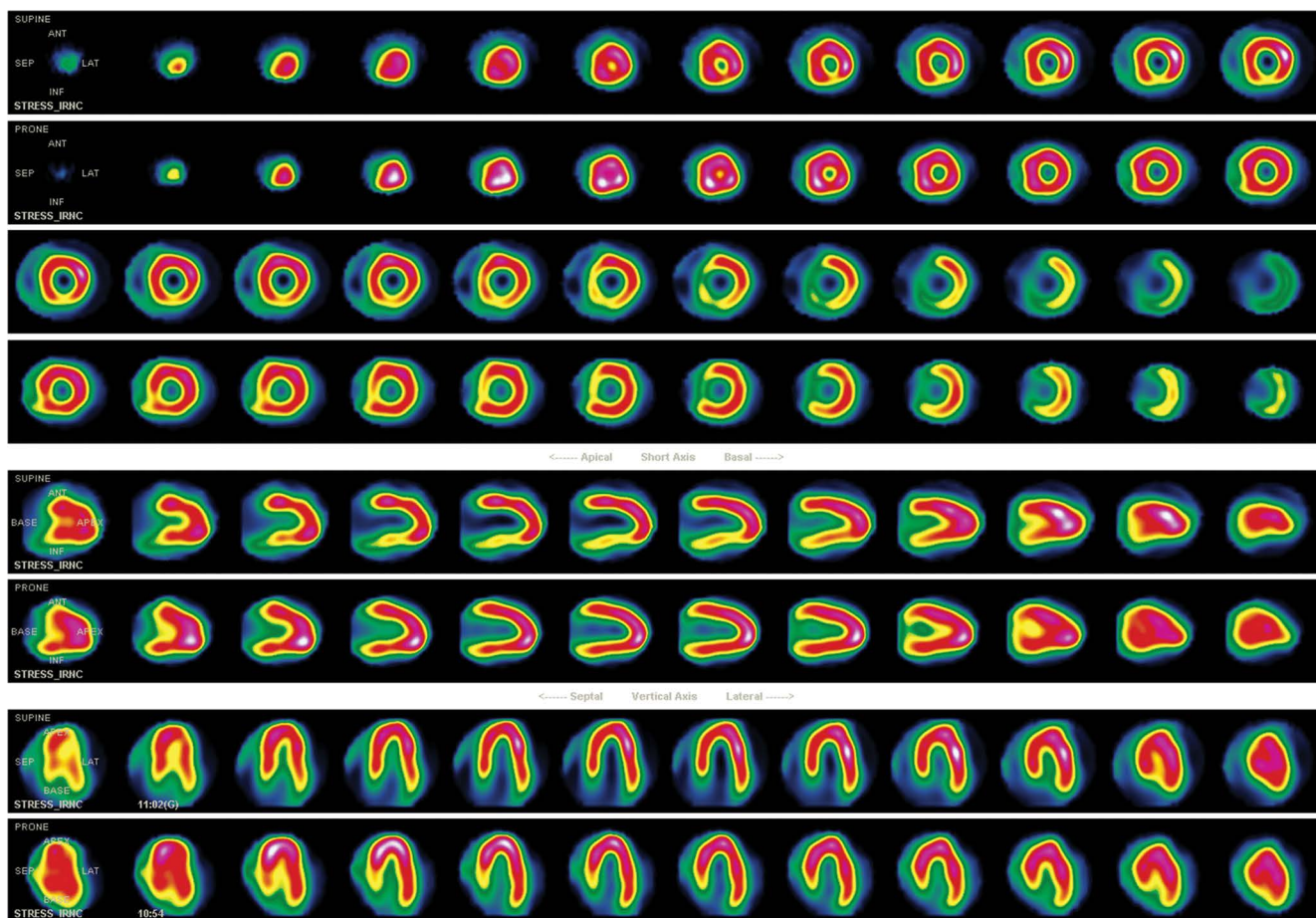


Figure 1. Supine and prone images of the same patient — stress study. Prone acquisitions reveal normal perfusion, which indicates that perfusion abnormalities in inferior wall observed on supine scans are generated by attenuation

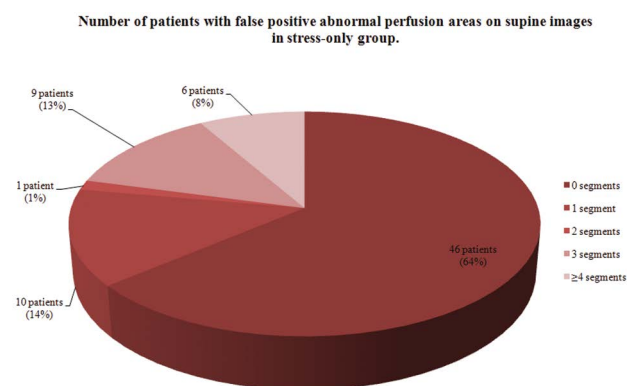


Figure 2. Stress-only patients with the prevalence of false positive perfusion abnormalities

Revascularization was performed most often in the double-positive group — patients with significant ischaemia and chest pain or ECG changes or both during the stress test. In this double-positive group, all 11 patients had coronary angiography (two of them prior to MPS). Nine patients had PCI or CABG, one patient with coronary angiography performed prior to MPS was diagnosed with overlapping

microvascular and vasospastic CAD and had no further invasive intervention.

