

MYOCARDIAL VIABILITY ON REST TC-99M SESTAMIBI SPECT IN PATIENTS WITH AND WITHOUT TYPE 2 DIABETES MELLITUS

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Abstract

Background: Type 2 diabetes mellitus is associated with accelerated atherosclerosis, coronary microvascular dysfunction, and a high burden of clinically silent ischemia. These mechanisms may reduce myocardial perfusion and the amount of dysfunctional myocardium that remains viable. In settings where positron emission tomography and cardiac magnetic resonance are not routinely available, rest technetium-99m sestamibi single-photon emission computed tomography (Tc-99m Sestamibi SPECT) offers a practical approach to viability assessment.

Objective: To compare myocardial viability and rest perfusion characteristics between diabetic and non-diabetic patients referred for viability assessment.

Methods: A retrospective cross-sectional study included 109 patients who underwent rest Tc-99m Sestamibi SPECT at a tertiary-care nuclear medicine department in Peshawar, Pakistan, from January to May 2026. The cohort comprised 67 patients with type 2 diabetes and 42 without diabetes. Myocardial tracer uptake was evaluated using the standard 17-segment model. Clinical characteristics, left ventricular ejection fraction (LVEF), perfusion-defect severity, viable and non-viable segment counts, and final viability interpretation were compared descriptively; categorical associations were assessed using chi-square testing.

Results: Men comprised 73.4% of the sample. Predominantly viable myocardium was identified in 81.0% of non-diabetic patients and 50.7% of diabetic patients, whereas predominantly non-viable myocardium was present in 19.0% and 49.3%, respectively. Severe perfusion defects occurred only in the diabetic group (11.9%), and moderate defects were also more frequent in diabetic patients (44.8% vs 28.6%). The mean number of non-viable segments was higher in diabetic patients (2.38 ± 1.25 vs 1.60 ± 1.12), while viable segments were fewer (14.68 ± 2.10 vs 15.42 ± 1.87). Diabetes status was strongly associated with final viability interpretation ($p < 0.001$) and perfusion-defect severity ($p = 0.005$), but not with LVEF category ($p = 0.845$).

Conclusion: Diabetes was associated with a substantially less favorable myocardial viability profile on rest Tc-99m Sestamibi SPECT. Rest-only SPECT may provide clinically useful viability information for risk stratification and revascularization planning, particularly where advanced multimodality imaging is limited.

INTRODUCTION

Cardiovascular disease remains the leading cause of morbidity and mortality worldwide, and ischemic heart disease continues to account for a large proportion of cardiovascular deaths and disability. The burden is particularly important in South Asian populations, where diabetes, hypertension, sedentary behavior, central obesity, and premature coronary artery disease frequently coexist. Type 2 diabetes mellitus is not simply a metabolic disorder; it is a major cardiovascular risk state that accelerates macrovascular atherosclerosis and produces diffuse abnormalities in the coronary microcirculation. Chronic hyperglycemia promotes endothelial dysfunction, oxidative stress, inflammation, advanced glycation, and vascular remodeling, all of which can impair myocardial blood flow and contribute to progressive myocardial injury [1,2]. The clinical assessment of ischemia in diabetes can be challenging because autonomic neuropathy may blunt or completely mask typical anginal symptoms. Consequently, substantial coronary disease or myocardial damage may be present before patients report classical symptoms. Non-invasive imaging therefore has an important role in identifying perfusion abnormalities and defining the functional state of the myocardium in individuals who are at elevated cardiovascular risk [3]. Among patients with left ventricular dysfunction or established coronary artery disease, one of the central questions is whether dysfunctional myocardial tissue is still viable and capable of functional recovery after restoration of blood supply. Myocardial viability refers to metabolically active myocardium with impaired contractile function that has the potential to recover after revascularization. Distinguishing viable myocardium from irreversible scar is clinically relevant because revascularization may provide meaningful functional and prognostic benefit when a substantial amount of viable tissue remains, whereas extensive non-viable myocardium may limit the expected benefit and increase the importance of individualized medical management [4,5]. Viability can be evaluated with several modalities, including dobutamine stress echocardiography, cardiac magnetic resonance imaging, positron emission

