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Gated single-photon emission computed tomography

The present-day "one-stop-shop" for cardiac imaging

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Gated single-photon emission computed tomography (SPECT) is the current state-of-the-art approach to myocardial perfusion imaging. Initially, major emphasis was given to the improvement in diagnostic accuracy of myocardial perfusion imaging for the detection of coronary artery disease, because the evaluation of wall motion and thickening allows the recognition of attenuation artifacts and increases the observer's confidence. Different processing algorithms make possible to perform a reproducible and reliable assessment of left ventricular (LV) function, which has been extensively validated against various reference methods. Several articles report the additional value of functional data derived from gated SPECT to increase the accuracy of myocardial perfusion imaging in particular patient groups, such as women, to enhance the detection of multivessel coronary artery disease, and to permit the recognition of severe stenosis. An extensive literature indicates that gated SPECT allows a more accurate and reliable prognostic stratification of patients with known coronary artery disease. More recently, the peculiar contribution of gated SPECT in the assessment of myocardial viability has been demonstrated, with the possibility to evaluate in a single myocardial perfusion study the presence of preserved tracer uptake and the amount of contractile reserve through the acquisition of gated SPECT during inotropic stimulation with dobutamine. The most recent advance in the application of gated SPECT is the use of this technique for the reproducible assessment of LV functional changes, at follow-up or during inotropic stimulation, with perfusion data in the background. Various clinical settings, such as assessment of response to medical or resynchronization therapy in dilated or ischemic cardiomyopathy, prediction of outcome in chronic coronary artery disease with LV remodeling, evaluation of different treatment strategies in acute myocardial infarction, could take advantage from the unique combination of perfusion and functional data made possible by the use of gated SPECT. In conclusion, myocardial perfusion imaging with gated SPECT is a convincing reality in the field of cardiac imaging and has a still largely unexplored potential for a wider use in heart disease.

Key words: Tomography, emission computed, single photon – Heart, radionuclide imaging – Myocardium.

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Since its introduction, gated single-photon emission computed tomography (SPECT) has been a major breakthrough in the practice of nuclear cardiology.[1, 2] The possibility to simultaneously assess both myocardial perfusion and left ventricular (LV) wall motion has deeply modified the approach to myocardial perfusion imaging. Most importantly, several applications of the combination of perfusion and functional data have been proposed, opening the way to a more comprehensive and accurate evaluation of patients with suspected or known coronary artery disease. In this regard, gated SPECT could be presently considered the imaging technique nearest to the ideal concept of a diagnostic and prognostic "one-stop-shop" in the field of coronary artery disease. The aim

TABLE I.—*Validation of gated SPECT LVEF and LV volume measurement against various reference methods.*

Authors	Patients	Reference method	LVEF	End-diastolic vol.	End-systolic vol.
Williams *et al.*[8]	38	First pass	r=0.83		
Germano *et al.*[9]	65	First pass	r=0.91		
Kang *et al.*[10]	31	First pass	r=0.96		
Yang *et al.*[11]	21	ERNA	r=0.87		
Marinque *et al.*[12]	50	ERNA	r=0.82		
Vera *et al.*[13]	43	ERNA	r=0.80	r=0.86	r=0.89
Chua *et al.*[14]	62	ERNA	r=0.94	r=0.88	r=0.95
Nichols *et al.*[15]	66	Echocardiography	r=0.85		
Cwajg *et al.*[16]	109	Echocardiography	r=0.72	r=0.87	r=0.86
Nichols *et al.*[17]	33	Echocardiography	r=0.92	r=0.90	r=0.90
Vourvouri *et al.*[18]	32	Echocardiography	r=0.83	r=0.94	r=0.96
Williams *et al.*[8]	54	Ventriculography	r=0.93		
Nichols *et al.*[15]	58	Ventriculography	r=0.86	r=0.87	r=0.91
Yoshika *et al.*[19]	21	Ventriculography	r=0.87	r=0.73	r=0.83
Stollfuss *et al.*[20]	19	MRI	r=0.71		
Vaduganathan *et al.*[21]	25	MRI	r=0.93	r=0.81	r=0.92
Bax *et al.*[22]	22	MRI	r=0.90	r=0.84	r=0.87
Tadamura *et al.*[23]	20	MRI	r=0.94	r=0.92	r=0.97

ERNA: equilibrium radionuclide angiocardiography; first-pass: first-pass ventriculography; MRI: magnetic resonance imaging; ventriculography: contrast ventriculography; vol.: volume.

of this review is to examine the state-of-the-art use of gated SPECT and to define its current value in the context of cardiac imaging.