Surprisingly revascularization rate in group with mild reversible perfusion abnormalities combined with positive treadmill stress test was higher than in group with significant ischaemia and no chest pain or ECG changes during stress test — 45% vs. 38%, respectively. However, these differences were not statistically significant ($p = 0.8$) and groups were not sufficiently large. The statistical significance in the difference of revascularization rate was observed only between groups with significant ischaemia and positive stress test compared to mild perfusion abnormalities and negative stress test ($p = 0.004$) among patients with reversible perfusion abnormalities.

Coronary angiography and revascularization rates in patients with positive MPS are summarized in tables 2 and 3, statistical significance in revascularization rates between groups is summarized in Table 4.

Discussion

Stress only protocol in MPS is known to be safe and efficient diagnostic tool for CAD exclusion. Słomka et al. indicated the improved diagnostic accuracy of myocardial perfusion imaging with

Table 2. A number of coronary angiographies in patients with reversible perfusion abnormalities in myocardial perfusion scintigraphy

	Number of coronary angiographies/patients with reversible perfusion abnormalities	
	Mild perfusion abnormalities	Significant ischaemia
No symptoms in treadmill stress test	10/27 (+7 coronarographies before MPS)	11/16 (+1 coronarography before MPS)
Chest pain or ECG changes or both in treadmill stress test	3/7 (+2 coronarographies before MPS)	9/11 (+2 coronarographies before MPS)

Table 3. A number of revascularized patients with reversible perfusion abnormalities in myocardial perfusion scintigraphy

Revascularization after MPS	Reversible perfusion abnormalities	
	Revascularizations/mild perfusion abnormalities	Revascularizations/significant ischaemia
No symptoms in treadmill stress test	4/27	6/16
Chest pain or ECG changes or both in treadmill stress test	3/7	9/11

Table 4. The statistical significance in revascularization rate between subgroups of patients with positive myocardial perfusion scintigraphy

No symptoms on treadmill + mild perfusion abnormalities	Significant ischaemia + chest pain or ECG changes during treadmill test	p = 0.004
Chest pain or ECG changes during treadmill test + mild perfusion abnormalities	Significant ischaemia + chest pain or ECG changes during treadmill test	p = 0.2
No symptoms on treadmill + significant ischaemia	Significant ischaemia + chest pain or ECG changes during the treadmill test	p = 0.06
Chest pain or ECG changes during treadmill test + mild perfusion abnormalities	No symptoms on treadmill + significant ischaemia	p = 0.8

conventional gamma cameras and two-position prone-supine protocol by resolving of subtle attenuation artifacts [1]. Edenbrandt et al. reported 6-year cardiac event rate lower than 1% in patients with normal stress SPECT on a large number of patients [2]. However, in this study different scanner (conventional dual-detector gamma camera), radiopharmaceutical and stress protocols were employed. Yokota et al. reported similar prognostic value of stress-only CZT scanner imaging compared to conventional stress-only MPS, but the whole group of patients underwent pharmacological stress test [3]. In our study, the majority of patients were subjected to exercise stress test on a treadmill, with no history of cardiac events prior to the study in the stress-only group. The high correlation between observers in the estimation of this group indicates low observer-dependence.

Data from the limited literature [4, 5] and our earlier observations [6] indicated that MPS in the prone position may diminish the attenuation impact on imaging in a relevant number of patients. Godo et al. demonstrated better assessment of inferolateral wall of left ventricle performing supine-prone vs supine-only imaging with CZT gamma camera, which improved specificity (93% vs. 72%, respectively) and accuracy (88% vs. 74%, respectively) without compromising high sensitivity (82% vs. 68%, respectively) [4]. Nishiyama et al. showed greater prone over supine stress MPS specificity (77% vs. 50%, respectively) with congruent sensitivity (80% vs. 78%, respectively) on CZT gamma camera in detecting significant coronary artery stenoses in coronary angiography [5]. The per-vessel analysis revealed a similar tendency in supine and prone MPS with better specificity in prone imaging. The authors concluded that combined supine and prone imaging had

high diagnostic accuracy in detecting significant CAD comparing with coronary angiography.

