EuroIntervention

Single-photon emission computed tomography for assessment of myocardial viability

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The authors have no conflict of interest to declare.

KEYWORDS

Coronary artery disease, hibernating myocardium, left ventricular dysfunction, myocardial hibernation, myocardial viability, single photon emission computed tomography

Abstract

Left ventricular dysfunction in patients with chronic coronary artery disease may be a result of dysfunctional but viable myocardium due to myocardial hibernation. Coronary revascularisation may substantially improve regional and global left ventricular dysfunction and long-term survival if a substantial amount of dysfunctional but viable myocardium is present. Because coronary revascularisation, by percutaneous coronary intervention or coronary bypass surgery, is associated with an increased periprocedural risk in patients with severe left ventricular dysfunction, careful preprocedural selection is needed. Assessment of myocardial viability with SPECT may facilitate clinical decision making and should be considered in patients with ischaemic left ventricular dysfunction who are eligible for coronary revascularisation. The most frequently used SPECT protocols use thallium-201 (^{201}Tl) rest-redistribution, technetium-99m (^{99m}Tc) labelled viability tracers, or ^{18}F-fluorodeoxyglucose (FDG) for assessment of myocardial glucose metabolism. Approximately 50% of the patients with ischaemic left ventricular dysfunction have a substantial amount of dysfunctional but viable myocardium on SPECT and should be considered for coronary revascularisation. The absence of myocardial viability can help to identify patients who will not benefit from high-risk percutaneous coronary interventions or surgery.

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Introduction

Advances in cardiac imaging techniques coupled with emergent therapeutic options have led to an increased use of cardiac imaging techniques[1]. Myocardial perfusion imaging with single-photon mission computed tomography (SPECT) is widely available and extensive experience has been obtained with this technique for the diagnosis of coronary artery disease and evaluation of left ventricular function[1]. The presence and extent of myocardial perfusion defects on SPECT have strong implications for long-term survival[2]. Assessment of myocardial viability with SPECT should be considered in patients with ischaemic left ventricular dysfunction who are eligible for coronary revascularisation. In patients with a substantial amount of dysfunctional but viable myocardium, coronary revascularisation is likely to improve symptoms, regional and global left ventricular function, and survival[3]. In patients with predominantly irreversibly scarred myocardium, these benefits of coronary revascularisation can not be expected and high-risk percutaneous coronary interventions or surgery can be avoided[3].

This review provides an overview of assessment of myocardial viability with SPECT, and summarises the available data on the diagnostic accuracy for the prediction of recovery of regional wall motion, global left ventricular function, and long-term survival following coronary revascularisation. Finally, this review addresses in which patients assessment of myocardial viability using SPECT may be most relevant, and how the SPECT results can be used for clinical decision making.

SPECT imaging protocols

Various radionuclide tracers have been used in combination with SPECT for the assessment of myocardial viability[4]. These tracers investigate different features of dysfunctional but viable myocardium (Table 1). The most frequently used radionuclide tracers and SPECT protocols will be addressed in this review. Historically, thallium-201 (^{201}Tl) has been used for the assessment of myocardial perfusion, subsequently several imaging protocols for viability assessment have been developed. The technetium-99m (^{99m}Tc) labelled tracers, ^{99m}Tc-sestamibi and ^{99m}Tc-tetrofosmin were introduced to overcome some of the limitations of ^{201}Tl, and have superior imaging physics and radiation safety. An alternative method, specifically developed for assessment of myocardial viability, is dual-isotope SPECT imaging using ^{99m}Tc-sestamibi or ^{99m}Tc-tetrofosmin to evaluate perfusion and ^{18}F-fluorodeoxyglucose (FDG) for assessment of myocardial glucose metabolism to evaluate viable myocardium.

^{201}Tl

^{201}Tl is a small, highly diffusible, gamma ray emitting cation. The myocardial uptake of ^{201}Tl has similarities with the myocardial uptake of potassium. The initial uptake of ^{201}Tl is relatively high and tracks myocardial blood flow reasonably well. In the hours after initial uptake, myocardial redistribution of ^{201}Tl may occur because of a different clearance of the tracer between normal and ischaemic myocardium. This redistribution effect facilitates the identification of viable and nonviable regions. The ^{201}Tl uptake over longer time is dependent on the integrity of the cell membrane, and thus indicates myocardial viability. In irreversibly scarred nonviable regions, ^{201}Tl is not retained. In most SPECT protocols, image acquisition is performed early after ^{201}Tl injection to optimise the detection of flow heterogeneity. Subsequently, image acquisition is repeated after 3-4 hours to allow tracer redistribution that becomes more apparent over time (Figure 1).

