

# Does myocardial viability detection improve using a novel combined $^{99m}\text{Tc}$ sestamibi infusion and low dose dobutamine infusion in high risk ischemic cardiomyopathy patients?

 Padma Subramanyam,  Shanmuga Sundaram Palaniswamy

Department of Nuclear Medicine & Molecular Imaging, Amrita Institute of Medical Sciences; Cochin-India

## ABSTRACT

**Objective:** Early identification of viable myocardium in ischemic cardiomyopathy (ICM) patients is essential for early intervention and better clinical outcome.  $^{99m}\text{Tc}$  sestamibi gated myocardial perfusion imaging (gMPI) is a well-established technique for myocardial viability evaluation. Detection of potentially viable segments is a predictor of hibernating myocardium. ICM patients with hibernation have a better prognosis after revascularization. We used a novel infusion technique to determine better viability detection preoperatively in challenging situations. Like thallium, does prolonged availability of sestamibi in circulation with additional low dose dobutamine steady infusion (DS Inf) facilitate improved myocardial viability?

**Methods:** A total of 58 ICM patients with infarct and left ventricular ejection fraction (LVEF) <45% underwent  $^{99m}\text{Tc}$  sestamibi bolus injection followed by slow intravenous infusion single-photon emission computed tomography (SPECT) using a 2 day protocol. After acquiring the second set of  $^{99m}\text{Tc}$  sestamibi infusion images, a third SPECT gMPI was performed during DS Inf.

**Results:** A 17-segment myocardial model was used; 52 of 58 patients (548/986 segments) demonstrated perfusion defects (nonviable myocardium) on bolus study. Only 24 patients demonstrated viable segments by standard bolus imaging protocol. The slow MIBI infusion study demonstrated 158 viable segments (12 ICM patients), while combined infusion ( $^{99m}\text{Tc}$  sestamibi+DS Inf) exhibited an additional 6 patients with improved myocardial viability. Thus, 18 high risk patients benefited by this novel infusion technique to demonstrate viable myocardium on SPECT. There was a significantly higher sensitivity ( $p=0.05$ ) and positive predictive value ( $p=0.01$ ) in viability identification with the combined DS Inf technique. In dysfunctional segments, the rate of concordance for detecting viability between infusion and bolus techniques was 65%. Paired t test showed statistically significant improvement in viability detection with combined infusion compared to the bolus study ( $p=0.001$ ).

**Conclusion:** This novel infusion technique was shown to be feasible and incremental in viability detection in ICM patients with severe left ventricular dysfunction. It is a robust tool to guide revascularization, in high risk ICM patients. This study also showed that patients with large transmural MI demonstrated no significant improvement in myocardial perfusion status using either protocol. (*Anatol J Cardiol* 2020; 24: 83-91)

**Keywords:** myocardial viability,  $^{99m}\text{Tc}$  sestamibi, rest gated SPECT, dobutamine infusion, myocardial perfusion imaging, novel MIBI plus low dose dobutamine infusion

## Introduction

The incidence of heart failure secondary to coronary artery disease (CAD), also known as ischemic cardiomyopathy (ICM), has been increasing. This problem is clinically important due to its high mortality and morbidity rates. Accurate noninvasive determination of myocardial viability is critically important for clinical decision-making in ICM patients (1). Robust imaging techniques are needed to identify and guide the management of patients who would benefit most from revascularization in this high risk setting. Patients with chronic ischemic myocardium

and substantial zones of viable but underperfused myocardium have a better prognosis if revascularization results in improved regional and global left ventricular (LV) function. This leads to a greater reduction in heart failure symptoms and better exercise tolerance after revascularization. Studies have shown that patients with hibernation as the prominent cause of ICM have a better prognosis after revascularization than after medical therapy (2). As a result, there has been much interest in the use of perfusion tracers to detect viable myocardium in cases with potentially recoverable, but severely dysfunctional myocardium. Myocardial viability is best identified noninvasively by rest gated

**Address for correspondence:** Shanmuga Sundaram Palaniswamy, Department of Nuclear Medicine & Molecular Imaging, Amrita Institute of Medical Sciences; Cochin-India  
Phone: 917306479318 E-mail: drpsundaram@gmail.com

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single-photon emission computed tomography (gSPECT) myocardial perfusion imaging (gMPI) using Thallium ( $^{201}\text{Tl}$ )/Technetium ( $^{99\text{m}}\text{Tc}$ ) based agents. However, the gold standard investigation for cardiac viability evaluation is the  $^{18}\text{F}$ Fluorodeoxyglucose (FDG) cardiac positron emission tomography (PET) (3).

Studies have analyzed novel techniques using infusion or intracoronary instillation of  $^{201}\text{Tl}$  and  $^{99\text{m}}\text{Tc}$  sestamibi for myocardial viability estimation (4, 5). A few studies have specifically investigated the use of sestamibi infusion and have shown promising results. This concept has been strengthened further by the fact that there is minimal redistribution of sestamibi over time. This may overestimate nonviable myocardium in patients with LV dysfunction, in whom blood flow may be reduced at rest. Several studies exist on myocardial viability assessment using combination of SPECT and PET techniques; however, to our knowledge none have used the novel combined slow sestamibi+low dose dobutamine steady infusion (DS Inf).