Technical issues

The basic principles of the electrocardiographic gating of SPECT are well known. The technical requirements for an acceptable study are nowadays fulfilled by most gamma camera systems. Similarly, the available processing algorithms allow a reliable calculation of functional parameters. However, the specific problems related to the electrocardiographic gating of tomographic studies should be kept in mind, since they may create unique artifacts. The presence of variability in the R-R interval may lead to major count loss in the later frames, which in turn may propagate in the reconstructed images in form of streaking artifacts, when the count-deficient frame is normalized to the reference frame. Filtering of low-counts, noisy projections may produce dark bands or apparent clumping of counts in the myocardial wall. Temporal blurring in the instance of major and persistent R-R interval variability may yield radial blurring of the reconstructed images, or affect the definition of the systolic frame and the consequent measurement of volumes and ejection fraction (EF).[3] Nichols *et al.*[4] demonstrated a relationship between arrhythmia severity and changes in gated SPECT parameters: atrial fibrillation is clearly the most adverse condition and wall thickening assessment the most sensitive parameter, while EF appeared a quite robust measurement. In the case of atrial fibrillation, even summed perfusion images could be affected by gating artifacts.[4, 5] Patients with severe arrhythmia pose a problem and may be considered unsuitable for gated SPECT imaging. In case of premature ventricular contractions, a rate of 1 every 6 beats has been proposed as the upper limit acceptable for gating.[3] More recently, ASNC proposed the limit of >20% of premature beats to classify a patient as not suitable for gated SPECT.[2]

The problem of count density is particularly relevant to Tl-201 gated SPECT, because the signal-to-noise ratio is clearly lower than in Tc-99m perfusion studies, and appropriate filtering must be used. On the other hand, filtering may interfere with the detection of ventricular boundaries and cause overestimation of EF. This is particularly important in case of small hearts, where it may be observed with the Tc-99m-labelled perfusion agents as well. However, the possibility to overcome these limitations by means of hardware zooming, filtering with high cut-off frequency and better system resolution has been demonstrated even in pediatric patients.[6] Another possible source of defective edge detection is the presence of extensive and severe perfusion defects.[7]

Validation of functional data derived from gated SPECT

As summarized in Table I,[8-23] a large number of clinical studies have convincingly proven the very good correlation between gated SPECT and other established techniques in the assessment of global LV function (LV volumes and LVEF) and in the evaluation of regional wall motion and thickening.[8-17, 19-25] Moreover, the reproducibility of gated SPECT measurements has been reported to be high. In a very recent study, Verberne *et al.*[26] demonstrated that in 22 patients who underwent 2 repeated gated SPECT acquisitions, the LVEF differed less than 1 EF unit: 0.9% (95% confidence interval – 1.15% to 1.33%). De Winter *et al.*[27] reported similar results in patients with LV dysfunction due to ischemic cardiomyopathy. Vallejo *et al.*[28] had observed slightly higher variations in repeated measurements, which appeared to be greater if the study was acquired after the injection of a low tracer dosage (555 MBq, 15 mCi). However, in the case of high-dose studies, the presence of perfusion defects did not affect the reproducibility of the LVEF measurement.[28] Differences exist when the processing algorithms currently available are compared: although this does not limit the overall clinical value of the various methods, it precludes the possibility to compare values that have not been obtained using the same procedure.[29, 30]

It has been shown that the lower limits of normalcy are slightly different, especially in the case of the LVEF, from those obtained using other imaging modalities. Recent studies have tried to identify the normal values in various groups of patients, demonstrating higher normal LVEF values in women than in men. Particularly, the lower limit of normal LVEF in men has been fixed at 41-43% and in women at 49-50%.[31, 32]

