Open Access

Original Article

Comparison of Myocardial Perfusion Scintigraphy Before and After Coronary Bypass Surgery

Asad Malik, Fida Hussain, Aleena Tariq*, Muhammad Adil, Mehmood Hussain, Zeeshan Sikandar**

Department of Nuclear Medicine, Armed Forces Institute of Pathology/National University of Medical Sciences (NUMS) Rawalpindi Pakistan, *Department of Nuclear Medicine, Rawalpindi Institute of Cardiology, Rawalpindi Pakistan, **Department of Medicine, Pak Emirates Military Hospital/National University of Medical Sciences (NUMS) Rawalpindi Pakistan

ABSTRACT

Objective: To study the change in left ventricular perfusion as well as functional parameters before and after Coronary Artery Bypass Grafting (CABG) using myocardial perfusion scintigraphy.

Study Design: Prospective observational study.

Place and Duration of Study: Nuclear Medical Centre, Armed Forces Institute of Pathology, Rawalpindi, from Feb 2019 to Jan 2022.

Methodology: A total of 42 patients, scheduled for CABG, underwent myocardial perfusion scintigraphy (MPS) using 99mTc-sestamibi, before and 8-12 weeks after surgery. Pre and post operatively, left ventricular relative perfusion and functional parameters were analyzed using commercially available software by two independent nuclear physicians.

Results: Among the enrolled patients (n=42), 38(90.5%) were male while 4(9.5%) were female with mean age of 61.04±8.82 years. Left ventricular ejection fraction improved and was found to be statistically significant (38.93±8.19 to 46.26±10.46, *p*-value <0.01). Similarly, wall motion increased significantly in anterior and lateral segments with concomitant decrease in septal wall motion. A correlation was observed post-operatively between change in ejection fraction and wall motion (r=0.76) while significantly improved post-CABG radiotracer uptake was seen in almost all myocardial segments which showed reversible ischemia with resting perfusion ≥50% in 97 segments with fixed perfusion defects on pre-CABG resting perfusion, but ≤50% did not show any significant improvement, while 5 segments with pre-CABG resting perfusion ≤50% showed improvement on post-CABG MPS.

Conclusion: There is significant improvement in left ventricular perfusion and functional parameters after CABG as assessed by myocardial perfusion scintigraphy.

Keywords: Coronary Artery Disease, Myocardial Perfusion Scintigraphy, Wall Motion.

How to Cite This Article: *Malik A, Hussain F, Tariq A, Adil M, Hussain M, Sikandar Z. Comparison of Myocardial Perfusion Scintigraphy Before and After Coronary Bypass Surgery. Pak Armed Forces Med J 2025; 75(3): 454-458. DOI: https://doi.org/10.51253/pafmj.v75i3.8667*

INTRODUCTION

Coronary Artery Diseases (CAD) are among the leading causes of fatalities and recognized as the prime cause of mortality and loss in Disability Adjusted Life Years (DALYs), globally contributing to 8.9 million deaths and 164 million DALYs.[1,2] The wide spectrum of outcomes associated with CAD are attributed to underlying insufficient myocardial perfusion leading to regional ischemic changes which may progress to ventricular dysfunctions, arrythmias, infarction and even death--thus, effective revascularization of viable myocardial tissue with either percutaneous coronary intervention (PCI) or coronary artery bypass graft (CABG) not only restore perfusion but also improve ventricular function.[3] A detailed evaluation of myocardial perfusion pattern is vital in order to determine which coronary artery should be revascularized to achieve better outcome as pre-operative localization of viable myocardial tissues with possible reversibility has important clinical implications.[4] All these factors together with rising prevalence of CAD lead to enhanced significance of myocardial perfusion single-photon emission computed tomography (MPS) which not only provides diagnostic information but also prognostic values due to which gated-MPS has become part of mainstream cardiology practice,[5] as it provides information on extent and severity of perfusion defect including viable ischemic myocardium or infarct, regional or global wall motion and wall thickening, left ventricular (LV) functional assessment and mechanical desynchrony while also providing important prognostic data, including transient ischemic dilation, right ventricular uptake, lung uptake, LV ejection fraction and sphericity index.[6] Combined assessment has better sensitivity and accuracy in determining viability and hence carries better prognostic value. Although studies have been done in this regard, no

Correspondence: Dr Asad Malik, Department of Nuclear Medicine, Armed Forces Institute of Pathology, Rawalpindi Pakistan
Received: 09 May 2022; revision received: 12 Jun 2022; accepted: 14 Jun 2022

data is currently available in our population and clinical setup. Keeping this perspective in mind, we conducted this study to evaluate functional outcome in patients who underwent CABG by MPS.