Our pilot study was performed to study the feasibility of a novel infusion technique [slow IV sestamibi infusion over 1 hour followed by 5–10  $\mu\text{g}/\text{kg}/\text{min}$  of low DS Inf during gSPECT acquisition] to enhance viability detection. We hypothesized that slow IV infusion of sestamibi would augment the availability of the radiopharmaceutical to the chronically ischemic myocytes, like  $^{201}\text{Tl}$  due to minimal MIBI redistribution phenomena. As with an echocardiogram, we attempted to assess if simultaneous use of DS Inf during gSPECT acquisition facilitated better systolic wall thickening and improved existing dyskinetic segments. This challenge may increase the sensitivity of viability detection at high volume cardiac centers with non availability of PET. It also may be a good alternate in patients who are candidates for FDG cardiac PET, but have poor glycemic control.

## Methods

We prospectively enrolled 58 consecutive patients (50 men, 8 women; 35–68 years old; mean age 55.7 years) with ICM who were referred for myocardial viability evaluation between 2015 and 2016. The procedure was explained and informed consent was obtained. An equal number of patients (29 each) under two category were enrolled i.e with prior non-ST (NSTEMI) or ST (STEMI) elevated myocardial infarction (MI) (Table 1). Inclusion criteria were patients with a documented history of previous MI, resting left ventricular ejection fraction (LVEF) <45%, and a recent coronary angiogram. Exclusion criteria were patients with a left bundle branch block, recent coronary bypass/angioplasty (<6 months), concomitant cardiopulmonary or severe valvular disease, and LV aneurysm.

Medical records including demographic and personal details were tabulated for each patient. History of previous MI; post-MI angina; medications; and comorbidities, such as hypertension, diabetes mellitus, and dyslipidemia, were documented. Echocardiogram and coronary angiogram findings also were recorded.

**Table 1. Baseline patient characteristics**

Baseline patient characteristics	No. of pts
Age (years)	35-68 (mean 55.7)
Male : Female	50:08
NSTEMI : STEMI	29:29
Systemic hypertension	43
Diabetes mellitus	48
Dyslipidemia	23
Previous MI	58
Prior revascularization (PTCA:CABG)	20:12
Triple vessel disease	38
Double vessel disease	10
Single vessel disease	10
Anterior wall MI	30
Inferior wall MI	18
MI (combined territories)	10

Patients were instructed to continue their medications on the day of these tests as advised.

## Procedure

Day 1: All patients underwent conventional nitrate-augmented rest myocardial perfusion gSPECT 1 hour after the bolus IV administration of 20 mCi  $^{99\text{m}}\text{Tc}$  sestamibi and fatty meal intervention.

Day 2: 20 mCi  $^{99\text{m}}\text{Tc}$  sestamibi diluted with 100 mL normal saline was infused at a steady rate (100ml/hr). Then, 10 mg sublingual nitrate (Isosorbide Isonitrite) was given 10 minutes before imaging. Rest gSPECT images were acquired after a fatty meal within 30 to 45 minutes after sestamibi infusion. Next, a set of gSPECT images were reacquired 2 minutes after starting DS Inf (using an infusion pump at a steady rate of 5–10  $\mu\text{g}/\text{kg}$  body weight for the entire duration of gSPECT; i.e., approximately 18 minutes). During and after the DS Inf, patients were monitored for alterations in heart rate and blood pressure until baseline conditions returned.

## Imaging acquisition parameters and processing

Images were acquired on an ECAM dual head gamma camera (Siemens, Munich, Germany) in cardiac mode (72° angle) using low energy, high resolution parallel-hole collimators. Images were acquired from 45° right anterior oblique to 45° left posterior oblique (74 projections), 25 seconds per projection in step and shoot mode in 128×128 matrix and a zoom of 1.2, resulting in a pixel size of 5.49 mm with 20% window centered at 140-keV photo peak. Images were processed using a Butterworth filter with a cutoff of 0.6 cycles/cm, an order of 4, and were reconstructed with a ramp filter into short axis, vertical, and horizontal long axis slices.

### Interpretation

Images were blinded and an experienced nuclear physician interpreted three image sets of each patient. SPECT images were compared visually and quantitatively using a 17-segment myocardial model and 4DM SPECT software. Wall motion and wall thickening, of each segment was scored with a 4-point scoring system: Score 1—normal, score 2—hypokinetic, score 3—akinetic, and score 4—dyskinetic segments. Using a step 10 visual quantitation score, any segment exhibiting 40% and >40% sestamibi uptake was considered viable (6).

A wall motion score index (WMSI) was computed by dividing the sum of the segment scores by the number of interpreted segments. A WMSI of 1 is normal (when all 17 segments are normokinetic). The 17 segment model as per American heart association recommendation includes 7 segments in LAD, 5 each in RCA and LCx territories. Higher scores indicate worse LV dysfunction (e.g a WMSI of 3.0 correlates with akinetic segments, while WMSI of 1.5, 2.0, and 2.5 are designated for mild, moderate and severe hypokinesia respectively). Reduction in WMSI from a higher score by at least 1 in response to combined infusion also were considered viable. Those with no improvement in WM and WT were considered nonviable. In a few segments with discordance between WM and WT, viability was defined as a change in both parameters.