With regard to the assessment of regional function, the agreement between gated SPECT and echocardiography, which is the most used reference standard in clinical practice, has been reported to range from 91% to 56%.[33, 34] Of particular concern is the evaluation of regional function in patients with wide perfusion defects. In patients with prior infarction and LV dysfunction, Leoncini *et al.*[35] could demonstrate a good agreement (68%) in the qualitative scoring of the regional wall motion between Tc-99m-sestamibi gated SPECT and echocardiography, with a k=0.54. No differences in the various coronary distribution territories were registered and the wall motion score index of the single coronary territories estimated using gated SPECT showed a good correlation with the corresponding value obtained using echocardiography (Spearman r=0.78, p<0.0001). These results were confirmed by Vourvouri *et al.*,[18] who, in a patient population with ischemic cardiomyopathy, demonstrated an overall 69% agreement (k=0.61) between gated SPECT and echocardiography for the assessment of regional wall motion and a close correlation in the measurements of both LV volumes and LVEF. Bax *et al.*[22] performed a similar comparative study between gated SPECT and magnetic resonance imaging: together with the close correlation of LV volumes and LVEF, an excellent agreement in the assessment of regional wall motion was registered, with 83% exact agreement and k=0.77.

Gated SPECT and diagnosis of coronary artery disease

It is well known that perfusion SPECT is highly sensitive but moderately specific for detecting coronary artery disease. One of the reasons that limit specificity is the presence of attenuation artifacts (breast tissue, diaphragm) that appear as perfusion defects and can be hardly differentiated from fixed defects caused by a previous myocardial infarction. By combining the evaluation of regional wall motion and thickening with the assessment of perfusion it is possible to distinguish an attenuation artifact, which will show some degree of preserved wall motion and thickening, from scarred tissue, which conversely will show absent or severely reduced wall motion and thickening.[36] Thus, the introduction of gated SPECT has increased the diagnostic accuracy of perfusion imaging by reducing the number of false positive or equivocal studies.

This was clearly established by Smanio *et al.*,[37] who showed that in 137 patients with low (<5%) pretest likelihood of coronary artery disease, the evaluation of gated images significantly increased the percentage of normally interpreted results (from 74% to 91%, p<0.001), with a clear reduction in the cases classified as probably normal or probably abnormal. More recently, Links *et al.*[38] demonstrated that gating and attenuation correction act synergistically in improving the diagnostic accuracy of perfusion SPECT. Furthermore, the use of gating increases the inter- and intraobserver reproducibility of the qualitative assessment of myocardial perfusion.[39] In a most recent study, the value of gated SPECT for discriminating infarct from artifact in perfusion imaging has been confirmed using tetrosfosmin instead of sestamibi.[40] In theory, the demonstration of normal regional wall motion and thickening is very useful also to reinforce the operator's opinion in case of a normal stress study and could at least in selected cases make unnecessary the acquisition of a resting perfusion scan.[41] The gain in specificity caused by the use of gated SPECT is particularly important in women, and supports the consensus that gated myocardial perfusion SPECT is probably the modality of choice for the noninvasive evaluation of women with an intermediate pretest likelihood of coronary artery disease.[42]