In clinical practice two SPECT imaging protocols are frequently used[4,5]. The rest-redistribution protocol (early and 3-4 hour acquisition), provides information on myocardial perfusion at rest, and myocardial redistribution which indicates myocardial viability. The stress-redistribution-reinjection protocol consists of initial image acquisition early after tracer injection during exercise or pharmacological stress, and delayed (3-4 hours) image acquisition to evaluate redistribution. Finally, a third image set is acquired one hour after tracer reinjection. The stress-redistribution-reinjection protocol provides information on both myocardial ischaemia and myocardial viability.

Table 1. Single-photon emitting and positron-emitting.

Tracer	Assessment	Uptake mechanism
^{201}Tl	Perfusion/Viability	Na^+/K^+-ATPase cell membrane pump
^{99m}Tc-sestamibi	Perfusion/Viability	Mitochondrial K^+-ATP channel
^{99m}Tc-tetrofosmin	Perfusion/Viability	Mitochondrial K^+-ATP channel
^{15}O-water*	Perfusion	Diffuses freely across cell membrane
^{13}N-ammonia*	Perfusion	Diffuses freely across cell membrane. The ammonium from is intracellularly trapped in glutamine.
^{82}Rb*	Perfusion/Viability	Na^+/K^+-ATPase cell membrane pump
^{18}FDG	Glucose consumption	Intracellular trapping after phosphorylation
^{11}C-acetate*	Oxidative metabolism/ Perfusion	Converted intracellularly to acetyl-CoA and further metabolised to $^{11}CO_2$ in the mitochondria
^{11}C-palmitate*	Free fatty acid metabolism	Converted intracellularly to FFA-CoA, cleavage of carbon fragments of FFA-CoA during beta-oxidation and further metabolised to $^{11}CO_2$ in the mitochondria

*: tracers for cardiac imaging; Table adapted from Slart et al[4].

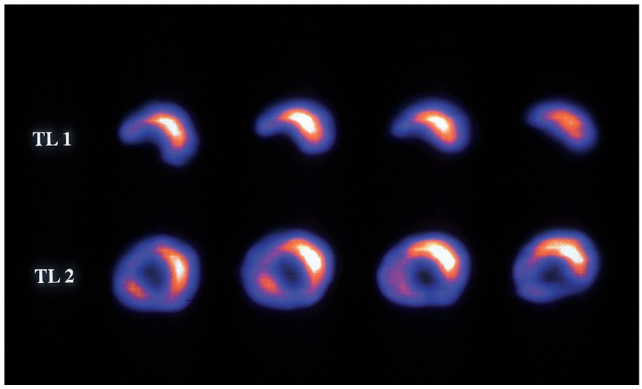

Figure 1. Corresponding series of ^{201}Tl rest-redistribution SPECT short-axis slices for assessment of myocardial viability. Early slices (top) show defect in inferoseptal wall, with redistribution on late slices (bottom). Figure reproduced from reference 5.

Myocardial viability is indicated by:
- normal ^{201}Tl uptake at stress
- stress defects with redistribution (reversible defects) at the 3-4 hour delayed image sets
- redistribution in fixed defects at redistribution following reinjection or delayed rest images (frequently a threshold of 10% increase in tracer uptake is used)
- tracer uptake >50% at the redistribution/reinjection images or the delayed rest images

