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Myocardial Perfusion Imaging in Diagnosis of Culprit Lesion in Patients Undergoing Elective Percutaneous Coronary Intervention

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1. Introduction

Myocardial perfusion imaging (MPI) was developed in the 1970s and has been used increasingly in clinical cardiology since the 1980s (Underwood et al., 2004). Technical developments that have fuelled this recent increases are single-photon emission computed tomography (SPECT) imaging, pharmacological stress and ECG-gated SPECT imaging. MPI comprises the only widely available method of assessing myocardial perfusion directly and many previously published reports support its evidence in the diagnosis of myocardial ischemia and necrosis. Moreover, the prognostic value of this method for patients' risk stratification has already been extensively reported, with an incremental prognostic value after clinical assessment, exercise electrocardiography and even above coronary angiography. Thus, MPI is an established imaging technique that is already an integral part of the management of coronary artery disease (CAD) (diagnosis, prognostication, selection for revascularization and assessment of acute coronary syndromes) and is included in a number of professional guidelines. (1, 2)

In the past two decades, a great body of literature has established the use of nuclear imaging for risk stratification in patients with known or suspected CAD. Risk stratification is of crucial importance for the practice of contemporary medicine. Extending the paradigm of noninvasive cardiac testing beyond the detection of disease is especially important, may risk assessment permits patients who are identified as being at a high risk for subsequent cardiac events should receive aggressive management, possibly including cardiac catheterization for potential revascularization procedures that may improve their outcome. Conversely, the management focus in patients with low future event rate should be shifted toward risk factor modification and aggressive medical therapy, reserving invasive procedures for

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patients who fail medical management. CAD is disease with a wide spectrum of severity and extent with outcome, such as nonfatal myocardial infarction (MI) or cardiac death being related to the severity of disease. Clinical trials have shown that patients with severe CAD as left main coronary artery disease, especially those with left ventricular dysfunction, can benefit from coronary artery bypass graft surgery (CABG) with significant reduction in their mortality rate (1, 2, 3). Whereas patients with single-vessel or with two-vessel disease (without proximal left anterior descending artery involvement) would have improved symptoms of angina following CABG and percutaneous transluminal coronary angioplasty with or without stent implantation, without any effect on their mortality rate.

Risk assessment based on clinical finding and resting ECG only is limited. Exercise testing can also help, especially when examining the patient's functional capacity. Exercise-induced ECG changes and risk indices also have substantial prognostic value. Unfortunately most patients (55%) with suspected CAD would fall in an intermediate-risk group, necessitating additional risk stratification.

Coronary angiography, considered the "gold standard" for the diagnosis of CAD, often does not provide information about the physiologic significance of atherosclerotic lesions, especially in borderline lesions. More importantly, it does not provide a clear marker of risk of adverse events, especially in patients with moderate disease severity. Andreas Gruentzig said; "*When coronary angiography founded coronary artery disease, I would like to have diagnostic procedure who will give me functional significance that lesion.*"(2, 3, 4, 5)

2. Risk based on nuclear imaging results

Determination culprit lesion

The current definition of culprit lesion; that is zone of ischemia under the coronary stenoses (what degree?) That is not quite good definition. Some autors offer degree of coronary stenoses ≤ 70 %, some ≤ 75%, even < 80-85%) but is not quite wright, because that is not definy two pathophysiologic aspects of ischemia; severity and extent. Ladenhaim et al. have also shown that the magnitude of ischemia (severity and extent) correlates well with cardiac events. Some other autors shown correlation between event rate (death, nofatal IM and revascularization) and extent of ischemia demonstrated by the number of ischemic segments on SPECT scan. Iskander and Iskadrian have also shown that defects reversibility is an important predictor of type of cardiac events, whereas reversible perfusion defects are associated with nonfatal MI. This is very important finding, since a reversible defect on the myocardial perfusion imaging (MPI) by single photon-emission computed tomography (SPECT) is the only available diagnostic tool that can independently predict the risk of nonfatal MI. Therefore, stress perfusion studies should be reported documenting defect severity (mild, moderate, severe), size (small, moderate, large) and reversibility to provide essential risk stratification (2, 4, 5, 6).

The value of MPI comes from the ability to identify and quantify the degree of jeopardized myocardium during stress tests. The size and severity of the perfusion abnormality provide powerful prognostic information and has been shown to directly relate to outcome. SPECT perfusion imaging and determination of culprit lesion is more predicitble of cardiac events than coronary angiography. As SPECT imaging may identify those patients at high risk for subsequent cardiac events, perfusion imaging may be used to help guide further testing and revascularization procedures, and this obviously has important cost-effectiveness ramifications.

The primary objective of those study was to determinate and localizes culprit lesion by knew introduce parameters SRS (*summary reversible score*) and ISRS (*index of summary reversible score*), under the angiographically detected coronary narrowing ≥75% for the least one coronary artery (2, 14).

A welt of literature supports the use of MPI for risk stratification in patients with known or suspected CAD. The ability of SPECT imaging to localize and define the culprit lesion (extent/severity) of disease predicts subsequent cardiac events such as MI or cardiac death. Furthermore, specific applications of these nuclear cardiology techniques, such as post infarction or in patients with unstable angina, have also successfully assessed risk of cardiovascular events. The prognostic applications of perfusion imaging are germane to all health care providers, as these methods may be used to guide subsequent tests and treatments. MPI has significantly impact on patient management decisions and the cost-effective utilization of health care.

The rapid rate of technical advances and improved operator expertise has enabled this technique to gain more widespread application. Despite the large number of PTCA performed yearly, preprocedure documentation of myocardial ischemia is uncommon, occurring in only 29% of patients. Despite the obvious value of nuclear cardiology to detect, localize, and define the extent of ischemia, this procedure appears underutilized before performance of percutaneous intervention. It is unclear whether this reflects an under utilization of noninvasive methods to objectively justify the performance of PTCA or whether the addition of such techniques is considered superfluous.

Myocardial perfusion imaging provides information on the extent and location of myocardial ischemia. The assessment of jeopardized myocardium may be performed and provides a measure of the relative value of PTCA in terms of the amount of jeopardized myocardium. The location of the stenosis may dictate the area at risk: extent and severity of perfusion defects were significantly smaller in patients with proximal compared with distal coronary artery occlusions (2, 14).

Before revascularization is performed, myocardial perfusion imaging may assist in management decisions by demonstrating the presence of myocardial ischemia, viability and delineating the severity and extent of coronary artery disease. The significance of equivocal lesions may be determined and culprit vessel may be successfully defined by SPECT imaging before angioplasty.