Another diagnostic advantage of gated SPECT is based on the recognition in the poststress acquisition of regional wall motion and thickening abnormalities caused by the persistence of postischemic stunning.[43] This finding can be particularly useful to detect patients with multivessel coronary artery disease. In a study by Mazzanti *et al.*,[44] the detection of transient LV dilatation at 15 minutes after stress compared with postrest gated SPECT identified the patients with diffuse and severe coronary artery disease with high specificity (95%) and good sensitivity (71%). Sharir *et al.*[45] showed that considering either the presence of a severe perfusion defect or of a postexercise wall motion abnormality allowed the detection of any severely stenosed vessel with 82% sensitivity, compared with 49% sensitivity of a severe perfusion defect alone. Emmett *et al.*[46] observed that the presence of reversible regional wall motion abnormalities identified as severe the coronary artery stenoses with 53% sensitivity and 100% specificity and was able to stratify the patients according to the severity of angiographic stenoses with a high positive predictive value; furthermore, there was a good correlation between the presence of reversible regional wall motion abnormality and the coronary artery jeopardy score. Two studies by the same group pointed out that the combination of reversible perfusion defects and poststress regional wall motion abnormalities or poststress worsening of LV EF was significantly more sensitive in the detection of multivessel coronary artery disease than reversible perfusion defects alone even using Tl-201 as the perfusion agent.[47,48] Finally, Lima *et al.*[49] demonstrated that the number of abnormal territories by combined perfusion/function was a most powerful predictor of multivessel disease and significantly more abnormal territories in patients with three-vessel disease were detected by this approach than using perfusion alone (60% vs 46%, $p<0.05$). The evaluation of regional function has been shown to be useful in the interpretation of the septal perfusion abnormalities in patients with left bundle branch block.[50] Finally, the availability of functional data, particularly of those obtained from gated SPECT, has been shown to improve the diagnostic reliability of cardiac imaging in patients admitted to the emergency department because of chest pain.[51]

Prognostic applications of gated SPECT

Gated SPECT offers important additional prognostic information over that given by perfusion data alone. The first and most obvious prognostic parameter is the resting LVEF, which importance cannot be overemphasized.[52] As recently demonstrated, this parameter has a predictive value for the development of heart failure in patients with a first non-complicated myocardial infarction.[53]

The widest experience about the prognostic value of the functional parameters derived from gated SPECT, however, is based on the poststress LVEF in the context of the dual isotope (rest Tl-201 – stress Tc-99m-sestamibi) protocols of the Cedars Sinai group. This parameter can be partly influenced by the presence of postischemic stunning and thus should be considered slightly different from a true resting LVEF. In a first report, Sharir *et al.*[54] proved the incremental prognostic value of the LV volumes and LVEF calculated using a poststress gated SPECT over the perfusion data of traditional perfusion SPECT. The incremental prognostic value was clearly apparent in the patients classified as intermediate risk on the basis of the perfusion pattern. In this group of patients, the functional parameters obtained using a poststress gated SPECT acquired 30 minutes after exercise differentiated the low risk patients ($LVEF>45\%$ or end-systolic volume <70 ml) from those at high risk of death ($LVEF<45\%$ or end-systolic volume >70 ml). In a later report, the same authors showed that perfusion data, in particular the extent of perfusion defect reversibility, were the most powerful independent predictors of nonfatal myocardial infarction, whilst the poststress LVEF was an independent predictor of death.[55] The combination of perfusion and functional changes identifies 3 groups of patients at different risk of major cardiac events (death and myocardial infarction). Low risk patients are those without inducible ischemia and with poststress LVEF>30% or those with moderate inducible ischemia but with preserved LV function (LVEF>50%). Intermediate risk patients are those with severe ischemia and with poststress LVEF>30% or those with moderate ischemia and with mild-moderate LV dysfunction (poststress LVEF>30 and ≤50%). High-risk patients are those with poststress LVEF<30%. These observations were confirmed by other authors,[56] who demonstrated that a poststress LVEF<40% has a unfavorable prognostic meaning in the prediction of major cardiac events even in patients without scintigraphic findings of ischemia. Hashimoto *et al.*[57] showed the incremental prognostic value of combined perfusion/function in patients candidate to major non-cardiac surgery. Spinelli *et al.*[58] demonstrated the incremental prognostic value of the assessment of regional ventricular function by gated SPECT in patients with acute myocardial infarction. Travin *et al.*[59] established the incremental prognostic value of regional wall motion abnormalities and LVEF in patients studied for suspect coronary artery disease and who were not submitted to early revascularization procedures. Most recently, Thomas *et al.*[60] demonstrated the prognostic value of functional parameters, including transient ischemic dilatation and LVEF in a large population of patients studied in an outpatient setting. In this study, both the increasing ischemic burden and the lower LVEF were related to a worse prognosis and to a higher rate of angiographic studies and revascularization procedures.

