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ORIGINAL ARTICLE

From Imaging to Intervention: Insights from Nuclear Imaging in Revascularization Strategies for Coronary Artery Disease

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Abstract

Background: Coronary artery disease (CAD) remains a leading cause of morbidity and mortality worldwide and is often associated with ischemic left ventricular dysfunction. In these patients, myocardial viability assessment is important when considering revascularization. Hybrid nuclear imaging modalities, including rest single-photon emission computed tomography myocardial perfusion imaging (SPECT MPI) and ^{18}F-fluorodeoxyglucose positron emission tomography (^{18}F-FDG PET), provide complementary information on myocardial perfusion, function, ischemia, and metabolism, enabling identification of viable and nonviable myocardium and supporting treatment selection.

Materials and Methods: This retrospective observational study included 75 post-myocardial infarction patients with angiographically confirmed CAD who underwent rest SPECT MPI and ^{18}F-FDG PET for myocardial viability assessment at INMAS, Dhaka, between December 2020 and November 2024. Perfusion-metabolism patterns were analyzed in relation to coronary anatomy, ventricular function, and subsequent treatment decisions.

Results: Combined MPI-PET imaging differentiated viable myocardium from nonviable scar and identified mismatch, matched defect, and reverse mismatch patterns across different coronary territories. A perfusion-metabolism mismatch pattern suggestive of hibernating myocardium was observed in 18% of patients. Based on integrated clinical and imaging findings, 34 patients (45.3%) underwent revascularization, including 23 CABG and 11 PCI, whereas 41 patients (54.7%) received optimal medical therapy. In the revascularized group, mean left ventricular ejection fraction improved from 34.7 ± 7.6% at baseline to 43.2 ± 6.65% on follow-up echocardiography performed 3–6 months after intervention.

Conclusion: Rest SPECT MPI combined with ^{18}F-FDG PET is a valuable tool for myocardial viability assessment in patients with CAD and ischemic cardiomyopathy. This integrated imaging approach facilitates more accurate identification of patients likely to benefit from revascularization and supports individualized treatment planning. Its incorporation into routine clinical practice may strengthen therapeutic decision-making and ultimately improve cardiovascular outcomes.

Keywords: Coronary Artery Disease, Myocardial Viability, Nuclear Cardiology, SPECT MPI, ^{18}F-FDG-PET, Revascularization.

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Introduction

Coronary artery disease (CAD) remains a leading cause of morbidity and mortality worldwide[1]. Advances in pharmacological therapy and interventional cardiology have significantly improved survival rates among patients with CAD; however, determining the most appropriate management strategy remains challenging in patients with chronic ischemic cardiomyopathy and impaired ventricular function[2].

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Revascularization procedures such as percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG) aim to restore myocardial blood flow and improve cardiac function. The potential benefit of these procedures largely depends on the presence of viable myocardium capable of functional recovery following restoration of coronary perfusion (2.6).

Coronary angiography remains the gold standard for assessing the anatomical severity of coronary artery stenosis. However, anatomical imaging alone does not provide information regarding myocardial viability or metabolic activity, and functional imaging is therefore needed to assess whether dysfunctional myocardial segments remain viable[3].

Nuclear cardiology imaging has an important role in this context. Single-photon emission computed tomography (SPECT) myocardial perfusion imaging (MPI) provides information on regional perfusion and ventricular function, while ^{18}F-fluorodeoxyglucose positron emission tomography (^{18}F-FDG PET) evaluates myocardial metabolic activity and improves identification of residual viable myocardium in dysfunctional segments (4,5). In addition, concepts such as myocardial hibernation and stunning are central to the interpretation of perfusion-metabolism patterns in chronic ischemic left ventricular dysfunction (14,15). The present study aimed to evaluate the role of combined rest SPECT MPI and ^{18}F-FDG PET in myocardial viability assessment and its impact on revascularization decision-making in patients with CAD.