^{99m}Tc-sestamibi and ^{99m}Tc-tetrofosmin

^{99m}Tc-sestamibi and ^{99m}Tc-tetrofosmin are lipophilic, gamma ray emitting cationic complexes. Myocardial accumulation is mainly by passive diffusion and depends on the cell membrane and mitochondrial transmembrane potentials. The first-pass extraction of ^{99m}Tc-sestamibi and ^{99m}Tc-tetrofosmin is somewhat lower as compared to myocardial ^{201}Tl uptake, and under resting or low-flow conditions track myocardial blood flow well. At stress conditions with high myocardial blood flow, ^{99m}Tc-sestamibi and ^{99m}Tc-tetrofosmin do not track myocardial blood flow as well as ^{201}Tl does, because myocardial accumulation is limited by diffusion. Myocardial redistribution of ^{99m}Tc-sestamibi is less than ^{201}Tl, whereas ^{99m}Tc-tetrofosmin demonstrates no redistribution. Both ^{99m}Tc-sestamibi and ^{99m}Tc-tetrofosmin are successfully used for assessment of myocardial viability; most experience has been obtained with ^{99m}Tc-sestamibi under resting conditions[4,5]. Administration of nitrates (orally or intravenously) before ^{99m}Tc-sestamibi and ^{99m}Tc-tetrofosmin SPECT can be used to improve diagnostic accuracy for assessment of myocardial viability.

Myocardial viability is indicated by:

^{99m}Tc-sestamibi or ^{99m}Tc-tetrofosmin uptake >50-60%

^{18}F-FDG

^{18}F-FDG is a glucose-analogue allowing evaluation of myocardial glucose metabolism. Myocardial glucose consumption is an adenosine triphosphate dependent process, requiring viable myocytes. After phosphorylation, ^{18}F-FDG-6-phosphate remains trapped in the myocytes and is not a substrate for further metabolism. Normally, free fatty acids are the preferred metabolic substrate for the myocardial tissue. During myocardial ischaemia, myocardial free fatty acid metabolism is decreased and glucose metabolism is increased. ^{18}F-FDG is a positron-emitting radionuclide and traditionally used in conjunction with positron emission tomography (PET); however the availability of this imaging modality for cardiac imaging is limited. Therefore, dual-isotope simultaneous-acquisition SPECT, including ^{99m}Tc-sestamibi or ^{99m}Tc-tetrofosmin to evaluate perfusion and ^{18}F-FDG imaging to assess glucose consumption has been developed[4,5]. Dedicated 511 keV collimators are used to evaluate glucose consumption using ^{18}F-FDG SPECT. Despite the inherent difference in resolution between PET and SPECT, similar diagnostic information can be obtained (Figure 2).

Control of metabolic circumstances before and during ^{18}F-FDG imaging is extremely important to optimise image quality[6,7]. Since myocytes use both free fatty acids and glucose to meet their metabolic demands, preparation is needed to ensure predominantly glucose metabolism at the time of ^{18}F-FDG imaging. Therefore, patients are asked to remain on a low-fat diet for the 24 hours before the study. On the day of the study, patients are allowed to have a light breakfast. To control metabolic conditions during imaging, hyperinsulinemic euglycemic clamping can be used. This approach results in optimal image quality, but can be time consuming for daily clinical practice. An alternative approach is ^{18}F-FDG imaging after oral administration of a nicotinic acid derivative, which effectively reduces plasma levels of free fatty acids, making glucose the preferred substrate for cardiac metabolism[6,7]. Before ^{18}F-FDG imaging glucose plasma levels are monitored and insulin is administered when necessary. This approach results in an excellent image quality, even in patients with diabetes[6,7].

^{18}F-FDG metabolic data are generally scored using semi-quantitative visual analysis, and compared with myocardial perfusion images. In dysfunctional myocardium, viability is evaluated:

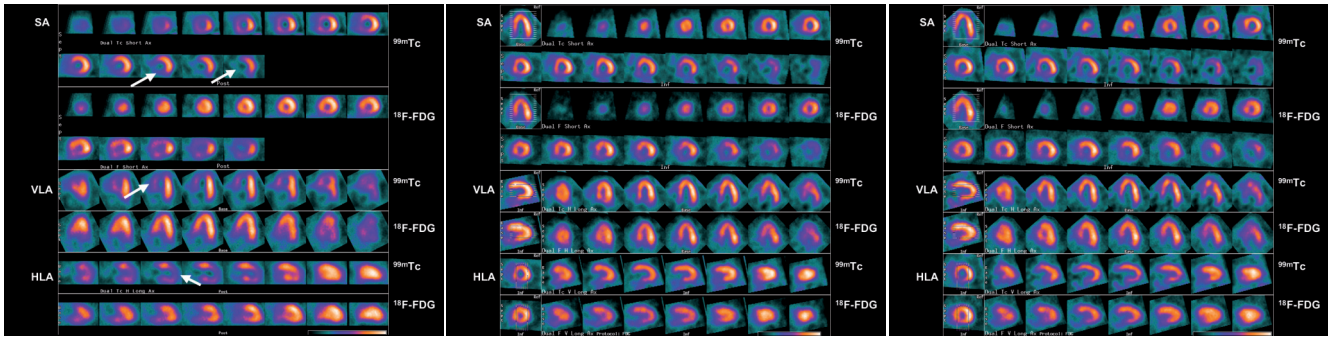

Figure 2. Example of dual isotope simultaneous acquisition ^{99m}Tc-sestamibi/^{18}F-FDG SPECT for assessment of myocardial viability. A. Pre-operative dual isotope simultaneous acquisition ^{99m}Tc-sestamibi/^{18}F-FDG SPECT in a patient with 3-vessel coronary artery disease and a left ventricular ejection fraction (LVEF) of 29%. From top to bottom: short-axis (SA), vertical long-axis (VLA), and horizontal long-axis (HLA) slices. There are extensive areas with perfusion/ metabolism mismatch indicating viable myocardium in the anteroseptal, posteroseptal, and apical regions (white arrows). B. Repeated ^{99m}Tc-sestamibi/^{18}F-FDG SPECT in the same patient one year after coronary bypass surgery. The perfusion defects substantially improved as compared to the pre-operative SPECT study, the LVEF improved to 36%. C. Repeated ^{99m}Tc-sestamibi/^{18}F-FDG SPECT in the same patient five years after coronary bypass surgery. The perfusion defects are comparable to the SPECT study at one year following revascularisation, the LVEF further improved to 45%.

– Normal or reduced perfusion with relatively increased ^{18}F-FDG uptake (metabolism-perfusion mismatch pattern) is considered viable.
– A perfusion defect with a concordantly reduced ^{18}F-FDG uptake (metabolism-perfusion match pattern) is considered nonviable.

Gated SPECT

Electrocardiogram-gated acquisition of SPECT images has been a major step forward in nuclear cardiology, allowing simultaneous assessment of myocardial perfusion and function. Gated SPECT is now routinely used in most nuclear cardiology laboratories. Automated algorithms for quantification of wall motion and thickening, left ventricular volumes, and ejection fraction are widely used (Figure 3 and 4). As the automated calculations are dependent on the quality of the acquired data set, the results may be influenced by rhythm disturbances (particularly atrial fibrillation), electrocardiographic artefacts, patient motion, and the presence of extensive and severe perfusion defects. A head-to-head comparison between gated SPECT and two-dimensional echocardiography demonstrated a good correlation between both techniques for the evaluation of left ventricular function and volumes in patients with severe ischaemic left ventricular dysfunction[8].

Additionally, gated SPECT information can be used to recognise attenuation artefacts and thereby improves diagnostic accuracy. Attenuation artefacts, caused by breast tissue or the left hemidiaphragm, are a major cause of false positive SPECT studies. Combined evaluation of myocardial perfusion and wall motion and thickening data is used to distinguish an attenuation artefact, which