tomography (PET), and single-photon emission computed tomography (SPECT). Although PET and cardiac magnetic resonance provide sophisticated metabolic and tissue-characterization information, their availability and cost can restrict routine use in many low- and middle-income settings. Technetium-99m Sestamibi is a lipophilic cationic radiotracer that accumulates in viable myocardial cells in relation to regional blood flow and mitochondrial integrity. Preserved tracer uptake supports the presence of viable myocardium, whereas markedly reduced or absent uptake is consistent with severe hypoperfusion, fibrosis, or scar. Tc-99m Sestamibi SPECT is widely used because it is non-invasive, comparatively accessible, and compatible with standard nuclear medicine infrastructure [6]. Rest-only imaging is particularly relevant for patients who are unable to exercise or undergo pharmacological stress and may also be useful when the primary clinical question is myocardial viability rather than inducible ischemia. Previous studies have shown that diabetic patients often demonstrate more extensive perfusion abnormalities, diffuse coronary involvement, and less favorable cardiovascular outcomes than non-diabetic patients [7,8]. However, evidence specifically comparing viability patterns on rest Tc-99m Sestamibi SPECT remains limited in many regional populations. Local data are important because the prevalence of diabetes, referral patterns, coexisting hypertension, access to revascularization, and availability of advanced imaging vary considerably between healthcare systems. The present study compared myocardial viability findings in diabetic and non-diabetic patients referred for rest Tc-99m Sestamibi myocardial perfusion imaging at a tertiary-care center in Peshawar. The analysis focused on perfusion-defect severity, the number of viable and non-viable myocardial segments, final viability interpretation, and the relationship of these imaging findings with diabetes status, diabetes duration, hypertension, and LVEF. The objective was to determine whether diabetes was associated with a less favorable viability profile and to evaluate the practical clinical value of rest SPECT for

viability assessment in a resource-constrained setting.

MATERIALS AND METHODS

Study design and setting

A retrospective cross-sectional study was conducted in the Nuclear Medicine Department of Northwest General Hospital and Research Center, Peshawar, Pakistan. Records and imaging findings from patients undergoing rest Tc-99m Sestamibi myocardial perfusion SPECT between January and May 2026 were reviewed. A non-probability sampling approach was used to include eligible cases available during the study period. The final sample consisted of 109 patients.

Study population

Patients were eligible if they had been referred for a rest Tc-99m Sestamibi scan for myocardial viability assessment and had either confirmed type 2 diabetes mellitus or confirmed non-diabetic status. Patients commonly had echocardiographic evidence of left ventricular dysfunction or known/suspected coronary artery disease. Exclusion criteria included type 1 diabetes, incomplete clinical or diabetes-status documentation, previous myocardial infarction or revascularization (CABG or PCI), severe valvular disease, uncontrolled arrhythmia, or documented hypersensitivity to Tc-99m Sestamibi or related compounds.

Clinical variables

Demographic and clinical information included age, sex, diabetes status, duration of diabetes where available, hypertension, known coronary artery disease, and the clinical indication for imaging. Age was categorized as <50, 50-59, 60-69, and ≥70 years. Imaging indications were grouped as left ventricular dysfunction, suspected coronary artery disease, known coronary artery disease, or other indications. Echocardiographic LVEF was categorized as normal (55-70%), mildly reduced (45-54%), moderately reduced (30-44%), or severely reduced (<30%). No patient in the analyzed dataset was classified in the severely reduced category.

SPECT image assessment

Rest myocardial perfusion imaging was performed according to departmental Tc-99m

Sestamibi protocols. Images were reconstructed and reviewed using the department's standard processing and analysis software. Myocardial assessment followed the conventional 17-segment left ventricular model. Segments were classified according to tracer uptake as viable or non-viable, and the total number of viable and non-viable segments was recorded for each patient. Perfusion defects were categorized as mild, moderate, or severe. A final study-level interpretation categorized the myocardium as predominantly viable or predominantly non-viable.