Materials and Methods

Study Design and Patient Population

This retrospective observational study was conducted at INMAS, Dhaka from December 2020 to November 2024 and evaluated the role of nuclear cardiology imaging in assessing myocardial viability and its impact on revascularization decision-making in patients with coronary artery disease (CAD). A total of 75 post-myocardial infarction patients aged 27 to 75 years were included, of whom 71 were male and 4 were female. All patients had angiographically confirmed CAD, and angiographic findings were reviewed to determine the extent and severity of coronary artery disease.

Clinical Assessment

All patients underwent clinical evaluation including medical history, physical examination, electrocardiography (ECG), and transthoracic echocardiography to assess cardiac function and left ventricular ejection fraction (LVEF). In patients with left ventricular dysfunction or suspected ischemic cardiomyopathy, nuclear cardiology imaging was performed to assess myocardial viability.

Nuclear Cardiology Imaging and Image Analysis

Rest SPECT MPI with ^{99m}Tc-methoxy isobutyl isonitrile (^{99m}Tc-MIBI) was performed on a Siemens SPECT system to evaluate regional myocardial perfusion. This was followed by ^{18}F-FDG PET imaging on a Philips PET/CT system to evaluate myocardial glucose metabolism and identify viable myocardial tissue through a dedicated cardiac protocol. Patient preparation for FDG cardiac PET, including glycemic optimization, was performed according to standard viability imaging principles to ensure adequate myocardial FDG uptake (11,17).

The SPECT MPI and FDG PET datasets were fused using Corridor 4DM software for integrated assessment of myocardial perfusion and metabolic activity. Fused images and polar maps were independently reviewed by two experienced nuclear medicine physicians. Perfusion and metabolic abnormalities were assessed visually, and their extent and severity were evaluated according to the major coronary artery territories, including the left anterior descending (LAD), left circumflex (LCX), and right coronary artery (RCA). Any discordance in image interpretation was resolved by consensus.

Tracer uptake in each myocardial segment was evaluated using a semi-quantitative 5-point scoring system (0 = normal uptake, 1 = mildly reduced uptake, 2 = moderately reduced uptake, 3 = severely reduced uptake, and 4 = absent uptake). Using the 17-segment model, segmental scores were summed to derive the summed rest score (SRS), reflecting the overall extent and severity of perfusion and metabolic defects (4,11).

The percentage of myocardial perfusion and metabolic defect burden was calculated relative to the maximum possible left ventricular score using the following formula:

Defect burden (%) = (Summed score / Maximum possible LV score) × 100

Using the 17-segment model, the maximum possible score was 68 (17 × 4).

Gated SPECT and PET datasets were also analyzed to derive functional parameters, including left

ventricular ejection fraction (LVEF), regional wall motion, and myocardial wall thickening. Perfusion-metabolism defect patterns were classified as mismatch, matched defect, reverse mismatch, and reduced-but-viable uptake patterns based on integrated perfusion and metabolic findings and illustrated in Figure 1 (8,14,15).

These findings were interpreted together with clinical parameters, ventricular function, symptom severity, and comorbidities, and coronary artery anatomy to guide management decisions regarding percutaneous coronary intervention (PCI), coronary artery bypass grafting (CABG), or optimal medical therapy. The study was conducted in accordance with institutional ethical standards, and patient confidentiality was maintained throughout. The overall workflow of patient evaluation, nuclear imaging, and treatment decision-making is illustrated in Figure 2.