METHODOLOGY

This study was conducted at Nuclear Medical Centre, Armed Forces Institute of Pathology (AFIP), Rawalpindi, Pakistan, from February 2019 to January 2022, over a period of three years. Study protocols were approved by Institutional Ethical Review Board before the start of study (IERB No. FC-NMC 18-10/READ-IRB/19/180). All individuals were selected by non-probability consecutive sampling after informed written consent was obtained from all the participants.

Inclusion Criteria: Patients aged more than 18 years, with angiographically proven CAD, scheduled for CABG and referred for pre-operative MPS were included.

Exclusion Criteria: Patients with previous revascularization, valvular disease requiring surgery, cardiomyopathy, perioperative myocardial infarction, surgical complications, non-sinus rhythm and those with contraindication to pharmacological stress MPS were excluded.

All patients underwent MPS before and 8-12 weeks after surgery. Gated rest/stress MPS was done on same day without attenuation correction. Before scanning, patients were instructed to abstain from coffee and caffeine-containing products for 24 hours, beta blockers, calcium channel blockers and theophylline derivatives for at least 48 hours and to come in fasting state. Single-photon emission computerized tomography (SPECT) was performed using dual head gamma camera (Cor Cam Gamma Camera System, DDD-Diagnostic Denmark) with low energy high resolution parallel hole collimator. The energy window was centered at 140 KeV±20% and 64 x images were obtained in 128 x 128 matrix over 1800 semicircular arc. At rest SPECT was performed 30-90 minutes after injection of 8-12 mCi of Tc-99m sestamibi. After rest imaging, patients were stressed with adenosine (140 mcg/kg/min) followed by Tc-99m sestamibi (3 x resting dose) given intravenously. Adenosine infusion was given under strict monitoring. Gated stress SPECT was performed 15-30 minutes after Tc-99m sestamibi injection. Frame mode acquisition (8 frames per cardiac cycle) was used for ECG gating. For image reconstruction, iterative reconstruction with Butterworth filter was used with cut off frequency 0.4 Cycles per cm and order of 8. After image reconstruction, data was processed and analyzed by using commercially available automatic-processing software for gated perfusion SPECT; Invia Corridor 4DM SPECT 2015 and Cedars-Sinai Medical Center, Quantitative Gated SPECT (QGS) and Quantitative Perfusion SPECT (QPS) 2012. Twenty myocardial segments model was used for perfusion study in which the basal, mid and distal areas of myocardium are divided into 6 segments each while apex into two segments. Five segments model was used for regional wall motion which divides the LV cavity into anterior, lateral, inferior, septum and apex. Double blinding was ensured, and 2 nuclear medical specialists independently analyzed all the images. Regional tracer uptake (perfusion) was calculated on non-gated images as percentage myocardial uptake to the maximum counts. Wall motion was expressed as inward movement of endocardium in millimeters from the end of diastolic phase to systolic phase. All data including patients' demographic data was entered and analyzed by using Microsoft Excel 365 and IBM Statistical Package for the social sciences (SPSS) version 25.00. Categorical data was expressed as Mean±SD while the significance of mean difference pre- and post-CABG was analyzed by using paired t-test. Nominal data was expressed as absolute values and percentages where a *p*-value ≤0.05 was considered as statistically significant.

RESULTS

Out of 42 patients, 38(90.5%) were male while 4(9.5%) were female with male to female ratio of 9.5:1. Age ranged from 40–73 years with mean age of 61.04±8.82 years. Along with CAD, 18(42.86%) patients had diabetes, 25(59.52%) had hypertension, 4(9.52%) had thyroid disease, 5(11.90%) had liver disease and 3(7.14%) had autoimmune disease. Total 109 vascular territories were intervened which included 41(37.61%) left anterior descending (LAD) and right coronary arteries (RCA) each and 27(24.77%) left circumflex (LCx) arteries. Table-I shows the baseline characteristics of all enrolled patients.

The global LV ejection fraction (LVEF) pre and post-CABG and pre and post-CABG wall motion changes in anterior wall, inferior wall, lateral wall, septum and apex are given in Table-II.