The aim of this study was to determinate and localizes culprit lesion by myocardial perfusion imaging (MPI), under the angiographically detected coronary narrowing ≥75% for the least one coronary artery. One hundred thirty-two (132) patients with known coronary artery disease (CAD) were studied. In all of them angiographically detected significant coronary narrowing (≥75% luminal stenosis for the least one coronary artery). Al patients submitted MPI ^{99m}Tc-MIBI, with pharmacologic adenosine stress protocol with concomitant low level bicycle exercise 50W **(AdenoEX)**. We were measured relative uptake ^{99m}Tc-MIBI for each myocardial segment using short-axis myocardial tomogram study. A 5-point scoring system was used to assess difference between uptake degree in stress and rest studies for the same segments, and we were created two index; Sum reversibility score (SRS), Index of sum reversibility score (ISRS). **Results:** A total of 396 vascular territories (2244 segments) were analyzed before elective percutaneous coronary intervention (ePCI). Overall sensivity, specificity, and accuracy using SS were 90.2%, 87.5%, 89.4%, with positive predictive value 94, 1%. Overall sensitivity, specificity, and accuracy using ISRS were 94.4%,

90.6%, 93, 2%, with positive predictive value 95, 7%. Conclusion: MPI with two created index SRS and ISRS significantly improves sensitivity, specificity, and accuracy for determination culprit lesion in patients undergoing PCI. **Conclusion:** AdenoEX MPI significantly improves sensitivity, specificity, and accuracy for determination and localization culprit lesion in patients undergoing ePCI.

3. Coronary artery disease – exercise and pharmacologic stress test

Coronary artery disease (CAD) is still single greatest cause of death of men and women. In the USA more than 9 million patients are referred yearly for diagnostic cardiac stress test with radionuclide imaging. Although an increasing number of patients undergo pharmacologic stress because they are unable to perform adequate physical stress, such as maximal workload, duration, hemodynamic response, exercise-induced symptoms, and electrocardiography (ECG) changes, provide invaluable additional information for assessing a patients condition not available with pharmacologic stress. Pharmacologic stress testing accounts for approximately 48% of stress myocardial perfusion studies done to detect CAD in the US. Exercise stress test is preferred for patients who can exercise and achieve adequate exercise endpoints. Pharmacologic stress testing is reserved for patients who have exercise limitations. It is estimated that at least 25% of patients and 50% of hospitalized patients cannot perform maximal exercise. Pharmacologic stress can be done with vasodilator agents (adenosine, dipyridamole, adenosine triphosphate, or selective adenosine A2a receptor agonist) or with inotropic and chronotropic agents (dobutamine or arbutamine). Patients with left bundle branch block (LBBB) or electronically paced rhythms may have anteroseptal perfusion defects with exercise or dobutamine perfusion imaging unrelated to stenosis of the left anterior descending artery and hence vasodilator stress testing is recommended in these patients (6, 7, 8, 9).

Adenosine and dipyridamole stress have been used in combination with exercise especially in patients with limited exercise capacity. The reported benefits of the combination protocols include improvement in ischemia detection and image quality, and reduction in side effects. The addition of exercise to vasodilator stress might partly overcome the roll-off phenomenon observed with vasodilators alone resulting in more radiotracer extraction and better estimation of CAD.

Simultaneous exercise in conjunction with adenosine stress was safe and significantly reduced adenosine side effects by 30%-40% and enhanced image quality. These benefits were similar with sub maximal or maximal exercise (6-9, 10)

Similar to adenosine, patients who underwent dipyridamole-exercise had fewer noncardiac side effects, more ischemic ECG changes, higher HR and systolic BP, and better image qualities with increased heart to liver and heart to gut count ratios.

One of the most powerful uses of MPI is the evaluation of the risk for future events in patients with suspected or known CAD. Over the years, MPI has evolved as an essential tool in the evaluation and assessment of patient prior to coronary revascularization. It has a dual role. Prior to coronary angiography, MPI is extremely useful in documenting ischemia and determining the functional impact of single or multiple lesions identified subsequently. MPI remains the test of choice for identifying the lesion responsible for the ischemic symptoms, or so called culprit lesion. That is extremely useful for further management decisions with respect to percutaneous interventions. In compare, the absence of reversible ischemia in

patients with known CAD is an excellent prognostic marker and predicts a low annual event rate. The current definition of culprit lesion that is zone of ischemia under the coronary stenoses is not quite right, because that is not defined two pathophysiologic aspects of ischemia; severity and extent. The primary objective of those study was to determinate and localizes culprit lesion by knew introduce parameters SRS (*summary reversible score*) and ISRS (*index of summary reversible score*), under the angiographically detected coronary narrowing ≥75% for the least one coronary artery (2, 14).

4. Methods

One hundred thirty-two (132) patients with known CAD were studied. In all of them angiographically detected significant coronary narrowing (≥75% luminal stenosis for the least one coronary artery). All patients were submitted to 2 iv injections of ^{99m}Tc-MIBI, one in a peak pharmacologic stress test with concomitant low level exercise stress test (50W) **AdenoEx** protocol; we administered adenosine (in the dose of 140 μg/kg/min) in combination with supine bicycle exercise low level 50W. We started infusion at the end of the 1st minute bicycle exercise, and finished in the 5th minute. Bicycle exercise was continuing one minute more until 6th minute. Radiopharmaceutical ^{99m}Tc-MIBI was administrated during the infusion at the end of 2nd minute. Imaging started 15 minutes after iv. ^{99m}Tc-MIBI 740 MBq and the other 370 MBq at rest 3 hour after in the rest study.

Images of the heart were taken; 15 min after injections for the stress studies, and 30 minutes after injections for the rest study, using an Orbiter Siemens gamma camera, which was fitted with a low energy, all purpose collimator, and connected with a dedicated computer system. Briefly, 32 projections were obtained over a semicircular 180^0 arch wich extended from the anterior 0^0 to the left posterior position 180^0. In each patient, we were using Stirner quantification program (Euro menu) modificated and standardized myocardial segmentation and nomenclature for topographic imaging of the heart analyzed SPECT. Quantification regional ^{99m}Tc-MIBI uptake was performed using short-axis myocardial tomography that was divided on 16 segments + apex for each study (2, 11).

The left anterior descedenting artery (LAD) vascular territory including; basal anterior, basal anteroseptal, mid anterior, mid anteroseptal, apical anterior, apical septal, and apex; Left circumflex artery (LCx); basal inferolateral, basal anterolateral, mid inferolateral, mid anterolateral, apical lateral; Right coronary artery (RCA); basal inferoseptal, basal inferior, mid inferoseptal, mid inferior, apical inferior.