Gated SPECT and myocardial viability

The recognition of viable myocardium in patients with LV dysfunction of ischemic origin has become a major task of diagnostic imaging in cardiology. From the very beginning of gated SPECT, various studies examined whether the gating of perfusion images might be helpful for improving the accuracy of myocardial perfusion scintigraphy in the prediction of reversible regional dysfunction. The most straightforward approach was to include in the definition of viable myocardium all segments with preserved thickening, independently of their perfusion pattern. Using this approach, Levine *et al.*[61] and Duncan *et al.*[62] were able to predict the functional recovery after revascularization with a sensitivity and accuracy higher than using resting Tc-99m-sestamibi perfusion data alone and comparable to those achieved with Tl-201 rest-redistribution imaging. On the other hand, Stollfuss *et al.*[20] did not find any significant improvement in sensitivity and specificity using the regional thickening than using perfusion data alone. More recently, Mabuchi *et al.*[63] reported very good results using the resting wall thickening data derived from the QGS program for predicting the presence of reversible dysfunction. However, Kang *et al.*[64] were unable to demonstrate a significant predictive value of preserved thickening in a large group of patients submitted to resting Tl-201 and dipyridamole sestamibi gated SPECT. Although in this study the influence of postischemic stunning on regional wall thickening should be considered, it must be reminded that the absence of systolic thickening does not exclude the presence of myocardial viability and, conversely, preserved thickening in the instance of subendocardial infarction does not imply a further improvement in regional function after revascularization.

Another approach was suggested by the observation that the activity thresholds for Tl-201 or Tc-99m-sestamibi that best separate the segments with from those without reversible dysfunction are different according to the severity of baseline echocardiographic asynergy, being higher in the hypokinetic than in the a-dyskinetic segments.[65] Gated SPECT is very well suited to recognize the dysfunctional myocardial segments, to classify them on the basis of the severity of baseline asynergy and to directly estimate the tracer activity within the dysfunctional segment. This simplifies the use of appropriate activity thresholds according to the degree of regional asynergy without the inherent difficulty of overlapping images obtained by different modalities. Leoncini *et al.*[66] demonstrated that the use of a ≥50% activity threshold for the a-dyskinetic segments and >68% for the hypokinetic segments, as identified on the basis of gated SPECT wall motion analysis, allowed a significant increase in specificity (from 54% to 73%, $p<0.0001$) and accuracy (from 64% to 74%, $p<0.02$) of nitrate-enhanced Tc-99m sestamibi perfusion imaging, without a significant decrease in sensitivity (from 83% to 76%).