The total average wall motion increased slightly from 24.43±8.19 to 27.80±7.71. Overall, wall motion changes revealed a reduction in septum with concomitant significant increase in anterior and lateral wall motion. On analysis of average functional parameters, a good correlation was observed between change in ejection fraction (ΔEF) and change in wall motion (ΔWM) as shown in Figure-1.

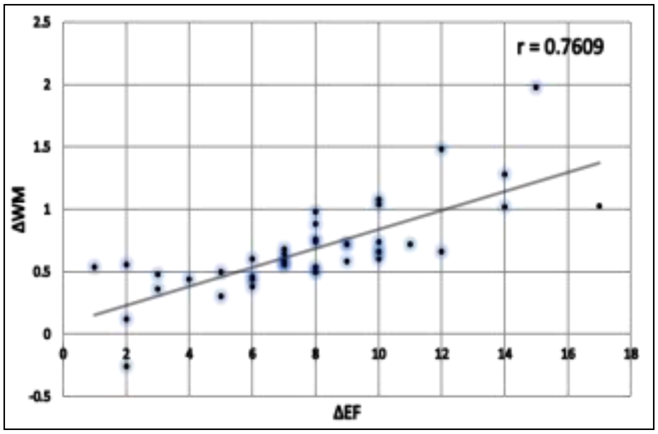

Figure-1: Correlation Between Change in EF and WM, (n=42)

Table-I: Baseline Characteristics, (n=42)

Characteristics	Mean±SD
Age (years)	61.04±8.82
Gender	n(%)
Male	38(90.5%)
Female	4(9.5%)
Comorbid	n (%)
Coronary Artery Disease	42(100%)
Diabetes Mellitus	18(42.86%)
Hypertension	25(59.52%)
Liver Disease	5(11.90%)
Thyroid Disease	4(9.52%)
Autoimmune Disease	3(7.14%)
Revascularized Territories	n (%)
LAD	41(37.6%)
RCA	41(37.6%)
LCx	27(24.8%)

** LAD: left anterior descending artery, RCA: and right coronary arteries, LCx: left circumflex arteries*

Significantly improved post-CABG radiotracer uptake was seen in almost all myocardial segments that showed reversible ischemia and where resting perfusion is ≥50% as 97 segments that show fixed perfusion defects and pre-CABG resting perfusion ≤50% did not show any significant improvement, however, 5 segments with pre-CABG resting perfusion ≤ 50 % show improvement on post-CABG MPS. Segments with normal perfusion on pre-CABG MPS remained the same on post-CABG MPS. Almost all patients had symptomatic relief after CABG as seen in myocardial relative segmental radiotracer uptake shown in Table-III.

Table-II: Pre and Post CABG Difference in LVEF and Wall Motion, (n=42)

Character		Pre CABG	Post CABG	*p*-value (≤0.05)
LVEF		38.93±8.19	46.26±10.46	<0.001
Wall Motion	Anterior	6.33±1.47	7.25±1.53	0.006
	Inferior	4.50±1.81	5.19±1.84	0.090
	Lateral	6.43±2.35	7.46±1.86	0.028
	Septum	3.60±2.12	3.44±2.01	0.708
	Apex	3.57±2.67	4.47±2.66	0.123
	Total	24.43±8.19	27.80±7.71	0.057

**CABG: coronary artery bypass grafting, LVEF: left ventricular ejection fraction*

Table-III: Segmental Relative Tracer Uptake on Stress Images, (n=42)

Segment	Relative Tracer Uptake (Mean±SD)		*p*-value (≤0.05)
	Pre CABG	Post CABG	
Basal Anterior	71.48±10.86	76.62±10.63	0.019
Basal Anterioseptal	63.45±12.54	69.52±12.56	0.029
Mid Anterior	66.67±13.50	72.98±12.96	0.031
Mid Anterioseptal	64.50±14.78	70.90±14.03	0.045
Mid Inferioseptal	67.07±13.07	73.64±11.91	0.018
Distal Anterior	57.07±17.50	64.90±17.65	0.040
Distal Anterioseptal	55.86±17.63	64.00±18.60	0.043
Distal Inferioseptal	61.00±14.07	68.70±14.07	0.014
Apicoanterior	50.33±17.26	57.67±19.62	0.073
Apicoinferior	47.79±14.83	56.60±17.50	0.015
Basal Inferioseptal	58.33±10.16	65.14±9.94	0.002
Basal Inferior	54.17±13.3	60.48±14.46	0.039
Mid Inferior	60.38±11.87	67.36±10.94	0.006
Distal Inferior	55.24±12.47	60.00±13.14	0.007
Basal Anteriolateral	80.33±12.31	82.67±9.96	0.343
Basal Inferiolateral	58.33±10.16	65.14±9.94	0.220
Mid Anteriolateral	81.10±14.44	84.76±11.01	0.194
Mid Inferiolateral	70.95±20.36	74.79±19.56	0.381
Distal Anteriolateral	68.88±14.23	74.86±12.96	0.048
Distal Inferiolateral	64.26±15.61	71.31±13.78	0.031