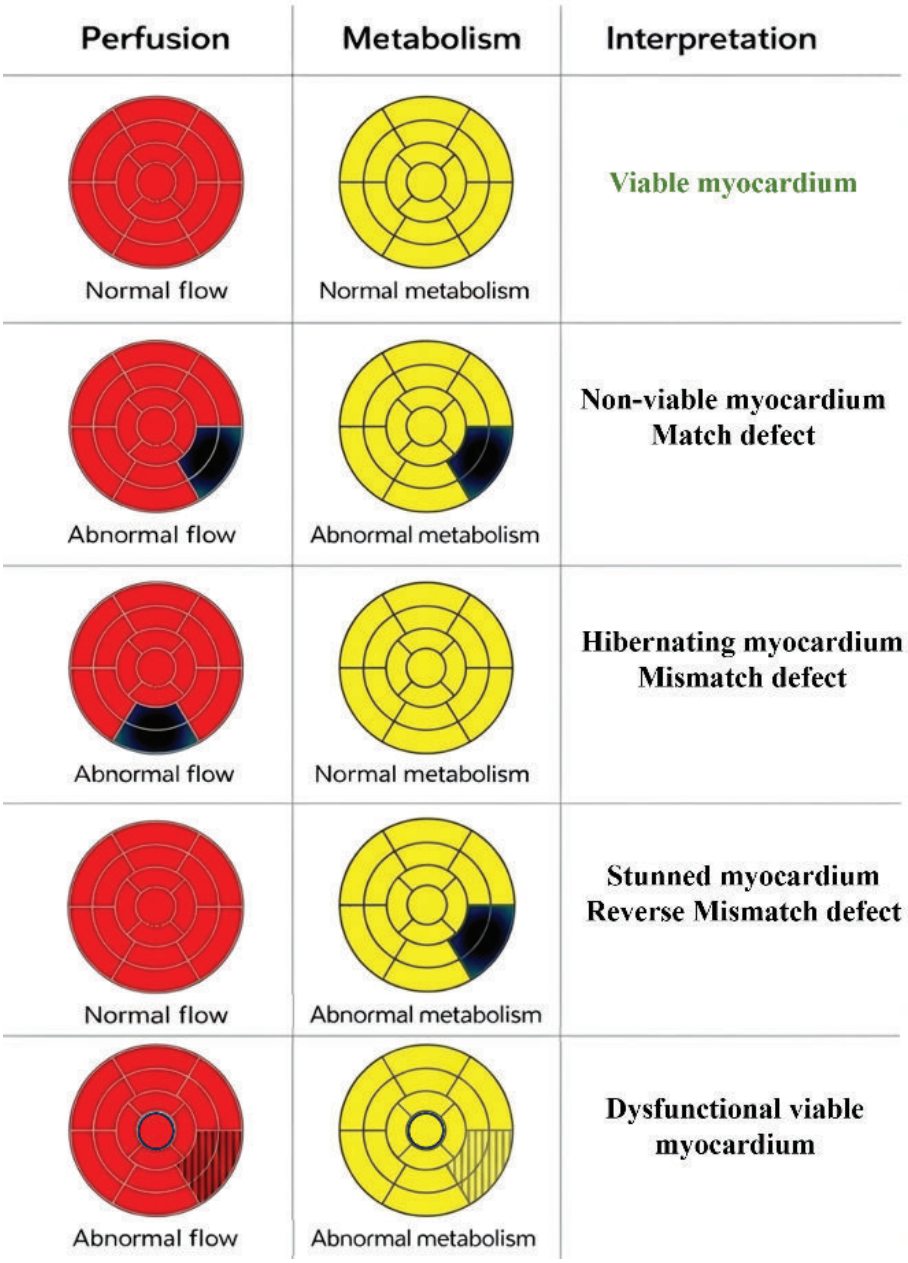


Figure 1: *Schematic representation of myocardial perfusion–metabolism patterns on ^{99m}Tc-MIBI SPECT MPI and ^{18}F-FDG PET for myocardial viability assessment.*