### Statistical analysis

Statistical analysis was performed with SPSS version 11.0 (IBM Corp, Armonk, New York, USA). According to the groups, one of the normality test [i.e., Kolmogorov-Smirnov (KS) or Shapiro-Wilk (SW)] needs to be performed to compare group means of continuous variables. In the KS test of normality,  $F^*(x)$  is considered a normal distribution with known mean,  $\mu$ , and standard

deviation,  $\sigma$ . However when continuous variables showed a normal distribution, the independent samples t-test was done. For group medians of variables not showing normal distribution, a Mann-Whitney U test was performed. For the paired samples, the differences were tested for normality with KS normality test. If differences are distributed normally, they can be tested by the paired t-test. If not, the nonparametric Wilcoxon t-test is used.

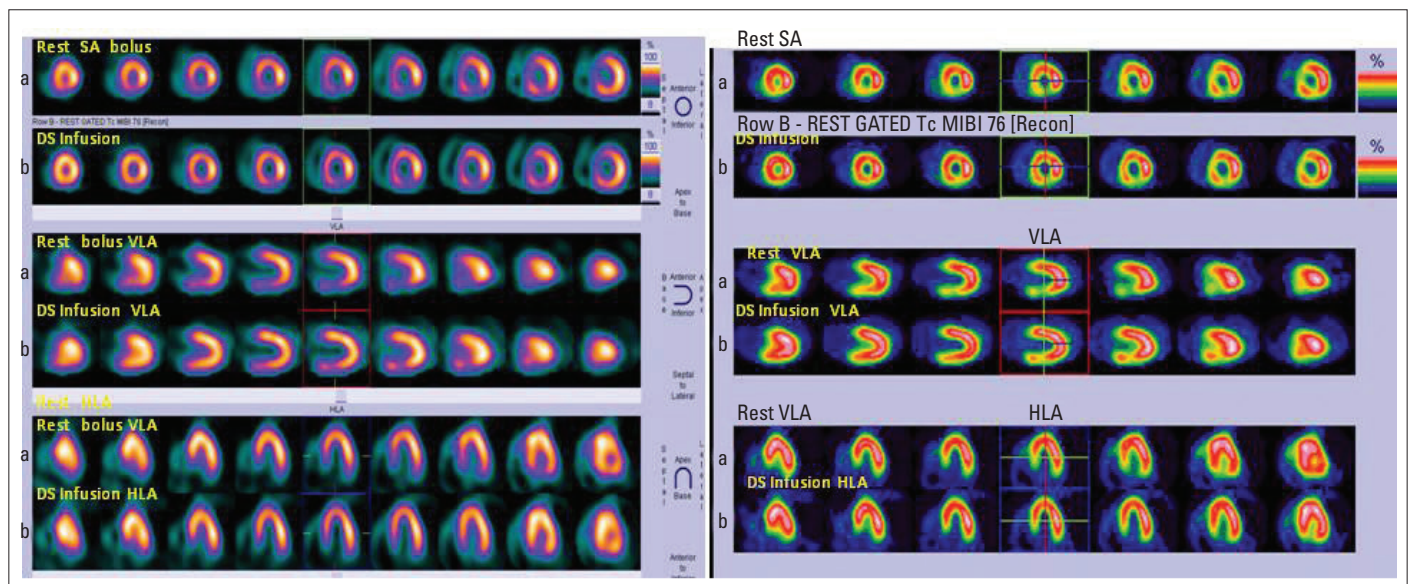
### Results

58 patients data were analyzed (29 each with NSTEMI and STEMI). Coronary angiography showed that 38 patients had triple vessel, 10 double vessel, and 10 single vessel disease (Figs. 1-4). The numbers of patients with anterior, inferior wall MI and combined territorial involvement were 30, 18, and 10, respectively. Systemic hypertension was documented in 43 patients, while diabetes mellitus was noted in 48 and dyslipidemia in 23.

No patient experienced any chest pain or significant ST depression during the DS Inf. There was a significant increase in heart rate, and systolic and diastolic blood pressures on DS Inf. Mean heart rate increased from  $68.8 \pm 9.5$  to  $82.4 \pm 14.9$  ( $p=0.001$ ). Systolic blood pressure increased from  $112 \pm 16.7$  to  $132.2 \pm 16.5$  mm Hg ( $p=0.001$ ), while diastolic blood pressure also increased from  $70.2 \pm 7.7$  to  $79.4 \pm 6.5$  mm Hg ( $p=0.001$ ).