DISCUSSION

Our study shows positive and significant changes in left ventricular perfusion and functional parameters after CABG as detected by MPS where the LVEF demonstrated a significant improvement 8-12 weeks after surgery and wall motion increased in anterior and lateral wall, however, it decreased in septum with increased myocardial uptake of Tc-99m sestamibi after surgery, signifying improved perfusion. LVEF is an important functional predictor of outcome after CABG and is commonly used for risk stratification before surgery.[7] In our study population, LVEF improved significantly after surgery (38.93±8.19 to 46.26±10.46, *p*-value <0.01) similar to one study, which observed an increase in LVEF in 40% of their patients.[8] Similarly, another author reported a significant improvement in

LVEF in their study population ($p<0.01$).[9] One study assessed LVEF improvement in patients with severe LVEF dysfunction who underwent CABG at Punjab Institute of Cardiology using echocardiography, with an observed mean LVEF before and after surgery being 23.63±1.17% and 32.11±1.98% respectively while mean improvement post-surgery was 8.5±2.7%.[10] This increased LVEF after coronary revascularization procedure is considered due to hibernation meaning resting ischemia in viable tissue. Another explanation for this increased LVEF could be stunning which would appear as stress induced ischemia on MPS with the absence of regional wall motion.[11] Pharmacological and physically induced wall motion abnormalities have been documented as one of the most sensitive markers of myocardial ischemia.[12] Wall motion analysis combined with perfusion analysis using SPECT MPS provides additional diagnostic and prognostic information.[13] Wall motion analysis by gated SPECT has limited role in evaluation of minor CAD.[14] In our sample, regional wall motion showed a significant improvement in anterior and lateral segments with concomitant decrease in septal wall motion, similar to another study, which showed a decrease in septal wall motion and an increase in lateral wall motion in post-revascularization analysis.[15] It has been postulated that decrease in septal wall motion after coronary revascularization surgery is due to systolic anteromedial translation of heart as septal wall motion was not evaluated because of recurrent wall motion aberrations even in the absence of new perfusion defects, perioperative myocardial insult or complication during post-operative period.[16] Myocardial tracer uptake is proportional to preservation of cell membrane integrity and metabolism and has well established role in detecting viability.[17] One study, which used Tc-99m myocardial ectomography, also observed immediate post CABG improvement in post adenosine stress myocardial perfusion in reversible perfusion defects.[18]

LIMITATIONS OF STUDY

Limited follow-up time meant that long term follow up was not done in our study, in terms of left ventricular functions, exercise tolerance and outcome. We also did not compare our results with other modalities and the effect of cardioprotective medications being used by patients was also not recorded in our study.

CONCLUSION

There is significant improvement in left ventricular perfusion and functional parameters, including left ventricular ejection fraction and segmental as well as global wall motion, after CABG as assessed by myocardial perfusion scintigraphy, however, decreased septal wall motion after coronary revascularization was also noted.

Conflict of Interest: None.

Funding Source: None.

Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

AM & FH: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

AT & MA: Conception, data analysis, drafting the manuscript, approval of the final version to be published.