Statistical analysis

Data were analyzed using SPSS version 27. Categorical variables were summarized as frequencies and percentages, while segment counts were summarized as mean ± standard deviation. Comparisons between diabetic and non-diabetic patients were primarily descriptive. Chi-square tests were used to evaluate associations between selected clinical variables and LVEF category, overall perfusion pattern, perfusion-defect severity, and final viability interpretation. A p value <0.05 was considered statistically significant. Because the study was cross-sectional, associations were interpreted without inferring causality.

Ethical considerations

The study protocol received institutional ethical approval (IRB/EC reference 0409; approval dated 14 April 2026). Patient information was handled in accordance with institutional requirements for confidentiality and research use of clinical data.

RESULTS

Patient characteristics

Of the 109 patients, 67 (61.5%) had type 2 diabetes and 42 (38.5%) were non-diabetic. The overall cohort was predominantly male: 80 patients (73.4%) were men and 29 (26.6%) were women. Male predominance was evident in both groups, with 43 men and 24 women in the diabetic group and 37 men and 5 women in the non-diabetic group. The 60-69-year age group was the largest category, comprising 46 patients, with 23 diabetic and 23 non-diabetic patients. Diabetes was more strongly

represented in younger age strata: among patients younger than 50 years, 10 were diabetic and only one was non-diabetic; among those aged 50-59 years, 18 were diabetic and 13 were non-diabetic. In the ≥ 70 -year category, 16 were diabetic and five were non-diabetic. Left ventricular dysfunction was the most frequent indication for rest SPECT, accounting for 54 referrals. It was notably more common among

diabetic patients (40 cases) than non-diabetic patients (14 cases). Suspected coronary artery disease was the second most frequent indication (17 diabetic and 9 non-diabetic cases). Hypertension was present in 58 diabetic patients compared with 25 non-diabetic patients, while known coronary artery disease was recorded in 38 and 20 patients, respectively.

Table 1. Demographic and clinical characteristics by diabetes status

Characteristic	Non-diabetic (n=42)	Diabetic (n=67)
Sex: male	37 (88.1%)	43 (64.2%)
Sex: female	5 (11.9%)	24 (35.8%)
Age <50 years	1 (2.4%)	10 (14.9%)
Age 50-59 years	13 (31.0%)	18 (26.9%)
Age 60-69 years	23 (54.8%)	23 (34.3%)
Age ≥ 70 years	5 (11.9%)	16 (23.9%)
Hypertension	25 (59.5%)	58 (86.6%)
Known CAD	20 (47.6%)	38 (56.7%)
Indication: LV dysfunction	14 (33.3%)	40 (59.7%)
Indication: suspected CAD	9 (21.4%)	17 (25.4%)
Indication: other	13 (31.0%)	7 (10.4%)
Indication: known CAD	6 (14.3%)	3 (4.5%)

Values are n (%). CAD, coronary artery disease; LV, left ventricular.

LVEF and perfusion-defect severity

Most patients had either normal or mildly reduced LVEF. Mildly reduced LVEF (45-54%) was present in 58 patients overall, including 37 diabetic and 21 non-diabetic patients. Normal LVEF (55-70%) was observed in 43 patients, including 25 diabetic and 18 non-diabetic patients. Only eight patients had moderately reduced LVEF (30-44%): five diabetic and three non-diabetic. Diabetes status was not significantly associated with LVEF category ($p=0.845$). Perfusion-defect severity differed more clearly between groups. Mild defects were

identified in 29 diabetic patients (43.3%) and 30 non-diabetic patients (71.4%). Moderate defects were present in 30 diabetic patients (44.8%) compared with 12 non-diabetic patients (28.6%). Severe defects were observed in eight diabetic patients (11.9%) and in none of the non-diabetic patients. The association between diabetes status and perfusion-defect severity was statistically significant ($p=0.005$). Defect severity was also significantly associated with diabetes duration ($p=0.009$) and hypertension ($p=0.019$).