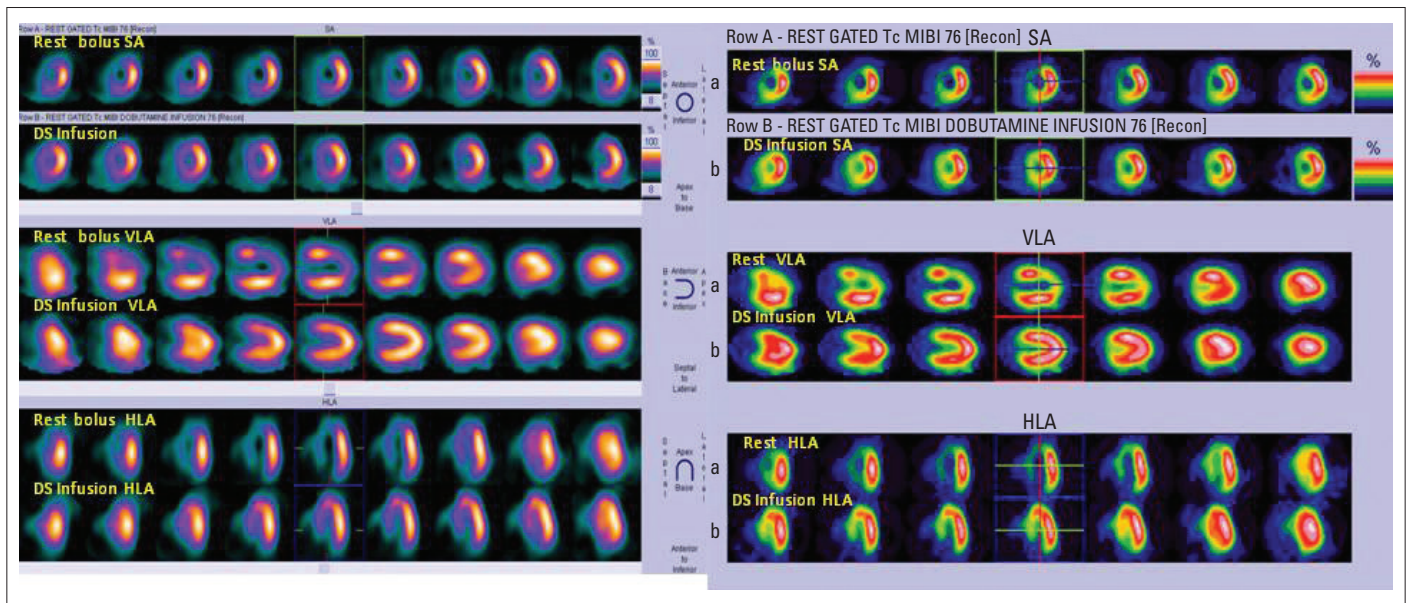
### Perfusion defects

In total, 986 segments were analyzed using the 17-segment myocardial model; 52 patients (548/986 segments, 55.5%) demonstrated perfusion defects in the bolus study. A total of 438 segments were viable (24 patients). The sestamibi infusion study demonstrated an additional 158 viable segments with 40% or more sestamibi uptake (Fig. 5). Thus, there was 28.8% improve-

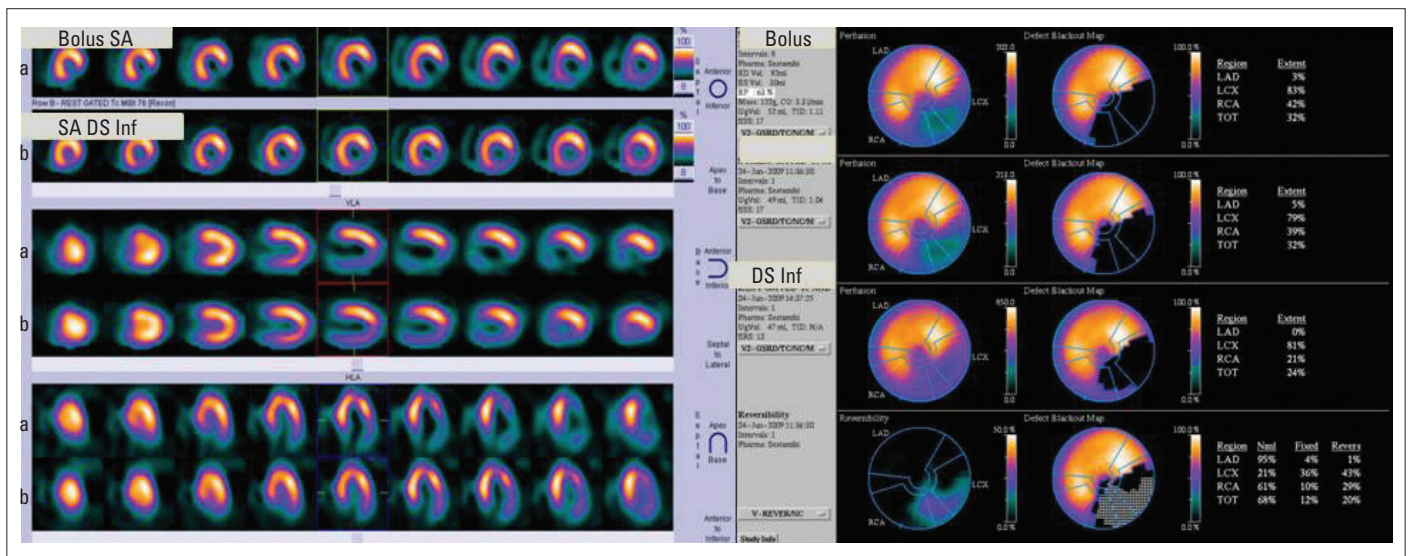


**Figure 1.** Rest MPI SPECT (bolus and infusion) of 38-year-old male with NSTEMI (inferior wall) and LV dysfunction. Quantitative improvement noted in sestamibi uptake in the inferior segment from 40% to 50% to >60%





**Figure 2.** Comparative SPECT images of a 57-year-old patient with ICM. Perfusion defects noted in the apex, major part of anterior and entire septal LV segments. Infusion study shows overall improvement in left anterior descending (LAD) myocardial viability. Step 10 scale display shows improvement in score on WM and WT



**Figure 3.** Rest MPI SPECT images of a patient with inferolateral MI showing significant improvement in segmental viability on infusion highlighted on visual and 4D MSPECT quantitation

ment ( $\geq 40\%$  sestamibi uptake) in the number of viable segments by slow steady sestamibi infusion. Therefore, an additional 12 ICM patients exhibited viability that otherwise would have been missed by bolus study alone. However, segmental improvement in sestamibi uptake was statistically significant in those segments that primarily displayed 40% to 50% and  $>50\%$  sestamibi uptake ( $p=0.001$  and  $p=0.001$ , respectively).