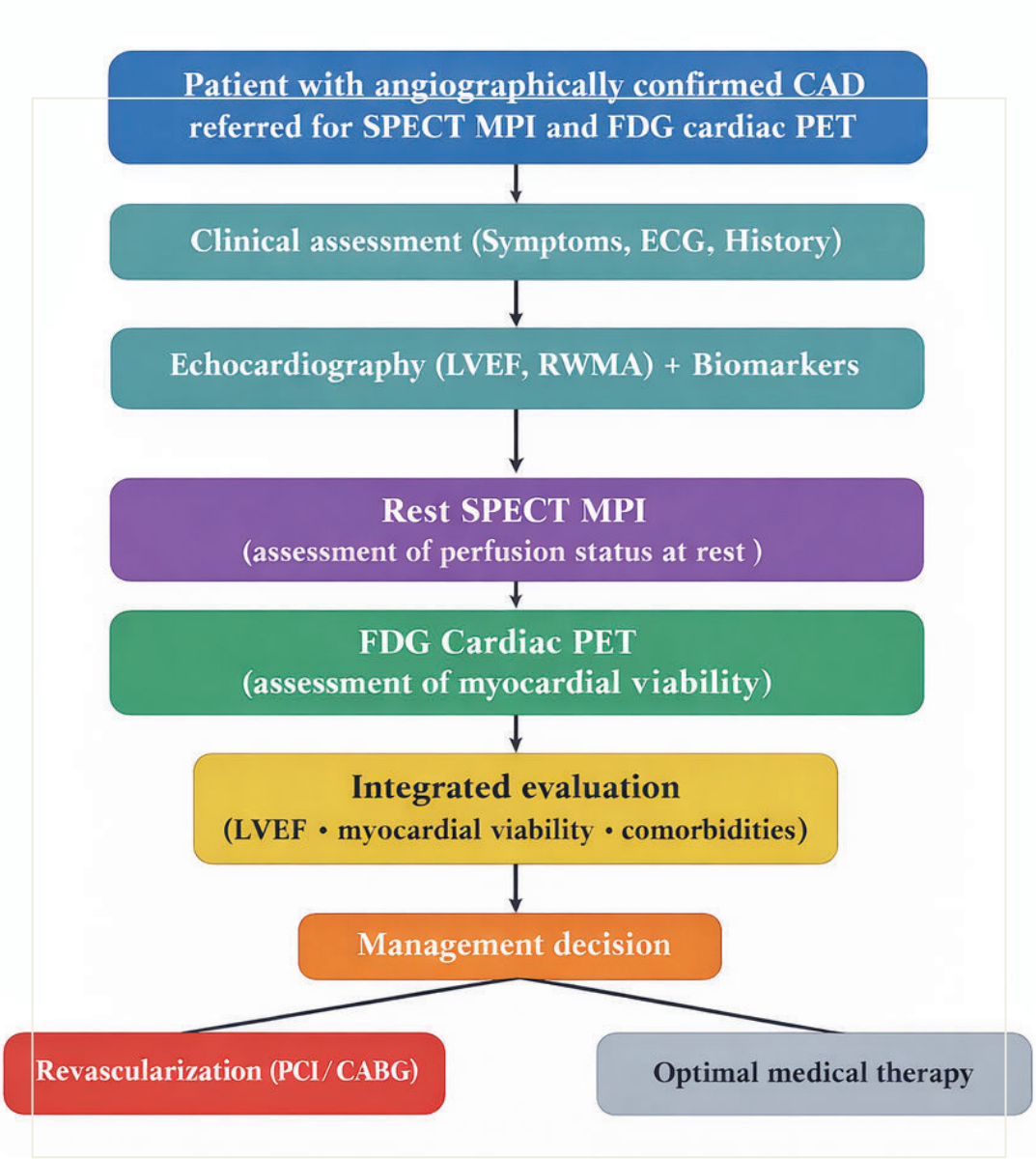


Figure 2: *Clinical workflow integrating nuclear imaging with clinical and functional evaluation to guide revascularization decisions or optimal medical therapy in patients with coronary artery disease. Department of Nuclear Cardiology, INMAS, Dhaka, BAEC.*

Results

Among the 75 post-myocardial infarction patients included in the study, the most common comorbidities were hypertension (55%) and diabetes mellitus (53%), followed by dyslipidemia (25%), smoking (9.3%), and chronic kidney disease (9%). Coronary angiography demonstrated triple-vessel disease (TVD) in 67%, double-vessel disease (DVD) in 20%, and single-vessel disease (SVD) in 13% of patients (Figure 6 a). At baseline, mean left ventricular ejection fraction was 34.7 ± 7.6% on echocardiography, 40.3 ± 13.3% on MPI, and 35.3 ± 9.6% on PET.