Table 2. LVEF categories and perfusion-defect severity

Characteristic	Non-diabetic (n=42)	Diabetic (n=67)
Normal LVEF (55-70%)	18 (42.9%)	25 (37.3%)
Mildly reduced LVEF (45-54%)	21 (50.0%)	37 (55.2%)

Characteristic	Non-diabetic (n=42)	Diabetic (n=67)
Moderately reduced LVEF (30-44%)	3 (7.1%)	5 (7.5%)
Mild perfusion defect	30 (71.4%)	29 (43.3%)
Moderate perfusion defect	12 (28.6%)	30 (44.8%)
Severe perfusion defect	0 (0.0%)	8 (11.9%)

Values are n (%). LVEF, left ventricular ejection fraction.

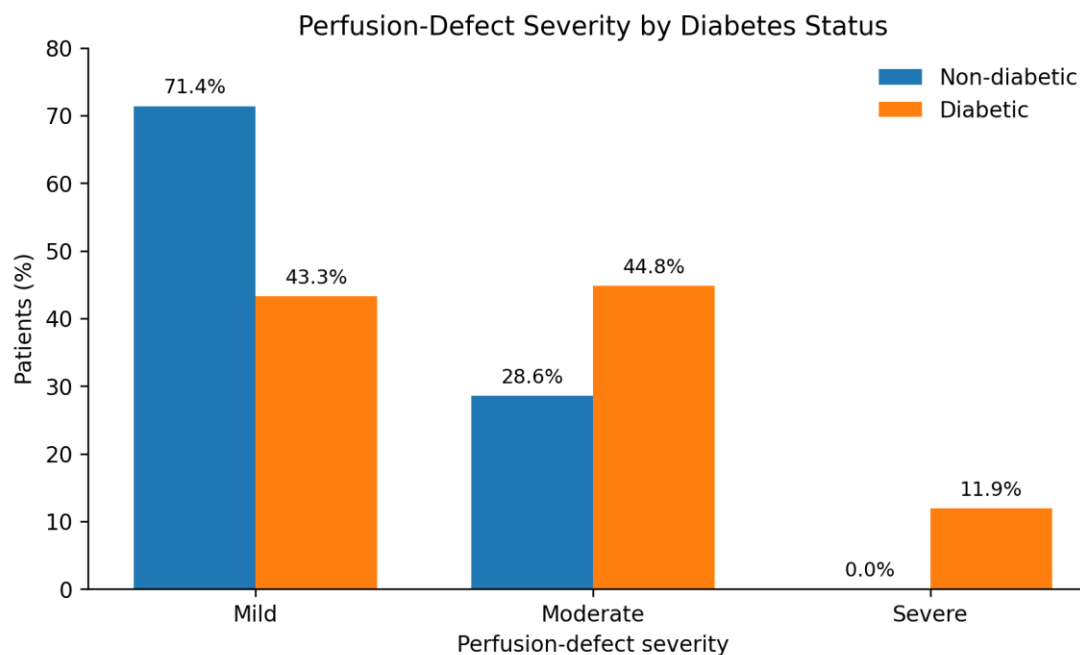


Figure 1. Distribution of rest myocardial perfusion-defect severity in diabetic and non-diabetic patients.

Segment-level viability

On the 17-segment analysis, diabetic patients had a higher mean number of non-viable segments than non-diabetic patients (2.38 ± 1.25 vs 1.60 ± 1.12). Conversely, the mean number of viable segments was lower in the diabetic group (14.68 ± 2.10) than in the non-

diabetic group (15.42 ± 1.87). Although the numerical difference per patient appears modest, the direction of both measures consistently indicated a greater burden of irreversible or severely compromised myocardium among diabetic patients.