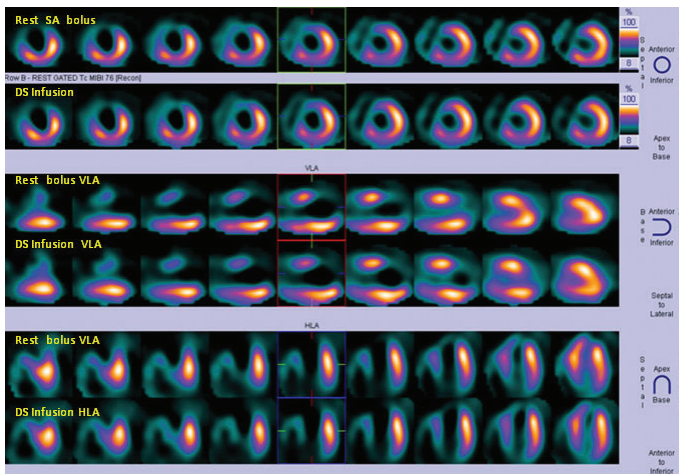
#### Wall motion

A total of 690/986 (69.9%) segments showed abnormal WM on bolus study. Of these 690 segments 230 (33.3%) had improvement in WM by combined infusion; 16 segments showed im-

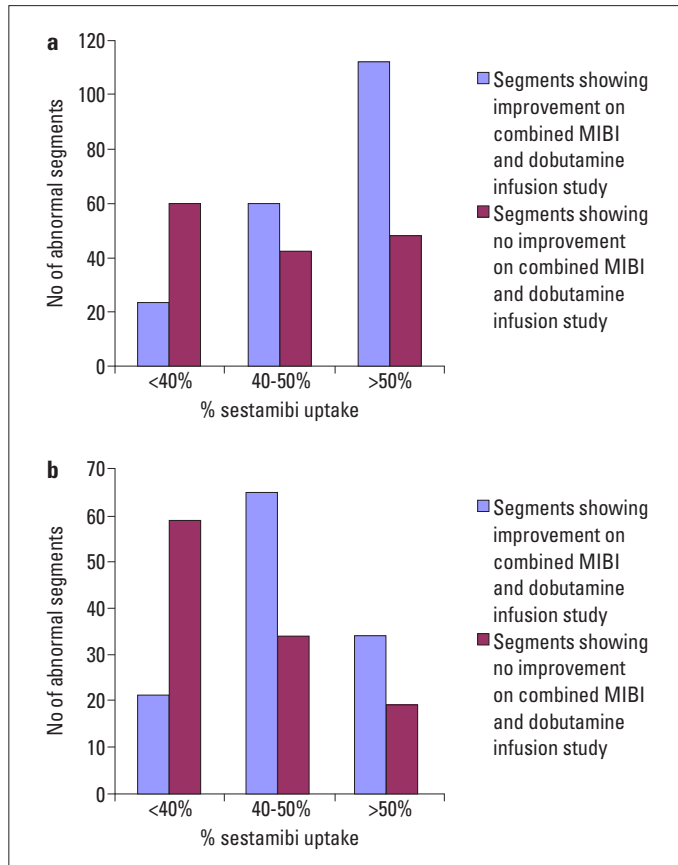
provement in contractile function by DS Inf only (four patients). WMSI was calculated (1–4 score) for bolus and infusion studies. Of 14 patients (114 segments) who demonstrated severe perfusion defects ( $<40\%$  uptake) associated with a high WMSI score index, 11 underwent revascularization with improvement in LVEF by 10% at the 3-month echocardiogram examination.

#### Wall thickening

Abnormal WT was noted in 460 segments on bolus study, 240 of which showed improvement with sestamibi infusion (52.1%). Sixteen segments showed improvement in contractile function on DS Inf gSPECT study when compared to sestamibi infusion.



**Figure 4.** A 67-year-old diabetic man with known transmural MI (LAD territory). Comparative SPECT images show no improvement in LAD segmental viability by rest sestamibi bolus and DS Inf SPECT studies



**Figure 5.** Tabular columns comparing mean number of viable segments per patient by sestamibi infusion and infusion protocols

Statistical analysis with Student's t-test was performed to compare mean continuous parameters between groups. Pearson correlation coefficient (r) and its significance (p) were calculated between variables. P typically was  $\leq 0.05$ , suggesting that the results derived were statistically significant. This indicated strong evidence against the null hypothesis, as there was less than a 5% probability that the null was correct. Therefore, we rejected the null hypothesis that there was no difference between the means, and concluded that a significant difference existed. While applying the normality test to compare group means of continuous variables (i.e., in the KS test, an  $\alpha$  of 0.05 was used as the cutoff for significance and the critical value was 0.00301; Critical region: Reject  $H_0$  if  $D > 0.00301$ ). The KS test did not show any further variance from values obtained by Student's t-test. For group medians of variables not showing normal distribution, a Mann-Whitney U test was performed.

Data are expressed as mean  $\pm$  standard deviation when parametric tests were used to compare continuous variables. On analysis with the paired t-test, the mean number of viable segments per patient was calculated by bolus and infusion study ( $p=0.001$ ; Table 2). Results showed a statistically significant improvement in the detection of viable segments on combined infusion when compared to the bolus study (mean number of viable segments per patient on bolus study was 12.58 compared to 15.16 on infusion,  $p=0.001$ ).