We were measured relative uptake, in area individual coronary artery vascular territory, from each segment and compare with the segment with the best uptake, and we founded in the **AdenoEx study;** Normal relative uptake (> 85%); Probably normal (75%-85%); Equivocal (65%-75%); Probably abnormal (50%-65%); Abnormal (< 50%). **Rest study;** Normal relative uptake (> 90%); probably normal (80%-90%); equivocal (70%-80%); probably abnormal (55%-75%); abnormal (< 55%). Different between relative uptake each segment we were scoring with a 5-point scoring system to ass's difference between uptake degree in stress and rest studies for the same segments (1= normal, 2= mild ischemia, 3= moderate ischemia, 4= reversibility, 5= severe reversibility).

We were introduced two knew index score to determinate culprit lesion. **Summary reversible score (SRS)** ≥ 3 in the territory of stenoses coronary artery was determinate culprit lesion. At least two segments with score **5 (index of summary reversible score-ISRS)** in the territory of stenoses coronary artery was determinate culprit lesion.

Results: A total of 396 vascular territories (2244 segments) were analyzed before elective percutaneous coronary intervention (ePCI). Overall sensitivity, specificity, and accuracy using SS were 90.2%, 87.5%, 89.4%, with positive predictive value 94,1%. Overall sensitivity, specificity, and accuracy using ISRS were 94.4%, 90.6%, 93, 2%, with positive predictive value 95, 7%. Conclusion: MPI with two created index SRS and ISRS significantly improves sensitivity, specificity, and accuracy for determination culprit lesion in patients undergoing PCI.

5. State of the art and future directions

Since the introduction of myocardial perfusion imaging (MPI) into clinical medicine in late 1970s, this technique has undergone considerable expansion and evolution. Initially, myocardial perfusion imaging was introduced as a noninvasive diagnostic tool in determining the presence or absence of coronary artery disease (CAD).

The ability to distinguish patients at low risk from those at high risk for future cardiac events has become an essential adjunct for clinicians in the management of patients of CAD. The power of myocardial perfusion imaging (MPI) for predicting future coronary events has been demonstrated in a large number of high-quality studies and in many thousands of patients. It is perhaps the area of nuclear cardiology where the evidence is most strong. The most important variables that predict the likelihood of future events are the extent and severity of inducible ischemia. In general, markers of left ventricular dysfunction tend to predict cardiac mortality and inducible ischemia predicts acute coronary syndromes. MPI has incremental prognostic value even after clinical assessment, exercise electrocardiography and coronary angiography. In other words, patients who appear to be high risk after coronary angiography can be separated into higher and lower risk groups by MPS. In addition, several studies have indicated that a negative SPECT study confers an excellent prognosis with an annual cardiac event rate of <1% for the general population. In the setting of a normal myocardial perfusion study in a low-risk patient, it takes 9 years for the risk of a cardiac event to reach 1%, suggesting that, in the absence of new symptoms, a repeat perfusion study may not be needed for 3 to 5 years (13, 14, 15). However, this "warranty period" does not appear to be absolute and is affected by clinical and technical factors, including the presence of diabetes or CAD, increasing age and male gender, and the need to perform a pharmacologic stress test rather than an exercise perfusion imaging test, which can increase the annual cardiac event rate in patients with a normal perfusion scan to as high as 1.8%. In these high-risk patients with normal myocardial perfusion studies, it may be prudent to perform repeat perfusion imaging on a more frequent basis.

Because of its prognostic power, MPI can be used as the gatekeeper to coronary angiography. Bateman and colleagues showed that referral to coronary angiography after normal, mild to moderately abnormal and severely abnormal perfusion scans was 3.5%, 9% and 60% respectively. Importantly, a policy of selective referral to coronary angiography based upon high-risk findings is defensible, as patients with mild to moderate abnormalities when managed medically have outcomes comparable to those undergoing invasive evaluation and subsequent revascularization. Besides, several reports underlie that such a policy can be also cost-effective even if it is more expensive than an alternative test such as the exercise ECG. Furthermore, MPS can provide useful information about cardiac risk in patients requiring non-cardiac surgery although these patients are generally at low risk and

the predictive value of a normal perfusion study is greater than that of an abnormal study, while the clinical value of MPS to assess patients with acute coronary syndrome has been well established.

MPS is of proven value to assess patients post revascularization. Information gained from post-intervention myocardial SPECT is important to differentiate patients with angina from those with echo-cardiac chest pain syndromes, to assess peri-intervention myocardial damage/acute vessel closure, to predict-detect restenosis after PCI and graft occlusion/stenosis after CABG surgery, to detect CAD progression in non-revascularized vessels, to evaluate the effects of intervention if required for occupational reasons and to predict patients' long-term prognosis (16, 17).

The assessment of patients' prognosis is central to the clinical management of patients with CAD. Patients with CAD can be characterized along a continuum of risk for cardiac events. When the risk of cardiac events low, cardiologists generally employ conservative medical management. Conversely, when the risk of cardiac events is high, aggressive patient management, such as the performance of coronary bypass surgery or coronary angioplasty, tends to be favored. Between these extremes of risk, are a large number of patients who have an intermediate risk of cardiac events, which can be arbitrary and roughly defined as a likelihood of from 2% to 5% of major cardiac events over the ensuing year. Decision making to such patients is challenging, since the indication for conservative versus aggressive treatment is most uncertain in this group. Thus, the clinical often desires additional prognostic information about such patient to better define the likelihood of cardiac events. It is this group of patients in whom radionuclide stress testing finds its greatest prognostic benefit. The prognostic utility of radionuclide stress tests derives from their ability to quantify the magnitude of jeopardized myocardium during exercise or during pharmacologic stress testing with dipyridamole or adenosine. Specifically, MPI measures two indices of ischemia: ischemic extent and ischemic severity. Ischemic extent indices reflect the area of myocardial mass that became during stress. Ischemic severity indices correlate roughly with the number of stenosed coronary arteries. The number of reversible myocardial perfusions defects seen by MPI SPECT, constitutes a typical variable of ischemic extent. By contrast, ischemic severities indices reflect the magnitude of inducible ischemia within a given myocardial region. For instance, the severity of a perfusion defects reflects the severity of subtending coronary stenoses. Variables of ischemia extent and severity that can be assessed with stress myocardial perfusion SPECT are shown in the Table 1.

Included in this list are two variables that may be assessed by obtaining an early anterior planar scintigram before SPECT imaging: a) the post-stress lung uptake of isotope, and b) the transient post-stress ischemic dilatation of the left ventricle.