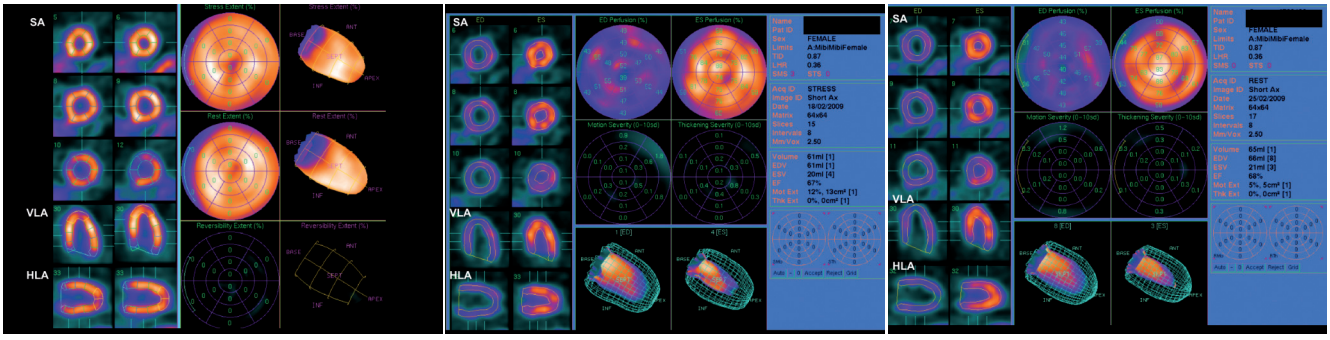

Figure 3. Example of a normal dobutamine stress gated ^{99m}Tc-sestamibi SPECT study for assessment of myocardial perfusion and function. A. Dobutamine stress gated ^{99m}Tc-sestamibi SPECT in an obese female patient with a body mass index 42, and a history of coronary intervention, hypertension and diabetes. Left column, from top to bottom: short-axis (SA), vertical long-axis (VLA) and horizontal long-axis (HLA) slices. All slices show normal perfusion without defect. Middle and right column: polar maps and 3-dimensional projection of the perfusion scan demonstrating a normal perfusion at stress and rest. B. Continued: quantitative analysis of the dobutamine stress SPECT images. Left column: end-diastolic (ED) and end-systolic (ES) slices. Middle column from top to bottom: ED and ES polar plots, quantitative analysis demonstrating normal wall motion and wall thickening, left ventricular ejection fraction (LVEF) is 67%. C. Continued: quantitative analysis of the resting SPECT images. Quantitative analysis demonstrating normal wall motion and wall thickening, LVEF is 68%.

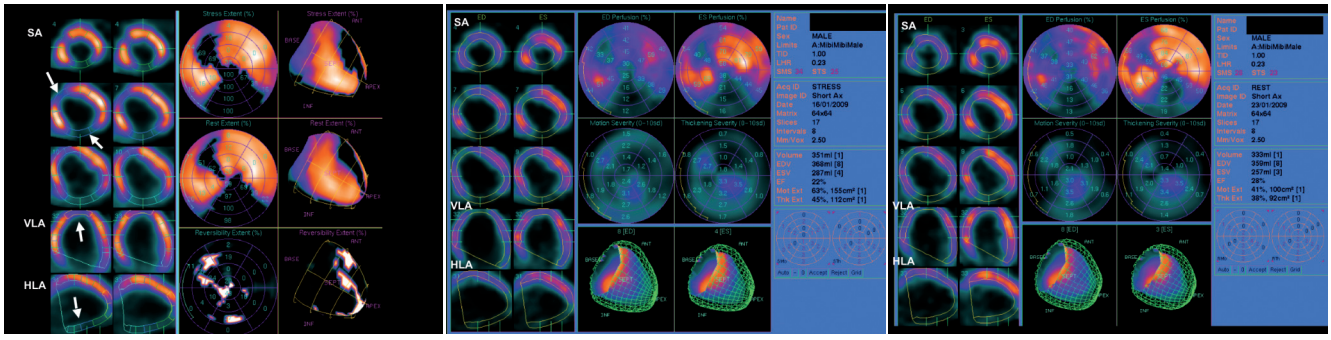

Figure 4. Example of a dobutamine stress gated ^{99m}Tc-sestamibi SPECT study in ischaemic left ventricular dysfunction for assessment of myocardial perfusion and function. A. Dobutamine stress gated ^{99m}Tc-sestamibi SPECT in a male patient with a history of myocardial infarction and coronary bypass surgery. Left column, from top to bottom: short-axis (SA), vertical long-axis (VLA) and horizontal long-axis (HLA) slices. There is a fixed perfusion defect in the anterior, septum, inferior and apical regions (white arrows). The polar maps in the middle and right column confirm these fixed perfusion defects and demonstrate limited defect reversibility at the borders of the fixed perfusion defect. This was reflected by the summed stress score (SSS) of 24, the summed rest score (SRS) of 18, resulting in a summed difference score (SDS) of 6. B. Continued: quantitative analysis of the dobutamine SPECT images. Left column: end-diastolic (ED) and end-systolic (ES) slices demonstrating extensive wall motion abnormalities, most pronounced in the regions with the fixed perfusion defects. Middle column from top to bottom: ED and ES polar plots, quantitative analysis demonstrating extensive and severe wall motion abnormalities and abnormal wall thickening. The summed wall motion score (SMS) is 34 and the summed thickening score (STS) is 25. The left ventricle is severely dilated with an end-diastolic volume of 368 ml and an end-systolic volume of 287 ml, the left ventricular ejection fraction (LVEF) at stress is 22%. C. Continued: quantitative analysis of the resting SPECT images demonstrating extensive wall motion abnormalities and abnormal wall thickening in the anterior, septum and inferior regions. The SMS is 28, STS is 23, and the LVEF at rest is 28%.

will appear as a perfusion defect with preserved wall motion and thickening, from a true perfusion defect with decreased wall motion and thickening. Therefore, with the introduction of gated SPECT, the number of equivocal and false positive studies has been significantly reduced.