A perfusion-metabolism mismatch pattern consistent with hibernating myocardium was observed in 18% of patients, predominantly among those assigned to the revascularization group. In these patients, regional myocardial perfusion was reduced while FDG uptake was preserved or increased, indicating viable but contractile-dysfunctional myocardium with potential for functional recovery following revascularization (Figure 3).

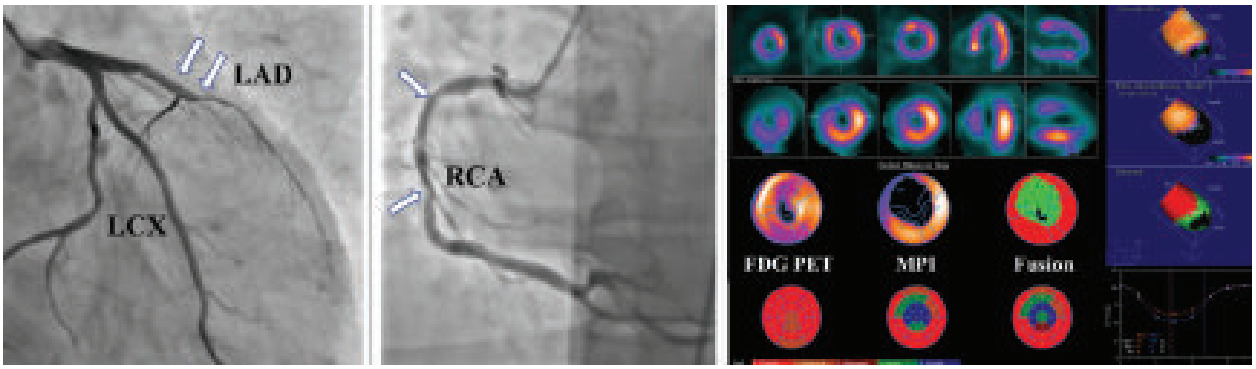


Figure 3: *A 74-year-old male with IHD, old anterior MI (LVEF: 35%), and multiple comorbidities. CAG revealed double-vessel disease involving the LAD and RCA. MPI-cardiac PET fusion imaging showed a large perfusion-metabolism mismatch defect in the anterior and anteroseptal wall (LAD territory), consistent with hibernating viable myocardium (green color on polar map), along with a small severe matched defect in the apex and apical inferior wall, suggesting nonviable myocardium. Left ventricular perfusion defect burden was 35%, whereas metabolic defect burden was 10%. The patient subsequently underwent successful PCI to the LAD.*

In the remaining patients, other perfusion-metabolism patterns were observed, often overlapping across different coronary artery territories within the same individual. Severely matched perfusion-metabolism defects, characterized by concordant reduction or absence of both myocardial perfusion and FDG uptake, were suggestive of non-viable myocardial scar and a low likelihood of functional recovery after revascularization (Figure 4).

A reverse mismatch pattern, defined by relatively preserved perfusion with reduced FDG uptake, was also observed in a subset of patients and was suggestive of stunned myocardium (Figure 5). The underlying pathophysiology involves temporary impairment of myocardial contractility following brief ischemia and reperfusion, mediated by oxidative stress, abnormalities in calcium handling, and transient metabolic disturbances. Although contractile function is depressed, myocardial cellular viability is preserved, and functional recovery may occur over time.