Table 3. Segment-level myocardial viability and final interpretation

Characteristic	Non-diabetic (n=42)	Diabetic (n=67)
Non-viable segments, mean $\pm$ SD	1.60 ± 1.12	2.38 ± 1.25
Viable segments, mean $\pm$ SD	15.42 ± 1.87	14.68 ± 2.10
Predominantly viable	34 (81.0%)	34 (50.7%)
Predominantly non-viable	8 (19.0%)	33 (49.3%)

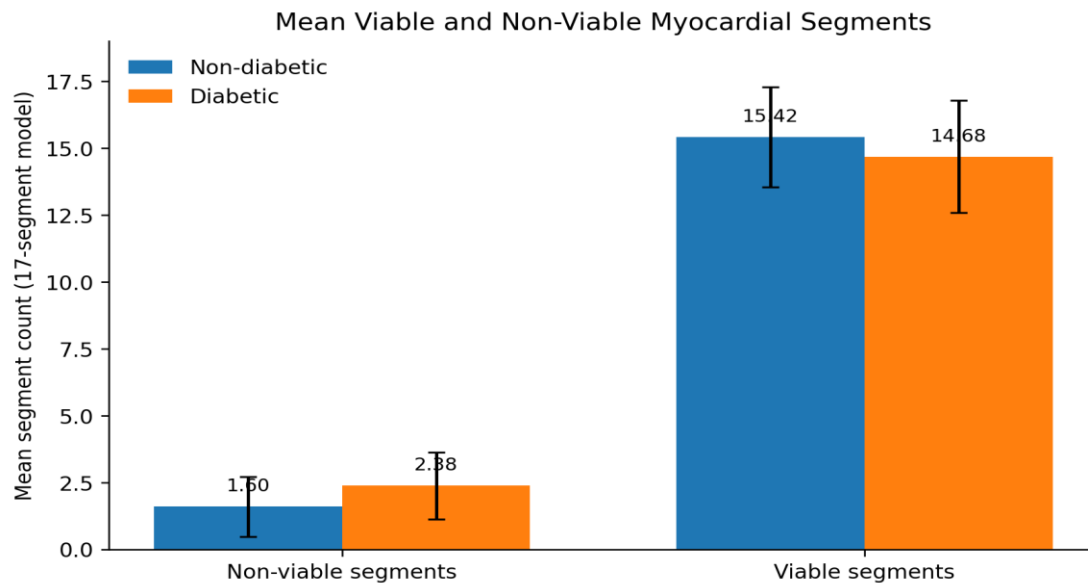


Figure 2. Mean numbers of viable and non-viable myocardial segments using the 17-segment model. Error bars represent standard deviations.

Final viability interpretation

The group difference was most pronounced in the final viability classification. Predominantly viable myocardium was reported in 34 of 42 non-diabetic patients (81.0%) and 34 of 67 diabetic patients (50.7%). Predominantly non-viable myocardium was identified in 8 non-diabetic patients (19.0%) and 33 diabetic patients (49.3%). Thus, the proportion of

patients with a predominantly non-viable pattern was approximately 2.6 times higher in the diabetic group. Diabetes status showed a highly significant association with final viability interpretation ($p < 0.001$). Diabetes duration was also strongly associated with final viability ($p < 0.001$), while hypertension showed a weaker but statistically significant association ($p = 0.037$).