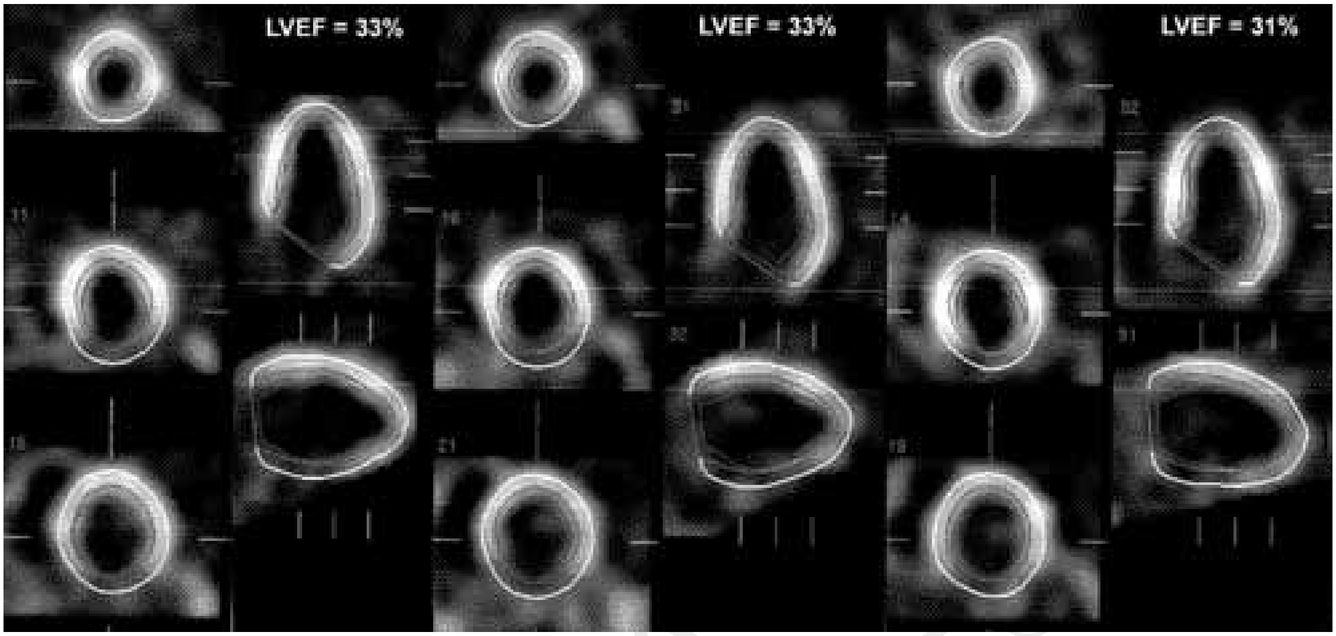

Figure 1.—Gated SPECT studies of a patient with coronary artery disease and LV dysfunction. From left to right: short axis slices, midventricular horizontal (top) and vertical (bottom) long axis slices of the prerevascularization nitrate-enhanced baseline study (columns 1 and 2); corresponding slices of the low-dose dobutamine study (columns 3 and 4) and of the postrevascularization follow-up study (columns 5 and 6). The absence of changes in regional wall motion and LVEF during inotropic stimulation predicts the lack of improvement after revascularization.

An alternative and probably more promising approach is based on the capability of gated SPECT to detect the regional wall motion and systolic thickening changes induced by inotropic stimulation and hence to assess the contractile reserve, which is another well established marker of myocardial viability, as clearly demonstrated by echocardiographic studies.[35, 67-69] In the comparison with FDG PET, the use of contractile reserve assessed by gated SPECT significantly increased the specificity over perfusion data alone (100% vs 52%, $p<0.05$).[70] However, sensitivity for FDG PET viable myocardium appeared to be lower than that registered using tracer uptake threshold criteria.[71] The gated SPECT evaluation of the contractile reserve predicted the postrevascularization functional recovery with higher specificity (88% vs 55%) but lower sensitivity (64% vs 85%) than tracer activity.[72] However, it was found that the higher specificity of contractile reserve is particularly remarkable in the baseline hypokinetic and the higher sensitivity of perfusion tracer activity is more apparent in the baseline a-dyskinetic ones. Thus, a combined approach that defines viable the hypokinetic segments according to their contractile reserve assessed using gated SPECT under dobutamine infusion and the a-dyskinetic segments according to their tracer activity allows to predict the presence of reversible regional dysfunction with significantly higher specificity (83%) and accuracy (81%) than using perfusion imaging alone, and significantly higher sensitivity (78%) than using contractile reserve alone.[72] The advantage of combining perfusion threshold, inotropic and/or ischemic response to low dose dobutamine for the prediction of postrevascularization recovery was confirmed by Zafrir *et al.*[73] In a different setting of patients studied after acute myocardial infarction, Simoes *et al.* demonstrated the feasibility of low dose dobutamine gated SPECT even using Tl-201 as the perfusion tracer and confirmed the increase in specificity obtained by adding the contractile reserve data to the assessment of tracer uptake.[74] Similar results have been recently reported by Heiba *et al.* using low dose dobutamine in conjunction with the Tl-201 study of the dual isotope imaging protocol.[75]

An additional advantage of performing the simultaneous assessment of perfusion and functional