Combined assessment of myocardial perfusion and left ventricular function cab be useful for assessment of myocardial viability. Several approaches have been used in an attempt to improve the diagnostic accuracy of SPECT for the prediction of improvement of left ventricular function following coronary revascularisation. In the most straightforward protocol, segments with preserved wall thickening are considered viable, irrespective of the perfusion pattern. Some studies have used this approach and showed an improved diagnostic accuracy of ^{99m}Tc-sestamibi SPECT for the assessment of myocardial viability[9].

A promising method for evaluation of myocardial viability is simultaneous assessment of myocardial perfusion and contractile reserve by gated SPECT. Contractile reserve is a well established marker of viable myocardium, and can be evaluated by inotropic stimulation with low-dose dobutamine infusion. Irreversibly scarred nonviable myocardium does not show contractile reserve during low-dose dobutamine infusion. Leoncini et al[10] studied 33 patients with ischaemic left ventricular dysfunction who underwent coronary revascularisation, with nitrate-enhanced resting and dobutamine ^{99m}Tc-sestamibi gated SPECT. Assessment of contractile reserve using dobutamine gated SPECT enhanced the reliability of nitrate-enhanced ^{99m}Tc-sestamibi SPECT when used to predict reversible dysfunction in hypokinetic segments, whereas perfusion quantification was superior in akinetic and dyskinetic segments.

Diagnostic accuracy of SPECT

A recent meta-analysis demonstrated that multiple studies have evaluated the diagnostic accuracy of SPECT for the assessment of myocardial viability[3]. In these studies different endpoints have been used. A total of 68 studies focused on the prediction of recovery of regional contractile function after revascularisation (Table 2). Seven studies evaluated the diagnostic accuracy of SPECT for the prediction of recovery of global left ventricular dysfunction (ejection fraction) after revascularisation (Table 3), and nine studies have focused on survival, which may be the most relevant endpoint from a clinical point-of-view.

^{201}Thallium

The pooled analysis of the 40 available studies, including a total of 1,119 patients, using ^{201}Tl SPECT for the prediction of improvement of regional contractile function after revascularisation demonstrated a sensitivity of 87% and specificity of 54%[3]. Three studies, including a total of 95 patients, evaluated ^{201}Tl SPECT for the prediction of recovery of global left ventricular function, demonstrating a sensitivity of 84% and specificity of 53%.

^{99m}Technetium

The pooled analysis of the 25 available studies, including 721 patients, that evaluated ^{99m}Tc-sestamibi and ^{99}mTc-tetrofosmin for the prediction of recovery of regional contractile function, demonstrated a sensitivity of 83% and a specificity of 65%[3]. Two studies including 98 patients evaluated ^{99m}Tc-sestamibi for the prediction of recovery of global left ventricular function after revascularisation, and had a sensitivity of 84% and specificity of 68%.

^{18}F-FDG

Three studies, including 149 patients, evaluated the diagnostic accuracy of ^{18}F-FDG SPECT[11-13]. Pooled analysis showed that the sensitivity and specificity for the prediction of recovery of regional contractile function after revascularisation were 87% and 80% respectively. Two of these studies, including a total of 94 patients, evaluated ^{18}F-FDG SPECT for the prediction of recovery of global left ventricular function after revascularisation, demonstrating a sensitivity of 83% and specificity of 96%[12,13].

A more recent study demonstrated that ^{18}F-FDG SPECT is practical for routine assessment of myocardial viability even in the challenging subset of patients with diabetes[7]. In 130 patients with ischaemic left ventricular dysfunction, ^{18}F-FDG SPECT had a sensitivity of 83% and specificity of 93% for the prediction of recovery of global contractile function after revascularisation in patients without diabetes, and a sensitivity 82% and specificity 89% in patients with diabetes; the differences were not statistically significant.

Table 2. Accuracy of SPECT to predict recovery of regional left ventricular function after revascularisation.