Because of its clinical importance, information about the extent and severity of jeopardized myocardium should be incorporated into the routine reporting of radionuclide stress test results. Conventional practice is to divide the short axis of the left ventricle into the three regions: apical, mid-ventricular and basal. The apex is assessed from the vertical long axis slices. Our approach is to assess the reduction in regional uptake of isotope in each of the 17 myocardial segments. On a five-point scale, as follows: 1 = none, 2 = mild, 3 = moderate, 4 = severe and 5 = complete reduction in regional uptake. Comparison of the stress and rest scores provides the physician with a quantitative estimation of the degree of reversibility of each myocardial defect. From the location of defects, it can be estimated which coronary vessels are the most likely culprit lesions for the induction of myocardial ischemia (2, 10, 16, 17, 18).

Predictor	Ischemia Extent	Ischemia Severity
- Number and/or location of reversible defections	++++	0
- Magnitude of defects	0	++++
- Delayed redistribution	+	++++
- Lung uptake of isotope[a]	+++	+
- Transient LV dilatation[a]	++++	++++
- Magnitude of WMA[1]	0	++++
- Number/location of WMA[1]	++++	0
- Change in LVEF stress[1]	+++	++

[a]Best assessed by obtaining a 5-minute and 4-hour anterior planar scintigram before the initiation of SPECT imaging.
[1]Obtained from concomitant rest-exercise first-pass radionuclide ventriculography when employing ^{99m}Tc-agents.
LV left ventricle; WMA wall-motion abnormality; EF ejection fraction

Table 1. Predictors of stress-induced ischemia extent and severity using SPECT and adjunctive scintigrams.

The relationship between the magnitude of inducible myocardial ischemia and the likelihood of cardiac events is not linear. Previous investigation has shown that the magnitude of ischemia has an exponential relationship to the occurrence of subsequent cardiac events. Patients who demonstrate only mild ischemia at a peak stress have only a small, relatively flat increase in the likelihood of cardiac events as compared to patients who manifest no scintigraphic evidence of inducible ischemia. But, once ischemia progressed to a moderate magnitude, the likelihood of cardiac events begins to increase sharply. Ladenheim and colleagues performed a 1-year follow-up of 1.689 patients without prior myocardial infarction (MI) who underwent exercises planar MPI for diagnostic or prognostic purposes. The frequency of hard cardiac events (MI/cardiac death) and late (> 60 days) bypass surgery after testing were recorded as cardiac events. Ischemic extent and ischemic severity were exponentially related to the cardiac event rate (2, 17, 18).
Based on the published prognostic literature, four points may be derived that can serve as general rules of thumb for the utilization of scintigraphic testing in clinical practice:

6. Use of radionuclide stress testing in patient-management decision

- Risk assessment in patients with a high likelihood of CAD
- Selection of therapy in patients with angiographically documented CAD;
- Selection between medical therapy versus revascularization.
- Identification of **culprit** lesions prior to coronary intervention.
- Evaluation of borderline coronary artery stenosis.
- Risk stratification of post-MI patients
- Predischarge exercise testing.
- Predischarge pharmacological stress testing.
- Evaluation of patients following thrombolysis.
- Predischarge evaluation of patients with unstable angina

- Risk stratification of the elderly
- Risk stratification of patients with congestive heart failure and/or left ventricular dysfunction
- Evaluation of patients following treatment modalities for CAD
- Percutaneous coronary intervention
- Coronary artery by-pass surgery
- Medical therapy
- Risk stratification of patients prior to elective noncardiac surgery

Substitution of pharmacological stress testing for risk stratification. In general, the performance of myocardial perfusion scintigraphy with exercise as opposed to pharmacological stress is preferable for prognosis purposes. Important prognostic variables associated with exercise ECG testing include exercise capacity, exercise-inducible chest pain or hypotension, and the ECG response to exercise, particularly the heart rate threshold and post-exercise duration of stress-induced ST-segment depression. These variables cannot be assessed when pharmacologic instead of exercise testing is employed.

However, the performance of myocardial perfusion imaging in conjunction with pharmacologic stress testing, either with dipyridamole or with adenosine, has essentially the same sensitivity and specificity for detecting CAD as does exercise myocardial perfusion scintigraphy. Moreover, studies done with both modalities indicate that magnitude of ischemic defects induces by exercise is not underestimated by those induces by pharmacologic stress. A normal scintigraphic study in association with pharmacological stress is associated with a same low risk of cardiac events as is a normal exercise myocardial perfusion study. Dipyridamole or adenosine SPECT is commonly employed as the pharmacological stress agent, given its ease to use. Myocardial perfusion imaging (MPI) can also be performed in conjunction with dobutamine or arbutamine stress, but is generally reserved for patients with asthma or chronic lung disease. Despite the theoretical advantages of exercise in assessment prognosis, excellent risk stratification has been reported with adenosine SPECT imaging, with results similar to those observed with exercise.

Based on the strongly documented prognostic efficacy, MPI has emerged as a key guide for major medical decisions involving patients with suspected or known CAD

Myocardial perfusion imaging provides incremental prognostic value, particularly in patients and an intermediate or high pretest likelihood of CAD or patients with stable CAD and mild symptoms. Patients who exhibit normal myocardial perfusion and function on gated SPECT have an excellent prognosis and should be referred for non cardiac evaluation for determining etiology of the presenting symptoms. Conversely, patients with high-risk scans may benefit from an early invasive strategy with a view toward revascularization depending on coronary anatomical finding. A substantial number of patients undergoing SPECT perfusion imaging will have mild ischemia without a multivessel disease scan pattern. If patients with mild ischemia have good exercise tolerance, they should be considered as candidates for intense medical therapy with follow-up exercise SPECT imaging possibly at 1 year. Unpublished data from the Clinical Outcomes Utilizing Revascularization and Aggressive Drug Evaluations (COURAGE) trial seem to indicate that many ischemic defects may markedly improve with aggressive lowering of abnormal lipids an the other pharmacological interventions. Hachamovitch and colleagues reported patients with the mildly abnormal scan had a 0.8% annual cardiac death rate compared with 0.9% for those who underwent revascularization. The death rate in medically treated patients who had moderately abnormal scans was 2.3% versus 1.1% for such patients undergoing

revascularization. Finally, patients with a severely abnormal scan treated medically had an annual cardiac death rate of 4.6% versus 1.3% for such patients who were revascularized. In the second study, these investigators showed that medically treated patients who had greater than 20% of the total myocardium rendered ischemic had higher annual cardiac death rate (6.7%) compared with 2.0% for patients with this degree of extensive ischemia who underwent revascularization. For patients with 10% or less of the total myocardium rendered ischemic, there was no difference in outcome between medical therapy and revascularization (2, 12, 13, 17, 18).