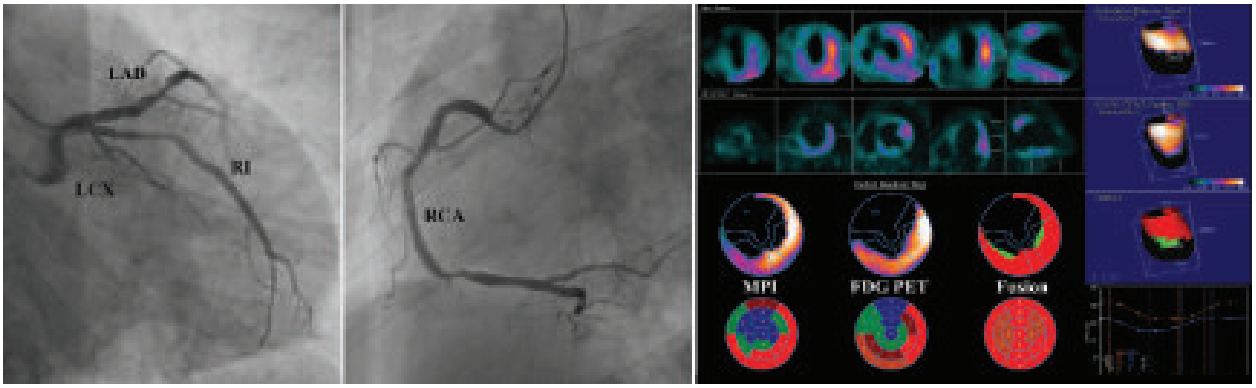


Figure 4: A 33-year-old man with ischemic cardiomyopathy and recent extensive anterior myocardial infarction (LVEF 25%). CAG revealed multivessel CAD involving the LAD, LCX, ramus intermedius, and RCA. MPI-PET Fusion imaging demonstrated a large infarct in the LAD territory, with small areas of nonviable myocardium in the apical lateral wall (LCX territory) and apical inferior wall (RCA territory). Areas of perfusion-metabolism mismatch in the mid inferoseptal and mid anterolateral walls suggested hibernating myocardium (green color on polar map). Total perfusion and metabolic abnormality burdens were 63% and 57%, respectively. The patient was not considered a suitable candidate for surgical revascularization and was advised optimal medical therapy.

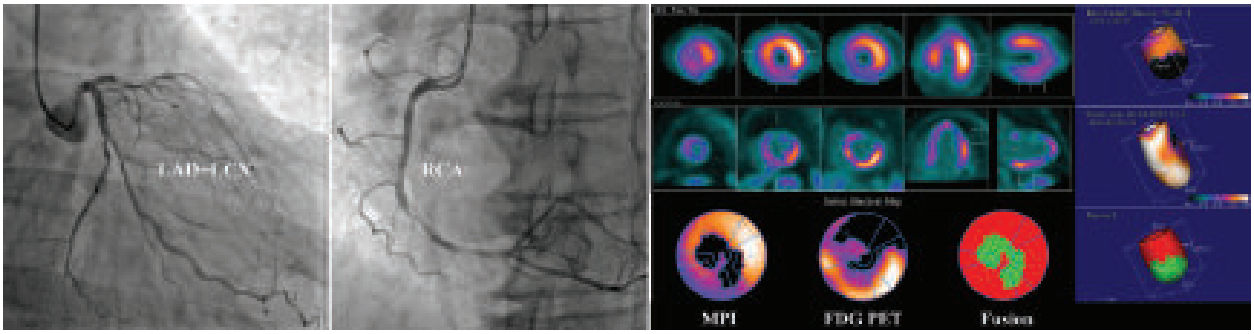


Figure 5: *A 69-year-old male with old inferior MI and severe triple-vessel disease (LVEF 30%). MPI-PET Fusion imaging showed perfusion-metabolism mismatch (apical anteroseptal and apical lateral wall) and reverse mismatch defects (mid to basal anterior and basal anterolateral wall) in the LAD and LCX territories, consistent with coexisting hibernating and stunned viable myocardium, and a mismatch defect (apical inferior) in the RCA territory, suggesting hibernating myocardium. The patient was considered suitable for surgical intervention, and subsequently underwent CABG.*