	Sensitivity (%) (segments)	Specificity (%) (segments)	PPV (%) (segments)	NPV (%) (segments)
^{201}Tl (1119 patients, 40 studies)	87 (2559/2931)	54 (1431/2655)	67 (2557/3810)	79 (1431/1814)
^{99m}Tc (721 patients, 25 studies)	83 (1170/1414)	65 (778/1189)	74 (1170/1581)	76 (778/1022)
^{18}F-FDG (149 patients, 3 studies)	87 (313/361)	80 (424/530)	75 (313/419)	90 (424/472)

NPV: negative predictive value; PPV: positive predictive value; Data based on references 3,11,12,13.

Table 3. Accuracy of SPECT to predict recovery of global left ventricular function after revascularisation.

	Sensitivity (%) (patients)	Specificity (%) (patients)	PPV (%) (patients)	NPV (%) (patients)
^{201}Tl (95 patients, 3 studies)	84 (51/61)	53 (18/34)	76 (51/67)	64 (18/28)
^{99m}Tc (98 patients, 2 studies)	84 (43/51)	68 (32/47)	74 (43/58)	80 (32/40)
^{18}F-FDG (94 patients, 2 studies)	83 (40/48)	96 (44/46)	95 (40/42)	85 (44/52)

NPV: negative predictive value; PPV: positive predictive value; Data based on reference 3,12,13

Long-term survival

In patients with ischaemic left ventricular dysfunction, multiple factors including age, left ventricular function, multivessel disease, and concomitant disease such as diabetes are important predictors of outcome[14]. Additional prognostic information is provided by assessment of myocardial viability using SPECT. The presence and extent of dysfunctional but viable myocardium is an important predictor of survival. Multiple retrospective studies have shown that patients with ischaemic cardiomyopathy and viable myocardium are at an increased risk for cardiac events when treated medically. There is a substantial survival benefit in patients with a substantial amount of viable myocardium after coronary revascularisation. Pooled analysis of eight studies using ^{201}Tl SPECT for the assessment of myocardial viability, demonstrated a annualised mortality rate of 4% in patients with a substantial amount of viability who underwent coronary revascularisation[3]. The annualised mortality rate was as high as 14% in patients without substantial viability on ^{201}Tl SPECT who underwent coronary revascularisation (Figure 5). Annualised mortality rate was 7% both in patients with and without substantial viable myocardium treated medically. One study employed ^{99m}Tc-sestamibi SPECT and demonstrated an annualised mortality rate of 3% in patients with substantial viability who underwent coronary revascularisation, and 9% in patients with substantial viability treated medically[15]. Patients without substantial viability were not studied. It should be noted however that most of these data were obtained retrospectively and treatment decisions were not standardised.

Suggested clinical applications

In which patients should assessment of myocardial viability be considered?

The European Society of Cardiology (ESC) practice guidelines for the diagnosis and treatment of acute and chronic heart failure recommend that assessment of myocardial viability should be considered in the diagnostic work-up in heart failure patients with coronary artery disease, as viable myocardium may be a target for revascularisation[16]. In line with this, the ESC guidelines for the management of acute ST-elevation myocardial infarction (STEMI) suggest assessment of myocardial viability in patients with severely impaired left ventricular function after STEMI when the need for revascularisation to improve function is considered[17]. Left ventricular dysfunction in patients who suffered from a myocardial infarction may be due to myocardial necrosis, to stunning of viable myocardium remaining in the infarct territory, to hibernation of viable myocardium, and patients frequently have a combination of all three.

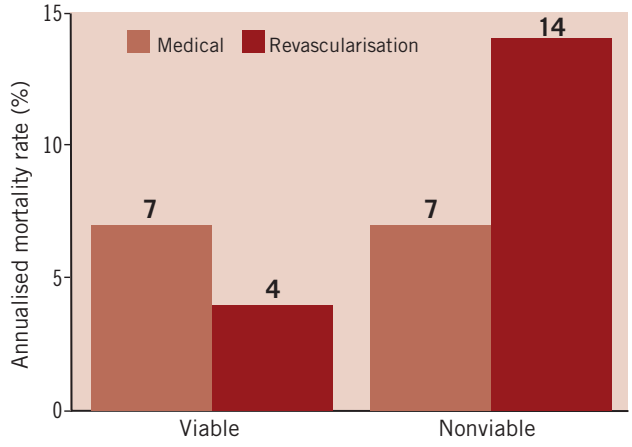

Figure 5: Pooled analysis of data from eight studies using ^{201}Tl SPECT for assessment of long-term survival. Annualised mortality rates in patients with viable and nonviable myocardium in relation to treatment (revascularisation or medical therapy). Figure based on reference 3.