Based on our imaging findings, cardiologists categorized these patients for medical management or revascularization. All patients were followed at 3 months with echocardiography to look for any functional improvement.

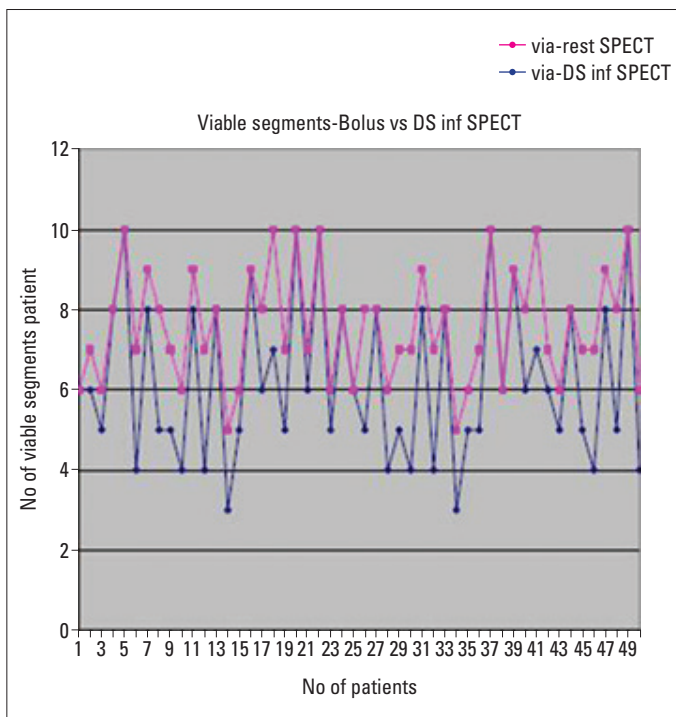
To summarize our results of 58 high risk ICM patients recruited, 52 demonstrated fixed perfusion defects (nonviable myocardium) on bolus rest SPECT MPI. Sestamibi infusion SPECT showed viability in 12 patients, while combined infusion (sestamibi+DS Inf) added six patients to the viability group. Thus, 16 patients benefited with this novel infusion technique to demonstrate viable myocardium on imaging (Fig. 6). Another important finding derived from this study is that patients with a large transmural MI showed no significant improvement in myocardial perfusion status using either protocol.

Patients showing viability were considered for revascularization based on surgical feasibility. There was a significantly higher sensitivity ( $p=0.05$ ) and positive predictive value ( $p=0.01$ ) in viability identification with the combined DS Inf technique. In dysfunctional segments, the rate of concordance for detecting viability between infusion and bolus techniques was 65%. The 3-month followup echocardiogram showed an increase in mean

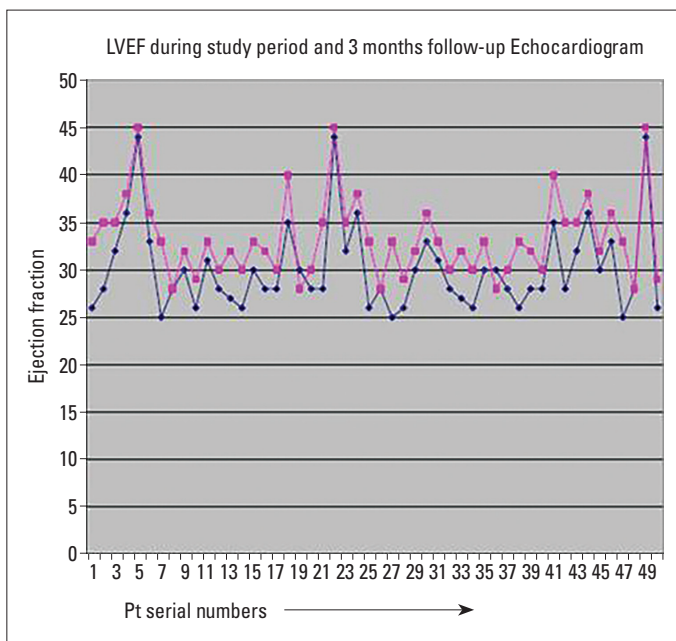
**Table 2.** Bar diagrams depict improvement in sestamibi uptake and changes in WM and WT in relation to infusion study

Protocol	Mean no. viable segments per pt	Standard deviation	P value
Bolus SPECT	6.26	2.018	0.001
DS inf SPECT	7.58	1.22	





**Figure 6.** Graph depicts higher number of viable segments detected on dobutamine+sestamibi infusion SPECT when compared to sestamibi bolus myocardial perfusion SPECT study



**Figure 7.** Comparison of LVEF at baseline and 3-month followup echocardiogram

LVEF from  $30.1\% \pm 4.6\%$  to  $33.4\% \pm 4.3\%$  ( $p=0.001$ ; Fig. 7). Revascularization was performed in 14 patients. Although the numbers are small, the majority of patients who underwent early revascularization (10 patients, within 6–8 weeks of imaging) showed a comparatively higher increase in LVEF at the 3-month followup echocardiogram.