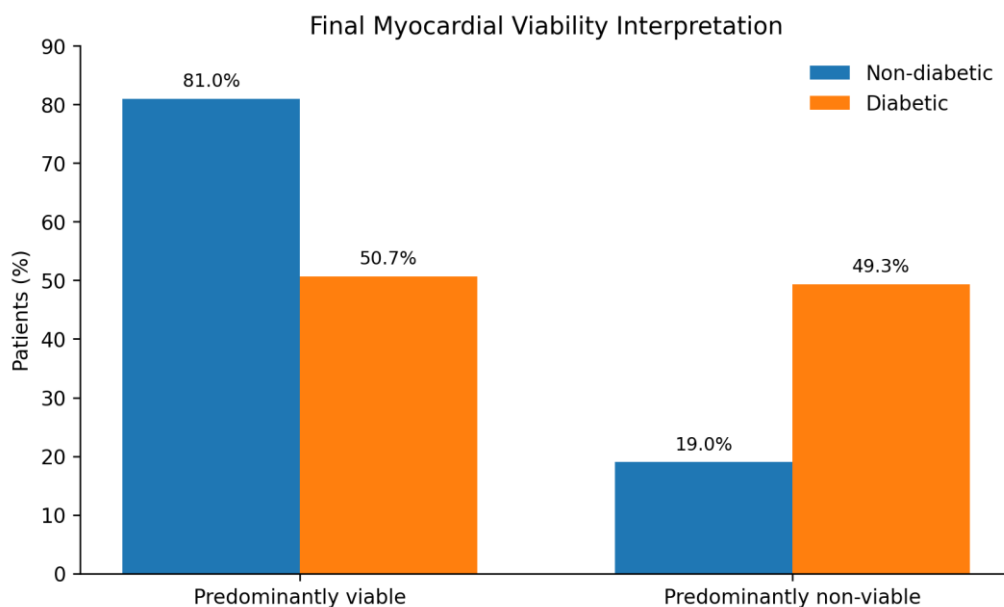


Figure 3. Final myocardial viability interpretation by diabetes status.

Other associations

Duration of diabetes was significantly associated with overall perfusion pattern ($p=0.006$), whereas diabetes status itself was not ($p=0.244$). Hypertension was not significantly associated with overall perfusion pattern ($p=0.475$). Neither duration of diabetes

($p=0.220$) nor hypertension ($p=0.089$) showed a significant association with LVEF category. These findings suggest that perfusion and viability abnormalities may identify myocardial injury that is not fully captured by global systolic-function categories.

Table 4. Chi-square associations between clinical variables and imaging outcomes

Predictor	Outcome	p value	Interpretation
Diabetes status	LVEF category	0.845	Not significant
Duration of diabetes	LVEF category	0.220	Not significant
Hypertension	LVEF category	0.089	Not significant
Diabetes status	Overall perfusion pattern	0.244	Not significant
Duration of diabetes	Overall perfusion pattern	0.006	Significant
Hypertension	Overall perfusion pattern	0.475	Not significant
Diabetes status	Perfusion-defect severity	0.005	Significant
Duration of diabetes	Perfusion-defect severity	0.009	Significant
Hypertension	Perfusion-defect severity	0.019	Significant
Diabetes status	Final viability interpretation	<0.001	Highly significant
Duration of diabetes	Final viability interpretation	<0.001	Highly significant
Hypertension	Final viability interpretation	0.037	Significant

DISCUSSION

The present study showed a consistent difference in myocardial viability between patients with and without type 2 diabetes, with the clearest separation seen in the final viability interpretation. Predominantly non-viable myocardium was identified in 49.3% of diabetic patients compared with 19.0% of non-diabetic patients, while predominantly viable myocardium was present in 50.7% and 81.0%, respectively. Thus, a predominantly non-viable pattern was approximately 2.6 times more frequent in the diabetic group, and the association between diabetes status and final viability interpretation was highly significant ($p<0.001$). This was the strongest finding of the study and directly supports the study hypothesis that diabetic patients referred for viability assessment have a less favorable myocardial viability profile. Previous myocardial perfusion SPECT literature has also described a greater

burden of abnormal myocardial perfusion in patients with diabetes [7,8], while contemporary reviews of viability imaging emphasize that the amount and distribution of viable and scarred myocardium are clinically relevant when evaluating ischemic ventricular dysfunction [4,9,10]. The current findings therefore add local rest Tc-99m Sestamibi SPECT data showing that the difference between diabetic and non-diabetic patients is evident not only in perfusion abnormalities but also in the final viability classification. However, because post-revascularization functional recovery was not assessed in this study, the scan classification should be interpreted as an imaging-based estimate of myocardial viability rather than direct evidence of subsequent contractile recovery. The second major result was the significant difference in perfusion-defect severity between the two groups ($p=0.005$). Mild defects were much