In some cases, both perfusion and metabolic activity appeared reduced; however, tracer uptake remained above established viability thresholds. Such findings may represent dysfunctional but viable myocardium, indicating residual cellular integrity despite impaired regional contractility. These abnormalities involved the major coronary territories with variable extent and severity. Because these patterns frequently coexisted across vascular territories within the same patient, findings other than mismatch were not classified as mutually exclusive patient-level categories.

Based on integrated clinical and imaging findings, treatment decisions were made by the multidisciplinary Heart Team, with revascularization offered to patients demonstrating myocardial viability. A total of 34 patients (45.3%) underwent revascularization, including 23 (30.7%) CABG and 11 (14.7%) PCI, whereas 41 patients (54.6%) received optimal medical therapy. (Figure 6 b). This cohort included patients without evidence of myocardial viability, as well as those who declined invasive revascularization and opted for medical management. In the revascularized group, mean left ventricular ejection fraction improved from 34.7 ± 7.6% at baseline to 43.2 ± 6.65% on follow-up echocardiography at 3–6 months. Overall mortality during follow-up was 14.7%, with 3 deaths occurring in the CABG group and 8 in the medically managed group.

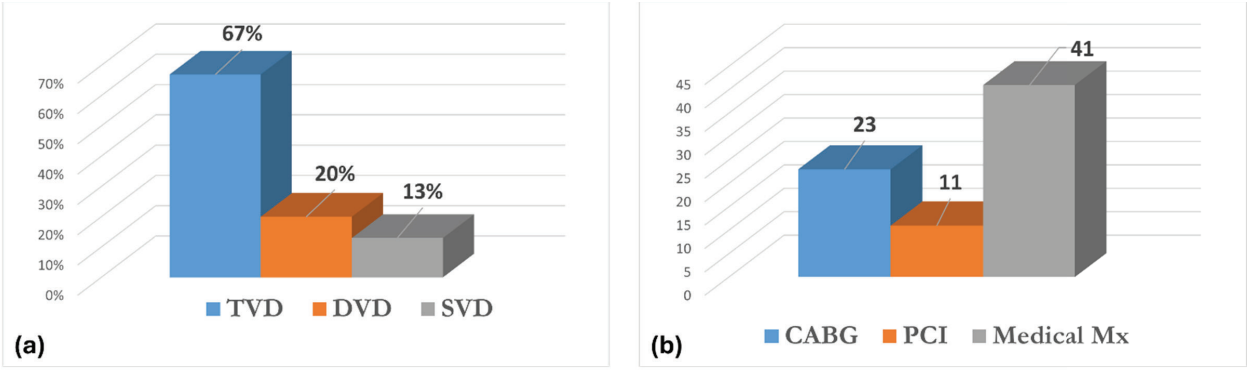


Figure 6: (a) *Distribution of coronary artery disease patterns and (b) treatment strategies in the study population. TVD: triple-vessel disease; DVD: double-vessel disease; SVD: single-vessel disease; CABG: coronary artery bypass grafting; PCI: percutaneous coronary intervention.*

Discussion

The present study highlights the clinical value of combining rest SPECT myocardial perfusion imaging (MPI) with ^{18}F-FDG PET for assessing myocardial viability in patients with coronary artery disease and suspected ischemic cardiomyopathy. Unlike coronary angiography, which primarily defines anatomical stenosis, this integrated approach provides physiologic, metabolic, and functional information that is directly relevant to treatment planning, particularly when considering revascularization[4,5].