## Discussion

Modifications in the existing protocols for viability assessment have been attempted. One must successfully differentiate viable from nonviable myocardium in dysfunctional regions to derive functional improvement after revascularization. Various SPECT radiopharmaceuticals for myocardial viability have been attempted with varying success. Similarly, different modes of radiotracer administration, including intracoronary instillation into culprit vessels, also have been investigated. Of the SPECT perfusion tracers used,  $^{201}\text{Tl}$  is the most validated agent for viability assessment (7). PET tracers, such as  $^{15}\text{O}$  water and  $^{18}\text{F}$ FDG, score over the SPECT tracers as they provide quantitative information on regional myocardial perfusion and regional oxidative or intermediary metabolism.

Other nonnuclear methods popularly used to identify myocardial viability are echocardiography and magnetic resonance imaging. They measure myocardial thickness, i.e. myocardial thickening in basal conditions and also during pharmacologic interventions. To evaluate the presence or absence of contractile reserve, echocardiography can be monitored throughout pharmacologic intervention (8). The most validated pharmacologic agent is dobutamine, but some recent reports have used dipyridamole. Currently,  $^{18}\text{F}$  FDG PET is accepted as the noninvasive gold standard for differentiating viable myocardial from scar tissue. However, improved function after revascularization is the ultimate gold standard for viability assessment.

### Efficacy of $^{99\text{m}}\text{Tc}$ sestamibi in assessing myocardial viability

Clinical studies have shown that the accuracy of sestamibi and tetrofosmin for detection of CAD is similar to that of TI. The majority of viability evaluations have been performed using sestamibi. In a comparative study of  $^{201}\text{Tl}$  and  $^{99\text{m}}\text{Tc}$  sestamibi in 19 patients with CAD and LV dysfunction, Cuocolo et al. (9) found good correlation in 90% of the segments between the resting TI and resting sestamibi images.

Pierard (10) used quantitative sestamibi SPECT analysis for viability estimation and revealed favorable positive (80%) and negative (96%) predictive accuracies for functional recovery after revascularization. However, several other studies suggest that sestamibi may underestimate myocardial viability (despite using quantitative analysis), particularly in patients with severe LV dysfunction (11). Whether the factors contributing to impaired sestamibi uptake and defect reversibility when compared to TI relate to differences in extraction fraction, blood clearance, redistribution, or response to altered metabolic states remains unknown.

In a study of 111 patients with angiographically proven CAD, Althoefer et al. (12) used  $^{99\text{m}}\text{Tc}$  sestamibi and  $^{18}\text{F}$ FDG to determine defect severity and viability status. They concluded that sestamibi uptake underestimates myocardial viability compared to FDG PET.

### Strategies used to improve efficacy of sestamibi in myocardial viability evaluation

To overcome the limitations of conventional sestamibi imaging, the following protocol modifications have been implemented:

(1) 10 mg of isosorbide nitrate sublingual administration before  $^{99m}\text{Tc}$  sestamibi bolus injection. Simultaneous administration of nitrates and Tc sestamibi is advantageous as it allows an increase in the radiopharmaceutical blood level and an improvement of hemodynamic conditions in viable but dysfunctional myocytes.

(2) Using gSPECT acquisition. Concomitant assessment of perfusion and WM by gSPECT significantly improves the sensitivity and accuracy for the prediction of viability.

(3)  $^{99m}\text{Tc}$  sestamibi as a slow infusion instead of a bolus injection extends the presence of  $^{99m}\text{Tc}$  sestamibi in the systemic circulation. This may enhance the tracer uptake by severely ischemic but viable myocardial tissue.

(4) Assessment of contractile reserve using slow infusion of low dose dobutamine.

#### $^{99m}\text{Tc}$ sestamibi bolus versus infusion techniques

It is well known that sestamibi uptake in severe CAD cases may be greatly reduced and underestimated compared to TI. Similarly, interpretation of systolic WM and WT in segments with severe hypoperfusion by gSPECT sometimes can be challenging. Thus, augmenting myocardial sestamibi availability slowly over time may be incremental. In our study, 16 of 52 ICM patients showed improved viability by the novel infusion technique. Using sestamibi slow infusion, 28.8% of segments displayed >40% uptake. Our series also showed that segments with <40% sestamibi uptake by bolus study did not show any improvement in a subsequent sestamibi infusion study. However, segments with 40% to 50% and >50% uptake on a bolus study showed statistically significant improvement in infusion ( $p=0.001$  and  $0.002$ , respectively). In a similar study by Miron et al. (13) comparing the results of  $^{201}\text{Tl}$  reinjection and sestamibi infusions, concordant results were observed in 22 of 25 patients. They concluded that sestamibi infusion might provide information about the presence of viable myocardium. Similar to our findings, they observed enhanced radiopharmaceutical uptake on infusion studies in 13 cases (52%).

In another study by Akpınar et al. (14) comparing conventional rest sestamibi, sestamibi infusion, and low dose dobutamine echocardiography in 17 patients (47%), there was either partial or prominent radiopharmaceutical uptake improvement in infusion myocardial perfusion imaging studies. This finding supports our hypothesis that under low flow condition, ischemic but viable myocardial tissue may demonstrate higher uptake in the extended presence of radiopharmaceutical in the blood than in single bolus injection. The likely explanation for various different degrees of radiopharmaceutical uptake improvement probably could be the various amounts of viable myocytes in different segments. Our study was comparable to that of Akpınar et al. (14). A total of 69.9% segments showed abnormal WM on bolus study, while they showed 68% agreement between regional uptake improvement on an infusion study and response to a dobutamine study.