more frequent in non-diabetic patients (71.4% vs 43.3%), whereas moderate defects were more common in diabetic patients (44.8% vs 28.6%). Importantly, severe defects were observed in 11.9% of diabetic patients and in none of the non-diabetic patients. This shift from predominantly mild defects in the non-diabetic group toward moderate and severe defects in the diabetic group is consistent with the final viability findings and suggests that the poorer viability classification in diabetes was accompanied by greater resting perfusion impairment. The result is biologically compatible with the known effects of diabetes on epicardial atherosclerosis and the coronary microcirculation, including endothelial dysfunction and impaired coronary flow regulation [1,2]. In this cohort, however, the importance of this mechanism is supported specifically by the observed distribution of defect severity rather than by a general assumption about diabetes. It is also notable that diabetes status was not significantly associated with the broader overall perfusion-pattern variable ($p=0.244$), even though it was significantly associated with defect severity and final viability. This difference suggests that the severity-based and viability-based classifications were more discriminating for the diabetic versus non-diabetic comparison than the broader perfusion-pattern category used in the dataset. Segment-level analysis showed the same direction of effect. Diabetic patients had a higher mean number of non-viable segments (2.38 ± 1.25) than non-diabetic patients (1.60 ± 1.12), while the mean number of viable segments was lower in diabetic patients (14.68 ± 2.10 vs 15.42 ± 1.87). These descriptive segment counts are important because they provide a quantitative basis for the difference seen in the final scan interpretation. The absolute difference in mean segment counts was modest, but both measures moved in the same direction as perfusion-defect severity and final viability classification. An inferential test for the difference in mean segment counts was not reported in the present analysis; therefore, these values should be interpreted as descriptive support rather than as independently proven statistically significant group differences. Their consistency with the categorical viability result

nevertheless strengthens the overall pattern observed across the SPECT findings. A particularly relevant finding was that diabetes status was not associated with LVEF category ($p=0.845$). Normal LVEF was present in 37.3% of diabetic and 42.9% of non-diabetic patients, mildly reduced LVEF in 55.2% and 50.0%, and moderately reduced LVEF in 7.5% and 7.1%, respectively. Therefore, the marked difference in myocardial viability occurred despite very similar distributions of global systolic-function categories. This finding supports the concept that LVEF and myocardial viability describe different aspects of cardiac status: LVEF reflects global ventricular systolic performance, whereas perfusion SPECT provides regional information about tracer uptake and the extent of viable or severely compromised myocardium. Current viability literature similarly recommends that viability findings be interpreted alongside, rather than substituted by, ventricular function and other clinical information [4,9,10]. The lack of an association between diabetes duration and LVEF category ($p=0.220$) and between hypertension and LVEF category ($p=0.089$) further emphasizes that the significant perfusion and viability associations in this dataset were not mirrored by the LVEF categories. Diabetes duration showed significant associations with overall perfusion pattern ($p=0.006$), perfusion-defect severity ($p=0.009$), and final viability interpretation ($p<0.001$). These findings indicate that within the diabetic group, longer disease duration was related to a progressively less favorable imaging profile across several rest-SPECT outcomes. This pattern is compatible with cumulative vascular and myocardial exposure to diabetes-related injury [1,2], but the cross-sectional design does not permit a causal conclusion. Detailed measures of glycemic control were also unavailable, so duration of diabetes cannot be assumed to represent the intensity of hyperglycemic exposure in individual patients. Hypertension was similarly associated with perfusion-defect severity ($p=0.019$) and final viability interpretation ($p=0.037$), but not with overall perfusion pattern ($p=0.475$) or LVEF category ($p=0.089$). This is clinically relevant because hypertension was considerably more