Exercise myocardial perfusion imaging is a valuable adjunct for separating high to low risk patients who present symptoms consistent with stable CAD, or in patients who have known disease and in whom further prognostication is warranted. Multiple high-risk nuclear imaging variables can be identified, and the greater the extent of exercise/induced ischemia, the greater the risk of cardiac events. Adjunctive variables, such as transient ischemic cavity dilatation and functional assessment with evaluation of regional wall thickening or wall motion and left ventricular ejection fraction greatly assist in the risk stratification process.

Nuclear cardiology is uniquely placed to address all the major determinants of prognosis in CAD can be assessed by measurements of stress-induced perfusion or function. These measurements include the amount of infarcted myocardium, the amount of jeopardized myocardium (supplied by vessels with hemodynamically significant stenosis), and the degree of jeopardy (tightness of the individual coronary stenosis). Recent evidence in large patient cohorts has revealed that factor estimating the extent of left ventricular dysfunction (left ventricular ejection fraction, extent of infarcted myocardium, transient ischemic dilatation of the left ventricle and increasing lung uptake) are excellent predictors of cardiac mortality. However, measurements of inducible ischemia are the best predictors of the development of acute coronary syndromes. Several reports have shown that nuclear testing yields incremental prognostic value over clinical information with respect to cardiac death, or the combination of cardiac death and nonfatal myocardial infarction as isolated endpoints. Now it is possible to tailor therapeutic decision making for an individual patient based upon combination of clinical factors and nuclear scan results. Patients with severe perfusion abnormalities on their stress image may have a five- to ten-fold higher likelihood of cardiac death versus patient with a normal myocardial perfusion SPECT. If the defects perfusion determined as a culprit lesion, invasive therapy (PCI) is an optimized outcome for that patient (2).

7. Clinical evaluation of MPS

The power of myocardial perfusion imaging (MPI) for predicting future coronary events has been demonstrated in a large number of high-quality studies and in many thousands of patients. It is perhaps the area of nuclear cardiology where the evidence is most strong. The most important variables that predict the likelihood of future events are the extent and severity of inducible ischemia. In general, markers of left ventricular dysfunction tend to predict cardiac mortality and inducible ischemia predicts acute coronary syndromes. MPS has incremental prognostic value even after clinical assessment, exercise electrocardiography and coronary angiography. In other words, patients who appear to be high risk after coronary angiography can be separated into higher and lower risk groups by MPS. In addition, several studies have indicated that a negative SPECT study confers an excellent prognosis with an annual cardiac event rate of <1% for the general population. In the setting of a normal myocardial perfusion study in a low-risk patient, it takes 9 years for

the risk of a cardiac event to reach 1%, suggesting that, in the absence of new symptoms, a repeat perfusion study may not be needed for 3 to 5 years. However, this "warranty period" does not appear to be absolute and is affected by clinical and technical factors, including the presence of diabetes or CAD, increasing age and male gender, and the need to perform a pharmacologic stress test rather than an exercise perfusion imaging test, which can increase the annual cardiac event rate in patients with a normal perfusion scan to as high as 1.8%. In these high-risk patients with normal myocardial perfusion studies, it may be prudent to perform repeat perfusion imaging on a more frequent basis.

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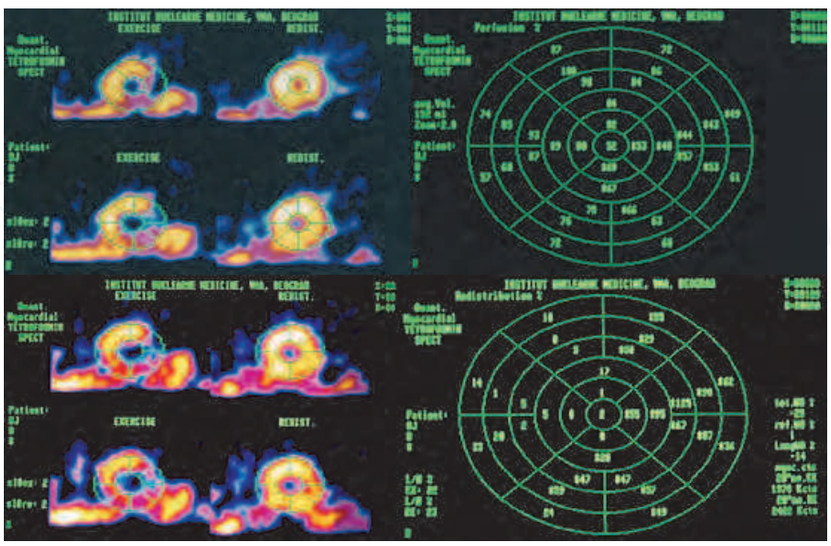


Fig. 1. Culprit lesion on the lateral and inferior segments on the short axis after SPECT MPI with AdenoEx protocol. In the rest study (right side) we showed normal finding of perfusion in the same area. We indicated invasive strategy.