A major advantage of this strategy is the complementary information provided by the two modalities. Rest SPECT MPI identifies regional perfusion abnormalities and, with gated acquisition, also provides left ventricular ejection fraction, regional wall motion, and myocardial wall thickening. FDG PET evaluates myocardial metabolic activity and improves identification of residual viable myocardium in dysfunctional segments. Together, these modalities offer a more complete evaluation than perfusion imaging alone, particularly in patients with chronic left ventricular dysfunction[8,11].

This combined approach is particularly important in chronic ischemic cardiomyopathy, where the key clinical question is whether dysfunctional myocardium remains viable and may recover after revascularization. Prior studies have shown that FDG PET adds significant value in differentiating viable myocardium from irreversible scar, particularly when perfusion findings are inconclusive or severe ventricular dysfunction is present[8,11]. Patients with viable myocardium who undergo revascularization may show improvement in left ventricular function, symptoms, and outcomes compared with medical therapy alone (6,9). Our findings are consistent with these observations and support the role of combined perfusion-metabolism imaging in selecting patients for PCI or CABG[10].

Equally important, patients with extensive myocardial scar are unlikely to benefit meaningfully from invasive revascularization and may instead be exposed to unnecessary risk if treatment decisions are made without viability assessment[6,11]. Thus, myocardial viability imaging is valuable not only for identifying patients who may benefit from revascularization, but also for avoiding inappropriate intervention in those with predominantly non-viable myocardium.

Although stress-rest MPI is generally preferred for full assessment of inducible ischemia and total ischemic burden[7], the primary aim of the present study was viability assessment rather than ischemia provocation. In this context, rest perfusion imaging combined with FDG PET was an appropriate and clinically relevant approach, particularly in patients with established CAD, impaired ventricular function, and known coronary anatomy.

Another practical consideration was the lack of access to PET myocardial perfusion tracers. In centers where tracers such as ^{13}N-ammonia or ^{82}Rb are available, a fully PET-based perfusion-metabolism protocol may offer technical and quantitative advantages [5,13,16]. However, such facilities are not widely available. Under these circumstances, the combination of rest SPECT MPI and ^{18}F-FDG PET provides a pragmatic and scientifically justified alternative, particularly in resource-limited settings.

Revascularization decisions, however, should not rely solely on imaging findings. Clinical status, symptoms, left ventricular function, ischemic burden, coronary anatomy, comorbidities, and procedural risk must also be considered[12]. Nuclear cardiology imaging therefore serves best as part of an integrated decision-making framework.

Several limitations should be acknowledged. Rest MPI alone does not allow formal assessment of inducible ischemia and may underestimate total ischemic burden compared with a stress–rest protocol[7]. Image interpretation was primarily visual and semi-quantitative and may therefore be partly observer dependent[4,11]. In addition, the use of separate SPECT and PET systems may introduce technical variability despite software-based fusion. FDG PET also requires strict patient preparation, including adequate glycemic control and optimization of myocardial glucose utilization; inadequate preparation, particularly in diabetic patients, may lead to suboptimal myocardial uptake and complicate interpretation[11,17].

This approach may be particularly relevant in developing healthcare systems such as Bangladesh, where revascularization decisions are often guided mainly by angiographic findings due to limited availability of advanced functional imaging. As nuclear cardiology services expand, incorporation of myocardial viability assessment into routine clinical practice may improve patient selection, optimize

treatment strategies, and potentially reduce procedure-related risk.

Conclusion

Rest SPECT MPI combined with ^{18}F-FDG PET provides valuable complementary perfusion and metabolic information for myocardial viability assessment in patients with CAD and ischemic cardiomyopathy. This integrated approach helps identify patients most likely to benefit from revascularization and supports individualized management in the setting of left ventricular dysfunction. Wider application of this approach in appropriately selected patients may ultimately enhance overall clinical outcomes and patient benefit.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this study.

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Ethical Approval

The study was conducted in accordance with the ethical standards of the institutional research committee of the Institute of Nuclear Medicine and Allied Sciences (INMAS), Dhaka.

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