frequent in the diabetic group (86.6%) than in the non-diabetic group (59.5%). The coexistence of hypertension may therefore have contributed to the less favorable perfusion and viability profile observed among diabetic patients. Because the analysis relied mainly on chi-square testing and did not include multivariable adjustment, the independent contribution of diabetes cannot be separated completely from hypertension or other unmeasured cardiovascular risk factors. This should be considered when interpreting the strong association between diabetes status and final viability. The study groups also differed in referral characteristics. Left ventricular dysfunction was the indication for imaging in 59.7% of diabetic patients compared with 33.3% of non-diabetic patients, and the groups differed in sex distribution and other clinical characteristics. These differences may reflect routine clinical referral patterns, but they also introduce the possibility of selection and confounding effects. At the same time, the absence of a significant diabetes-LVEF association despite more frequent referral for LV dysfunction in the diabetic group suggests that the viability difference cannot be explained simply by the categorical LVEF distribution recorded in this dataset. From a clinical perspective, the findings support the value of regional viability assessment in patients in whom global ventricular function alone does not fully characterize myocardial integrity. Tc-99m Sestamibi uptake depends on myocardial perfusion and preserved cellular/mitochondrial function [6], which provides the physiologic basis for its use in viability assessment. Reviews and scientific statements on myocardial viability also emphasize integrating imaging findings with coronary anatomy, symptoms, ventricular function, comorbidity, and procedural risk when revascularization is considered [4,9-13]. The current study did not compare SPECT findings with PET, cardiac magnetic resonance, dobutamine echocardiography, or post-revascularization recovery, and it did not evaluate clinical outcomes. Therefore, the present results should not be interpreted as showing that rest SPECT alone can determine revascularization benefit. Rather, they show that rest Tc-99m Sestamibi SPECT identified

clear differences in perfusion-defect severity and final myocardial viability between the diabetic and non-diabetic patients studied. The main limitations are directly relevant to these findings. The retrospective, single-center design limits generalizability and precludes causal inference; the modest sample size restricts subgroup analysis; the absence of multivariable modeling limits control of confounding; and important variables such as smoking, dyslipidemia, obesity, renal function, medications, and detailed glycemic indices were not comprehensively analyzed. In addition, the lack of an external viability reference standard or follow-up after treatment means that the prognostic and functional consequences of the observed SPECT patterns remain untested. Nevertheless, the agreement across the principal study outcomes—more moderate-to-severe perfusion defects, a higher descriptive burden of non-viable segments, fewer viable segments, and a substantially higher frequency of predominantly non-viable myocardium in diabetic patients provides internally consistent evidence of a less favorable rest SPECT viability profile in the diabetic group. Future prospective studies should confirm these findings using larger matched cohorts, multivariable adjustment, quantitative gated SPECT parameters, glycemic-control measures, coronary anatomy, and post-treatment outcomes.

CONCLUSION

In this cohort, patients with type 2 diabetes had a less favorable myocardial viability profile on rest Tc-99m Sestamibi SPECT than non-diabetic patients. Predominantly non-viable myocardium was present in 49.3% of diabetic patients compared with 19.0% of non-diabetic patients, and diabetes status was strongly associated with final viability interpretation ($p < 0.001$). Diabetic patients also had more moderate and severe perfusion defects ($p = 0.005$), a higher mean number of non-viable segments, and fewer viable segments. In contrast, LVEF category did not differ significantly by diabetes status ($p = 0.845$). Diabetes duration was associated with overall perfusion pattern, defect severity, and final viability, while hypertension was associated

with defect severity and final viability. These findings indicate that rest Tc-99m Sestamibi SPECT can demonstrate regional perfusion and viability differences that are not captured by LVEF category alone. Because the study was retrospective and lacked an external viability reference standard or clinical follow-up, the findings should be confirmed in larger prospective studies before being used to predict treatment response or outcomes.

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