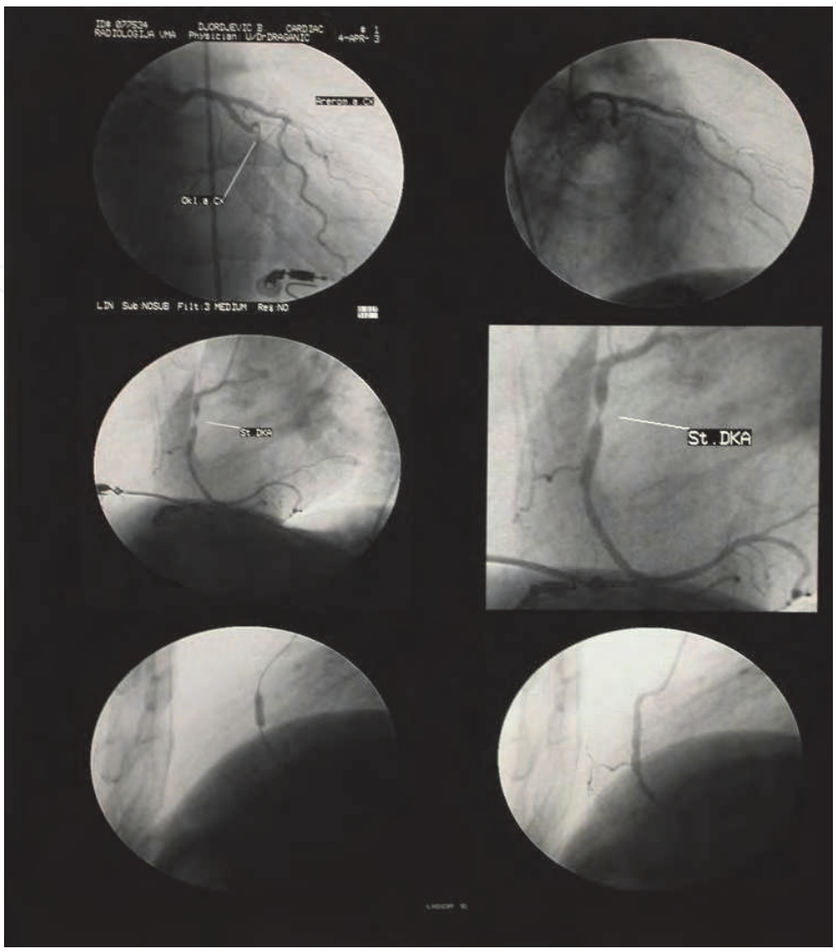


Fig. 2. Occlusion ACx, and subtotal stenosis RCA. In the same acts we perfiormed PCI with stent implantation

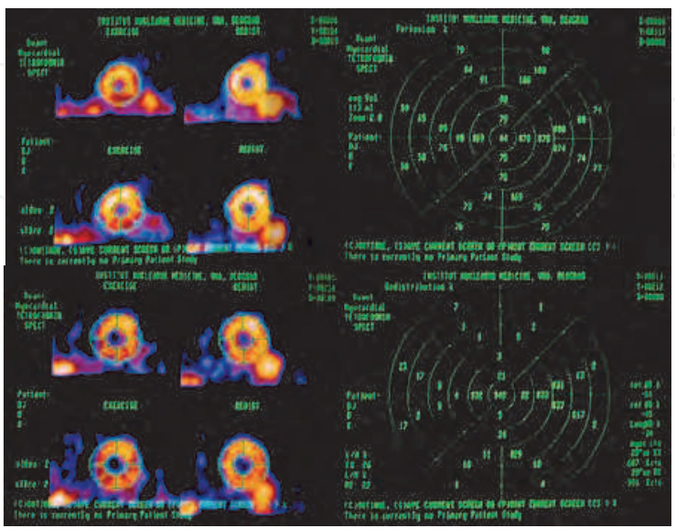


Fig. 3. MPI nearly after PCI (two weeks) showed normal findinig

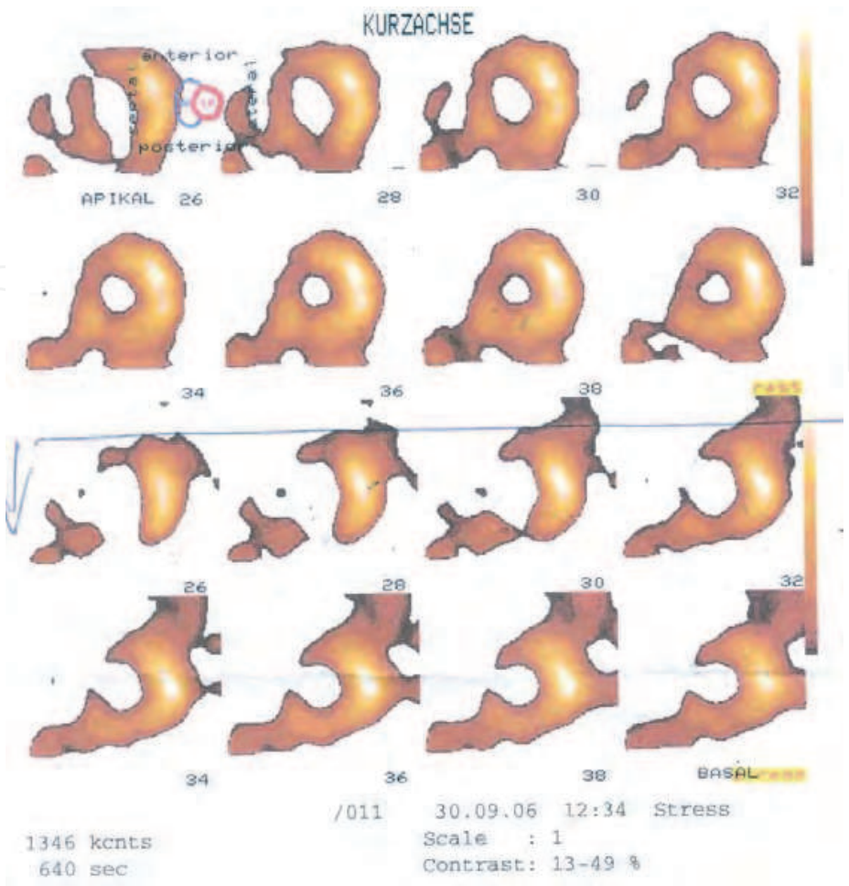


Fig. 4. Rest study showed normal MPI finding; **stress two lines short axis below;** culprit lesion in the anterospetal segments