#### Combined sestamibi and low dose dobutamine infusion SPECT

Our study demonstrated 33.3% segmental improvement in WM by combined infusion. Of this, an additional 16 segments showed improvement in contractile function by DS Inf when compared to sestamibi infusion. This was supported by paired t-test analysis. There was a statistically significant improvement in the detection of viable segments on combined infusion compared to bolus study (mean number of viable segments per patient on bolus study was 6.26 compared to 7.58 on infusion study,  $p=0.001$ ). We were able to demonstrate significant improvement in WM and WT with slow infusion in 43 patients, especially in segments showing 40% to 50% and >50% sestamibi uptake ( $p$  value=0.001 and 0.001, respectively). Similarly abnormal wall thickening was noted in 460 segments, of which 240 showed improvement on infusion.

There was a significant increase in heart rate, systolic and diastolic blood pressures, and ejection fraction on dobutamine infusion. Leoncini et al. (15) showed that dobutamine gSPECT enhances the reliability of nitrate-enhanced sestamibi SPECT when used to predict reversible dysfunction in hypokinetic segments, but perfusion quantitation remains superior in akinetic segments.

Zafir et al. (16) used sestamibi uptake quantitatively as a basis for myocardial viability evaluation. They also evaluated contractile reserve in segments with lower uptake of sestamibi. Their results showed that in segments with sestamibi uptake of <50%, there was no enhancement of the predictive value of sestamibi for WM improvement after coronary artery bypass grafting. However, adding the response of dobutamine assessment in segments with 60% uptake and lower yielded a significant increase in sensitivity (from 70% to 85%). It seems that the best prediction of WM improvement is supplied by sestamibi, using a cutoff point of 60% combined with a positive finding for the presence of contractile reserve in segments with perfusion below this point. The positive and negative predictive values were 82% and 81%, respectively.

Yoshinaga et al. (17) compared conventional rest SPECT, low dose dobutamine SPECT, dobutamine echocardiography (DSE), and PET. No significant differences were observed between DSE and DS SPECT with respect to the sensitivity, specificity, and positive and negative predictive values for the detection of dysfunctional, but viable myocardium. In the dysfunctional segments, the rate of concordance for detecting viability between infusion and DSE was 86%. Infusion and bolus studies did not significantly differ in sensitivity and negative predictive value for detecting dysfunctional, but viable myocardium. However, the dobutamine study had a significantly higher specificity ( $p=0.05$ ) and positive predictive value ( $p=0.01$ ) than did perfusion SPECT at rest. In dysfunctional segments, the rates of concordance for detecting viability between combined DS Inf SPECT and bolus sestamibi SPECT at rest were only 65%.

While discussing the incremental value of revascularization in ICM patients, various studies have demonstrated the beneficial

effect of viable myocardium on outcome after revascularization. Improvement is judged by regional and global LV function that is highlighted in a few studies (18, 19). In our study, an improvement in global LV function was confirmed at the 3-month followup, especially in patients with a shorter waiting time for revascularization.

This pilot study determined the best radionuclide imaging technique for viability assessment in high risk patients at centers with no PET facility. We conclude that the novel infusion technique (combined sestamibi and DS Inf gSPECT) is a better predictor of viability compared to the conventional bolus study.

### Study limitations

This study, limited by the small sample size, is far from ideal at concluding that a particular viability protocol could be considered better than the current conventional protocol for detecting myocardial viability. A similar study recruiting more patients could establish conclusively the role of combined <sup>99m</sup>Tc sestamibi infusion and DS Inf for detecting myocardial viability. Also, we could not compare our study to the FDG PET scan, which, although expensive, is considered as the noninvasive gold standard investigation for detecting viability.

<sup>99m</sup>Tc sestamibi infusion imaging, with improved tracer delivery over time, may overcome some of the inadequacies of standard sestamibi imaging for assessing myocardial viability. The implication of this observation is that resting Tc sestamibi infusion SPECT MPI can provide useful information when evaluating patients for the presence of hibernating myocardium.

### Conclusion

A simplified and robust method for assessing myocardial viability is of utmost importance especially in high risk cardiac patients. This pilot study showed that a combined <sup>99m</sup>Tc sestamibi infusion and DS Inf augmented gSPECT adds higher sensitivity in myocardial viability detection. The additive effect of dobutamine in segments considered nonviable by perfusion heightens the predictive accuracy of WM improvement after revascularization. This protocol was simple, practically feasible, and well tolerated by our patients with a good yield. Patients with large transmural MI show no significant improvement in myocardial perfusion status using either protocol. The infusion study was incremental in NSTEMI patients posted for viability evaluation. There was significant improvement in perfusion, WM and WT in abnormal segments with >40% sestamibi uptake on the combined infusion protocol, but the same was not noted in abnormal segments with <40% sestamibi uptake.

**Conflict of interest:** None declared.

**Peer-review:** Externally peer-reviewed.

**Authorship contributions:** Concept – P.S., S.S.P.; Design – P.S., S.S.P.; Supervision – P.S., S.S.P.; Fundings – P.S., S.S.P.; Materials – P.S., S.S.P.;

Data collection and/or processing – P.S., S.S.P.; Analysis and/or interpretation – P.S., S.S.P.; Literature search – P.S., S.S.P.; Writing – P.S., S.S.P.; Critical review – P.S., S.S.P.

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