What is the preferred imaging technique for assessment of myocardial viability?

In patients with ischaemic left ventricular dysfunction, echocardiography is the most useful method for the evaluation of systolic and diastolic left ventricular function[16]. In all patients with suspected heart failure and/or left ventricular dysfunction this diagnosis should be confirmed shortly by echocardiography. Evaluation of cardiac dimensions, regional and global left ventricular function, wall thickness, valvular structure and function, mitral diastolic flow profile, tricuspid regurgitation, the pericardium, and inferior vena cava, may provide important information on the aetiology, severity, and prognosis of heart failure. In patients with ischaemic left ventricular dysfunction, assessment of left ventricular wall thickness by echocardiography provides information on myocardial viability[18]. A wall thickness <6 mm is indicative of nonviable scar tissue, and virtually excludes the presence of viable myocardium. In dysfunctional segments with a preserved wall thickness an additional imaging technique is needed to evaluate myocardial viability.

Several imaging techniques are available for assessment of myocardial viability. The most frequently used techniques for the evaluation of myocardial viability are: stress echocardiography, magnetic resonance imaging, SPECT and positron emission tomography[2,3]. These imaging techniques investigate different features of dysfunctional viable myocardium, resulting in a different diagnostic accuracy between these techniques. A recent meta-analysis of the available literature demonstrated that positron emission tomography and SPECT have a high sensitivity for the prediction of recovery of function following revascularisation, whereas dobutamine stress echocardiography has a somewhat lower sensitivity than the other imaging technique[3]. Conversely, dobutamine stress echocardiography has a high specificity for the prediction of recovery of function following revascularisation, whereas the specificity of the nuclear imaging techniques is somewhat lower. The choice of the imaging technique not only depends on the diagnostic accuracy but also on patient-related factors such as body habitus, heart rhythm (atrial fibrillation), contraindicated devices (implantable pacemakers and defibrillators), renal function, claustrophobia, and hospital-related factors including local expertise, cost, and availability. Each of the aforementioned imaging techniques may provide valuable information on myocardial viability.

How to use information on myocardial viability for clinical decision making?

Treatment of patients with ischaemic left ventricular dysfunction has been reoriented by the development of novel surgical approaches and the increased use of percutaneous coronary interventions in patients with complex coronary artery disease[19]. In high-risk patients, percutaneous coronary intervention during support with a left ventricular assist device may contribute to a reduced procedural risk and improved survival. The increasing therapeutic options for patients with ischaemic left ventricular dysfunction render clinical decision-making for intervention more complex. Assessment of myocardial viability may help to select the appropriate therapy for these patients.

Preferably, the clinical information, the results from coronary angiography and the information on myocardial viability are evaluated by a heart team consisting of cardiologists, cardiothoracic surgeons, and anaesthesiologists. Optimal medical therapy according to current practice guidelines is indicated in all patients with ischaemic left ventricular function, some patients may benefit from additional coronary revascularisation[16,17]. Clearly, clinical variables, including symptoms, coronary anatomy, prior revascularisation, concomitant valvular heart disease, comorbidities, and patient preferences and expectations are important factors in the clinical decision making in patients with ischaemic left ventricular dysfunction. The presence and extent of myocardial viability assessed by non-invasive imaging can be used to estimate the effect of coronary revascularisation on regional and global left ventricular function and survival. On basis of the available literature, approximately 50% of the patients with ischaemic left ventricular dysfunction has a substantial amount of dysfunctional but viable myocardium and should be considered for coronary revascularisation[20]. The absence of myocardial viability can help to identify patients who will not benefit from high-risk percutaneous coronary interventions or surgery.

Conclusions

In patients with ischaemic left ventricular dysfunction eligible for coronary revascularisation, assessment of myocardial viability with ^{201}Tl, ^{99m}Tc-sestamibi, ^{99m}Tc-tetrofosmin, or ^{18}F-FDG SPECT should be considered. The information on myocardial viability obtained with SPECT may facilitate clinical decision making and thereby improve long-term survival of patients with ischaemic left ventricular dysfunction.

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