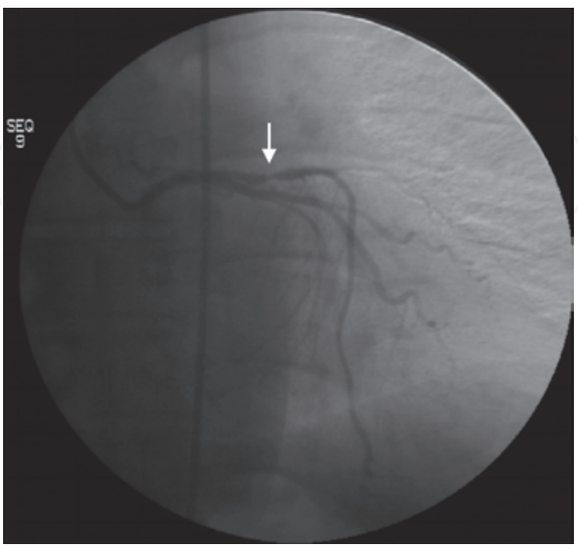


Fig. 5. Coronarography finding; subtotal stenosis LAD

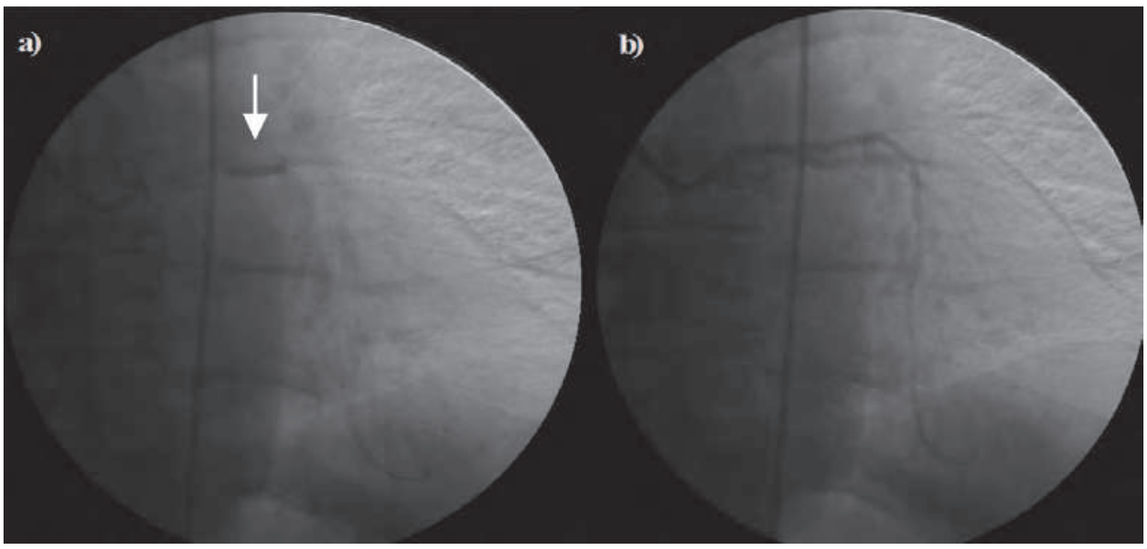


Fig. 6. In the same acts we performed PCI with stent implantation

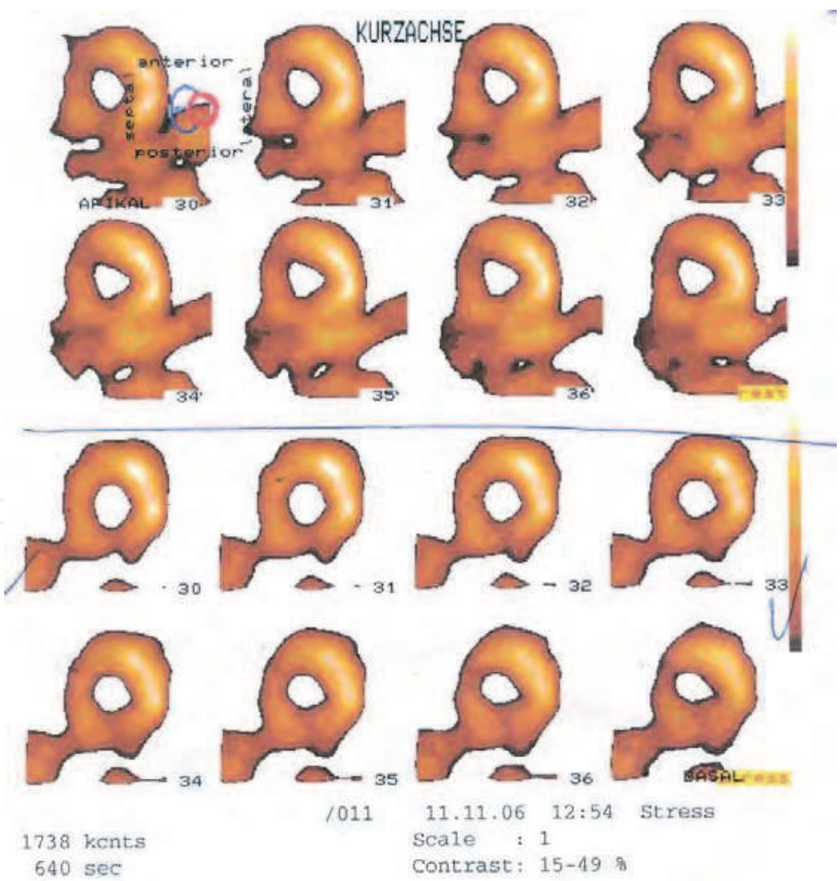


Fig. 7. Two months after we performed MPI for assessment elective PCI theraphy. We fnded normal perfusion in the rest (up) and AdenoEx study (below two lines short axis)

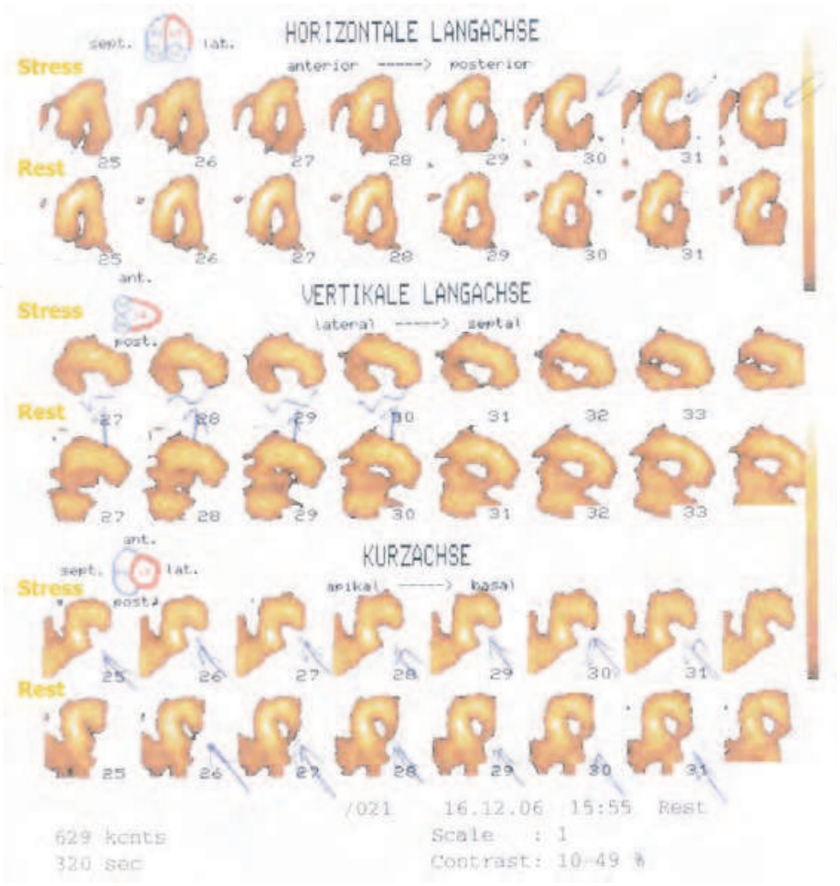


Fig. 8. Culprit lesion in the inferolateral segments in the AdenoEx (up line slices) MPI study