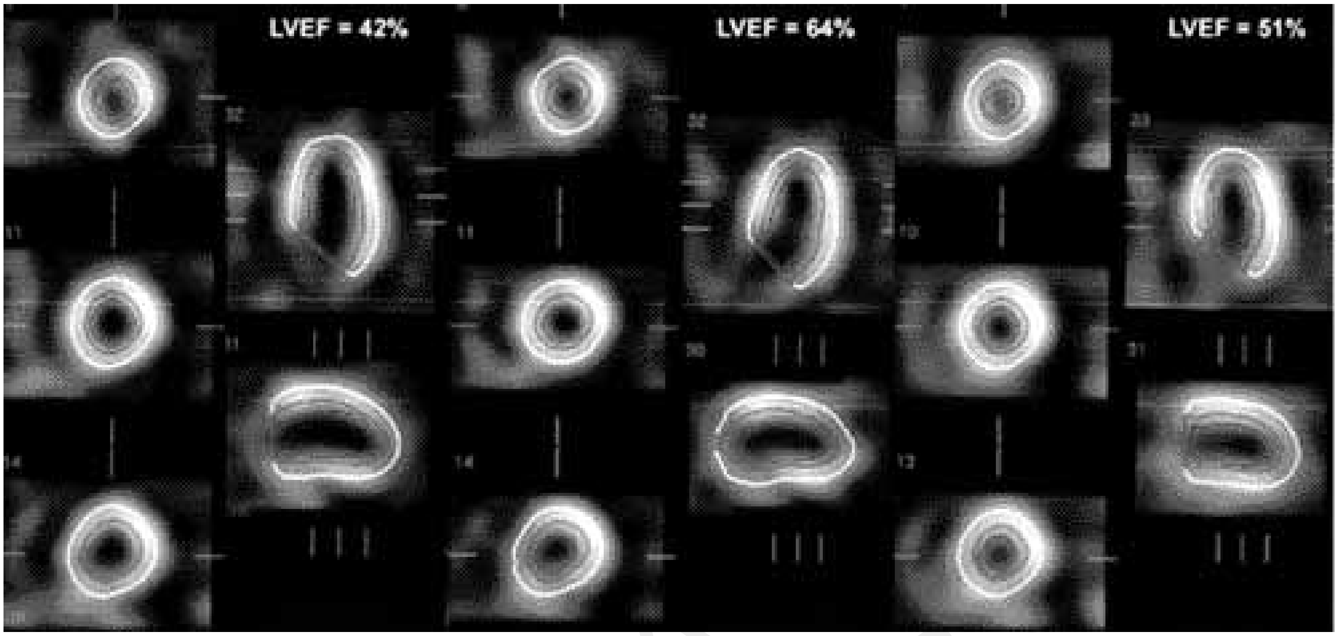

Figure 2.—Gated SPECT studies of a patient with coronary artery disease and LV dysfunction. Same image disposition as in Figure 1. The significant improvement in regional wall motion and the increase in LVEF during inotropic stimulation are predictive of postrevascularization recovery.

changes induced by an inotropic stimulation is the possibility to differentiate between the various physiopathologic conditions that lead to LV dysfunction. In the experimental setting, Chin *et al.*[76] demonstrated the value of this combined approach to differentiate between viable non-functioning myocardium and nontransmural scarring in a model of canine stunning and subendocardial infarction. In a human study, Sciagrà *et al.* used the combined perfusion/function assessment to differentiate between chronic stunning and true hibernation.[77]

Although the regional functional recovery is the established reference standard to define the presence of viable hibernating myocardium, in clinical terms the main purpose of viability imaging is to predict the presence and the amount of recovery in global LV function after successful revascularization.[78] It has been proven that the LVEF increase after revascularization is related to the extent of viable myocardium.[79, 80] However, a direct estimate of the future LVEF changes would be desirable. The reproducibility of gated SPECT functional data is very interesting for this aim. Leoncini *et al.*[81] observed a good correlation between the LVEF values measured during dobutamine infusion and those registered after revascularization ($r=0.84$, $p<0.00001$). Furthermore, a LVEF increase ≥5 EF units during dobutamine predicted an increase ≥5 EF units after revascularization with 77% accuracy, 73% positive and 81% negative predictive value. Figure 1 and Figure 2 show typical examples of low-dose dobutamine gated SPECT studies in the setting of ischemic cardiomyopathy.