In our study, all patients underwent both supine and prone imaging, what remains the standard procedure in the routine practice in our Nuclear Medicine Department. In stress-only group over one-third of patients had minor perfusion abnormalities in supine study, which were not observed on prone scans. Performing additional prone imaging allowed us to avoid rest study and thus significantly decreased the radiation exposure and shortened the procedure duration.

Standard exercise stress test is positive if typical chest pain or ischaemic ECG changes or both are observed. The sensitivity and specificity of such tests are estimated to be about 45–50% and 85–90% respectively, with lower sensitivity and specificity in women (according to ESC guidelines) [7]. On the other hand, as stated above, negative exercise stress MPS corresponds with cardiac event rate less than 1%. In our study, the 15 patients had a positive exercise test and negative MPS and underwent stress-only protocol. In this group chest pain and ischaemic ECG changes during the test had no influence on clinical outcomes. However positive MPS correlated with chest pain and/or typical ischaemic ST depression correlated more often with invasive coronary interventions than positive MPS alone.

Conclusions

Supine-prone myocardial perfusion imaging with cardiac CZT gamma camera is efficient and has diagnostic and prognostic value in CAD. In patients with no significant perfusion

abnormalities omitting rest study is safe with excellent one-year risk prognosis of acute cardiac events and allows to limit the radiation exposure and procedure duration. Additional prone acquisitions in stress-only protocol are valuable supplements in determining the decision of safe early completion of myocardial perfusion imaging.

References

1. Slomka PJ, Berman DS, Germano G. New Imaging Protocols for New Single Photon Emission CT Technologies. *Curr Cardiovasc Imaging Rep.* 2010; 3(3): 162–170, doi: [10.1007/s12410-010-9021-0](https://doi.org/10.1007/s12410-010-9021-0), indexed in Pubmed: [20461125](https://pubmed.ncbi.nlm.nih.gov/20461125/).
2. Edenbrandt L, Ohlsson M, Trägårdh E. Prognosis of patients without perfusion defects with and without rest study in myocardial perfusion scintigraphy. *EJNMMI Res.* 2013; 3: 58, doi: [10.1186/2191-219X-3-58](https://doi.org/10.1186/2191-219X-3-58), indexed in Pubmed: [23902737](https://pubmed.ncbi.nlm.nih.gov/23902737/).
3. Yokota S, Mouden M, Ottervanger JP, et al. Prognostic value of normal stress-only myocardial perfusion imaging: a comparison between conventional and CZT-based SPECT. *Eur J Nucl Med Mol Imaging.* 2016; 43(2): 296–301, doi: [10.1007/s00259-015-3192-5](https://doi.org/10.1007/s00259-015-3192-5), indexed in Pubmed: [26392197](https://pubmed.ncbi.nlm.nih.gov/26392197/).
4. Goto K, Takebayashi H, Kihara Y, et al. Impact of combined supine and prone myocardial perfusion imaging using an ultrafast cardiac gamma camera for detection of inferolateral coronary artery disease. *Int J Cardiol.* 2014; 174(2): 313–317, doi: [10.1016/j.ijcard.2014.04.069](https://doi.org/10.1016/j.ijcard.2014.04.069), indexed in Pubmed: [24768390](https://pubmed.ncbi.nlm.nih.gov/24768390/).
5. Nishiyama Y, Miyagawa M, Kawaguchi N, et al. Combined Supine and Prone Myocardial Perfusion Single-Photon Emission Computed Tomography With a Cadmium Zinc Telluride Camera for Detection of Coronary Artery Disease. *Circulation Journal.* 2014; 78(5): 1169–1175, doi: [10.1253/circj.cj-13-1316](https://doi.org/10.1253/circj.cj-13-1316).
6. Piszczek S, Dziuk M, Giżewska-Krasowska A, et al. Inferior wall attenuation artifact on CZT gamma camera. Is prone imaging better than stand-alone CT attenuation correction (CTAC)? *Eur J Nucl Med Mol Imaging.* 2013; 40(Suppl 2): S1–S477.
7. Montalescot G, Sechtem U, Achenbach S, et al. Task Force Members, ESC Committee for Practice Guidelines, Document Reviewers. 2013 ESC guidelines on the management of stable coronary artery disease: the Task Force on the management of stable coronary artery disease of the European Society of Cardiology. *Eur Heart J.* 2013; 34(38): 2949–3003, doi: [10.1093/eurheartj/ehz296](https://doi.org/10.1093/eurheartj/ehz296), indexed in Pubmed: [23996286](https://pubmed.ncbi.nlm.nih.gov/23996286/).