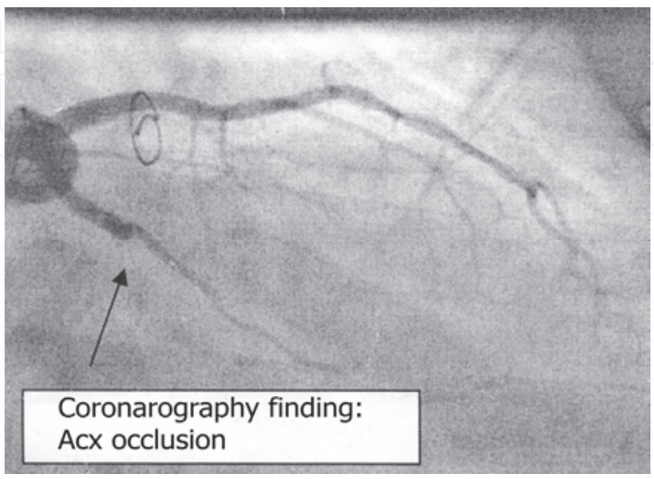


Fig. 9.

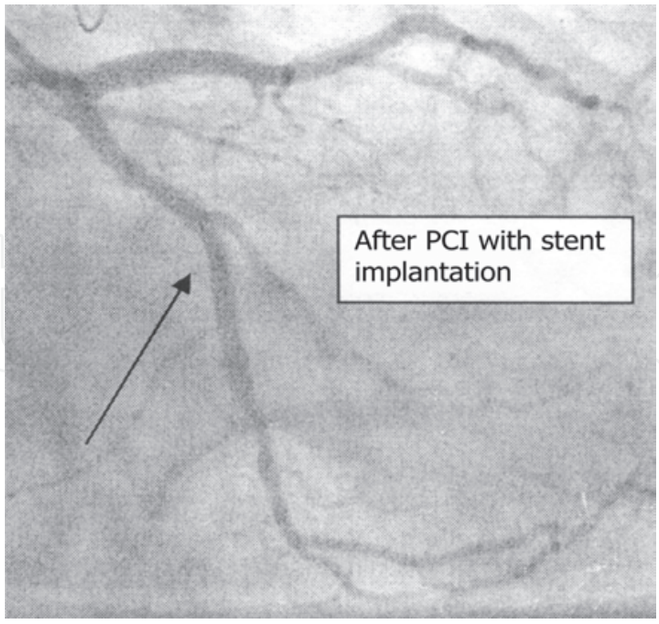


Fig. 10.

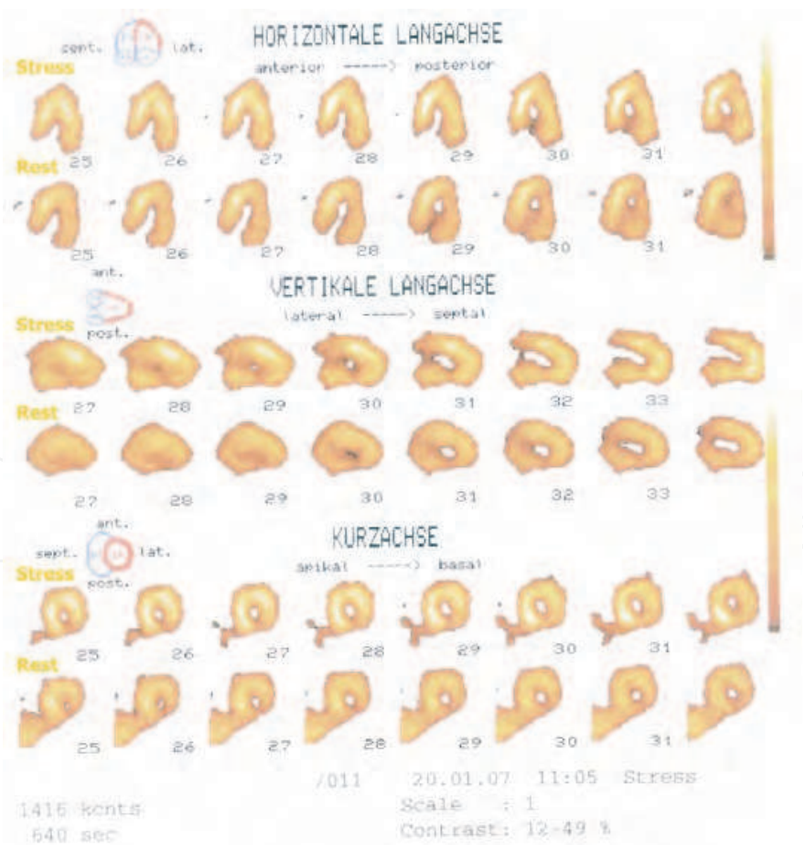


Fig. 11. Nearly after elective PCI intervention we performed MPI with normal finding of perfusion

8. Conclusion

Myocardial perfusion imaging by SPECT, with pharmacologic stress test AdenoEX significantly improves sensitivity, specificity, and accuracy for determination and localization culprit lesion in patients undergoing elective percutaneous coronary intervention.

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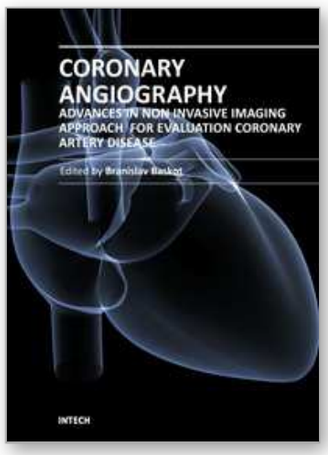
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In the intervening 10 years tremendous advances in the field of cardiac computed tomography have occurred. We now can legitimately claim that computed tomography angiography (CTA) of the coronary arteries is available. In the evaluation of patients with suspected coronary artery disease (CAD), many guidelines today consider CTA an alternative to stress testing. The use of CTA in primary prevention patients is more controversial in considering diagnostic test interpretation in populations with a low prevalence to disease. However the nuclear technique most frequently used by cardiologists is myocardial perfusion imaging (MPI). The combination of a nuclear camera with CTA allows for the attainment of coronary anatomic, cardiac function and MPI from one piece of equipment. PET/SPECT cameras can now assess perfusion, function, and metabolism. Assessing cardiac viability is now fairly routine with these enhancements to cardiac imaging. This issue is full of important information that every cardiologist needs to now.

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