Perfusion gated SPECT beyond perfusion

As described in the previous sections, the additional value of gating perfusion SPECT is certainly high. However, in the last few years, there is a growing number of reports describing settings in which the main purpose of the execution of gated SPECT is not the assessment of myocardial perfusion but the evaluation of ventricular function. The feasibility of gated SPECT and the good reproducibility of its functional measurements are the prerequisites for the novel applications of this technique. The clinical settings in which gated SPECT has been proposed to estimate functional changes are mainly those related to the presence of LV dysfunction.

In patients with recent-onset idiopathic dilated cardiomyopathy, Kasama *et al.*[82] could demonstrate that the LVEF changes induced by low dose dobutamine and evaluated using gated SPECT were predictive of the response to medical treatment, whilst the perfusion pattern was useless in this regard. Fukuchi *et al.*[83] examined using gated SPECT patients with established idiopathic dilated cardiomyopathy and demonstrated that the size of the perfusion defects and the sphericity index derived from gated SPECT volumes were both predictive of the response to β-blocker therapy. In patients with severe heart failure due to idiopathic dilated or ischemic cardiomyopathy submitted to cardiac resynchronization therapy with biventricular pacing, Sciagrà *et al.*[84] examined the changes in LV volumes and EF using repeated gated SPECT studies and observed that a significant objective improvement in functional parameters was detected only in the patients without perfusion defects. In a similar setting, Tsurugaya *et al.*[85] could classify the patients in responders and nonresponders to biventricular pacing on the basis of the improvement in LV synchrony assessed by repeated gated SPECT studies performed before and shortly after the onset of cardiac resynchronization therapy. In patients with severe LV dysfunction due to prior infarction, Fujii *et al.*[86] studied by gated SPECT the functional changes produced by endoventricular circular patch plasty performed in addition to coronary artery bypass grafting. They could demonstrate both short- and long-term reverse remodeling, with significant reduction in LV volumes and increase in LVEF. Most recently, Schäfers *et al.*[87] used gated SPECT to examine the evolution of myocardial remodeling in dilated cardiomyopathy after partial left ventriculectomy and mitral valve repair: the authors could identify a significant decrease in both end-diastolic and end-systolic volumes and an increase in LV ejection fraction early after the intervention, with further, albeit not statistically significant, improvement at late follow-up approximately 1 year later.

The evaluation of functional data can be an indication for performing gated SPECT in patients with preserved LV function as well. Zellweger *et al.*[88] studied patients treated with percutaneous coronary interventions and detected the presence of reverse remodeling with a significant decrease in both LV volumes in the patients without prior infarction and a significant decrease in endsystolic volume only in those with previous infarction. Another field of application of gated SPECT functional data is the characterization of regional wall motion abnormalities. For instance, Giubbini *et al.*[89] recently demonstrated that the combination of functional and perfusion data obtained from gated SPECT is the optimal approach to interpret the meaning of septal wall motion abnormalities in patients submitted to coronary artery bypass grafting. It is well known that gating offers major advantages for evaluating the meaning of septal perfusion defects in patients with left bundle branch block [47] and a recent study suggests that it could be a most important tool to clarify the many unresolved issues of this electrocardiographic pattern.[90] Finally, the execution of repeated gated SPECT studies appears a valuable method to assess the effectiveness of primary percutaneous coronary interventions in the setting of acute myocardial infarction, offering the possibility to directly correlate the extent of myocardial salvage with the degree of functional recovery.[91, 92]

Although these functional indications to gated SPECT are still investigational, they open the way to a more widespread use of perfusion imaging. There are no doubts that the execution of gated SPECT in patients in whom perfusion data are redundant will be limited to particular cases. Nevertheless, as shown by several examples, the availability of both perfusion and functional data is significantly advantageous in various circumstances, and not necessarily the most important is the perfusion pattern. Moreover, because of the overwhelming prevalence of coronary artery disease as etiology of LV dysfunction, the execution of gated SPECT in patients presenting with heart failure symptoms is fully justified both from the point of view of establishing the diagnosis and of assessing the functional status. Therefore, it is predictable that we will assist to a growing use of perfusion gated SPECT and to the expansion of its indications, at least until other imaging modalities will not be capable to achieve the same degree of feasibility and reliability in the assessment of perfusion and function.

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