MH & ZS: Data acquisition, critical review, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

REFERENCES

1. Aboul-Enein F, Aljuaid M, Alharthi H. The concordance between myocardial perfusion imaging and coronary angiography in detecting coronary artery disease: a retrospective study in a tertiary cardiac center at King Abdullah Medical City. Cardiol Res Pract 2016; 2016: 1-6.
   https://doi.org/10.1155/2016/6146243
2. Ralapanawa U, Sivakanesan R. Epidemiology and the magnitude of coronary artery disease and acute coronary syndrome: a narrative review. J Epidemiol Glob Health 2021; 11(2): 169-77.
   https://doi.org/10.2991/jegh.k.210525.001
3. Eckardt R, Kjeldsen B, Haghfelt T. Angiography-based prediction of outcome after coronary artery bypass surgery versus changes in myocardial perfusion scintigraphy. Interact Cardiovasc Thorac Surg 2011; 13(5): 505-10.
   https://doi.org/10.1510/icvts.2011.272538
4. Mabuchi M, Kubo N, Morita K. Prediction of functional recovery after coronary bypass surgery using quantitative gated myocardial perfusion SPECT. Nucl Med Commun 2003; 24(6): 625-631.
   https://doi.org/10.1097/00006231-200306000-00008
5. Garcia E, Faber T, Esteves F. Cardiac dedicated ultrafast SPECT cameras: new designs and clinical implications. J Nucl Med 2011; 52(2): 210-217.
   https://doi.org/10.2967/jnumed.109.069195
6. Bajaj N, Singh S, Farag A. The prognostic value of non-perfusion variables obtained during vasodilator stress myocardial perfusion imaging. J Nucl Cardiol 2016; 23(3): 390-413.
   https://doi.org/10.1007/s12350-016-0444-0
7. Fallahzadeh A, Sheikhy A, Ajam A. Significance of preoperative left ventricular ejection fraction in 5-year outcome after isolated CABG. J Cardiothorac Surg 2021; 16(1): 1-8.
   https://doi.org/10.1186/s13019-021-01553-4

8. Eckardt R, Kjeldsen B, Johansen A. Can preoperative myocardial perfusion scintigraphy predict changes in left ventricular perfusion and function after coronary artery bypass graft surgery? Interact Cardiovasc Thorac Surg 2012; 14(6): 779-784. https://doi.org/10.1093/icvts/ivs050
9. Petretta M, Storto G, Acampa W. Relation between wall thickening on gated perfusion SPECT and functional recovery after coronary revascularization in patients with previous myocardial infarction. Eur J Nucl Med Mol Imaging 2004; 31(12): 1599-1605. https://doi.org/10.1007/s00259-004-1636-4
10. Ahmed T, Masood A, Dastgir N. Independent beneficial impact of surgical revascularization on ischemic left ventricular dysfunction. Pak Heart J 2022; 54(4): 357-360.
11. Camici P, Prasad S, Rimoldi O. Stunning, hibernation, and assessment of myocardial viability. Circulation 2008;117(1):103-114. https://doi.org/10.1161/CIRCULATIONAHA.107.702993
12. Carluccio E, Tommasi S, Bentivoglio M, et al. Usefulness of the severity and extent of wall motion abnormalities as prognostic markers of an adverse outcome after a first myocardial infarction treated with thrombolytic therapy. Am J Cardiol 2000; 85(4): 411-415. https://doi.org/10.1016/S0002-9149(99)00770-4
13. Zhang F, Wang J, Shao X. Incremental value of myocardial wall motion and thickening to perfusion alone by gated SPECT myocardial perfusion imaging for viability assessment in patients with ischemic heart failure. J Nucl Cardiol 2020; 28(6): 2545-2556. https://doi.org/10.1007/s12350-020-02281-3
14. Patel KK, Bateman TM. Applications of nuclear cardiology in. In: Nuclear Cardiology and Multimodal Cardiovascular Imaging. Elsevier; 2022. p. 90.
15. Taki J, Higuchi T, Nakajima K. Electrocardiographic gated 99mTc-MIBI SPECT for functional assessment of patients after coronary artery bypass surgery: comparison of wall thickening and wall motion analysis. J Nucl Med 2002; 43(5): 589-595.
16. Okada R, Murphy J, Boucher C. Relationship between septal perfusion, viability, and motion before and after coronary artery bypass surgery. Am Heart J 1992; 124(5): 1190-1195. https://doi.org/10.1016/0002-8703(92)90400-7
17. Wiefels C, Kandolin R, Small G. PET and SPECT evaluation of viable dysfunctional myocardium. In: Nuclear Cardiology. Elsevier; 2021. p. 399-418.
18. Anderson RE, Bone D. Myocardial perfusion after coronary artery bypass surgery: a study using ectomographic myocardial scintigraphy and adenosine provocation. Scand Cardiovasc J 1998; 32(2): 69-74. https://doi.org/10.1080/14017439850140281

....