



E-ISSN: 2706-9575
P-ISSN: 2706-9567
IJARM 2021; 3(1): 209-213
Received: 29-11-2020
Accepted: 07-01-2021

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Assessment of LV function after revascularization in patients of CAD with severe LV Dysfunction: A prospective study

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DOI: <https://doi.org/10.22271/27069567.2021.v3.i1d.139>

Abstract

Introduction: The “awakening” of a contractile myocardium after restoration of blood flow referred to as hibernating myocardium has generated considerable interest with regard to survival advantage following revascularization. Thus, before embarking on revascularization in patients with severe LV dysfunction, it is important to carefully assess presence and extent of viable myocardium.

Material and Methods: This is prospective and descriptive study conducted at tertiary care teaching hospital over a period of 1 year. The patients with coronary artery disease and severe LV dysfunction (with EF <35%) underwent nuclear scan (rest gated MIBI) to assess viability. Those patients in whom viability was detected underwent revascularization procedure either PTCA or CABG. The choice of revascularization was dependent on the nature of lesions.

Results: At baseline mean EF was 29.24 ± 2.94 , wall motion score index was 1.91 ± 0.19 . Out of 37, 24 had CABG (64%) and only 13 (36%) patients had PTCA. Mean EF improved from 29.2% from baseline to 31% after 1 month ($p=NS$). At the end of 6 months EF improved to 34.9% ($p<0.01$) and after 12 months improved to 38%, again $p<0.01$. Similarly, WMSI improved from 1.91 from baseline to 1.87 at the end of 6 months ($p=NS$) and 1.76 at the end of 6 months ($p<0.01$). After 12 months WMSI improved further to 1.67 ($p<0.01$). PA pressure improvement was non-significant at 1, 6 and 12 months. At baseline 8 had moderate MR, but the end of 1 month only 7 were found to have moderate MR. At the end 6 months 2 had moderate MR, but none after 12 months. At baseline 16 had mild MR, at one month 17 and after 6 months 16 had mild MR. At the end of 12 months 12 were found to have mild MR. Overall improvement in MR was not found to be significant.

Conclusion: Revascularization in patients with severe LV dysfunction and viable myocardium resulted in improvement in EF and WMSI at 6 and 12 months follow up.

Keywords: Left ventricular dysfunction, coronary artery disease, revascularization, nuclear scan

Introduction

The “awakening” of a contractile myocardium after restoration of blood flow referred to as hibernating myocardium has generated considerable interest with regard to survival advantage following revascularization^[1]. This assumes greater importance in patients with severe left ventricular (LV) systolic dysfunction as the surgical risks of performing revascularization in this group vary between 6% and 10%. On the other hand, since resting left ventricular ejection fraction (LVEF) is a strong, independent predictor of survival, a small increment in LVEF in patients with severe LV systolic dysfunction significantly improves event-free survival^[2].

Thus, before embarking on revascularization in patients with severe LV dysfunction, it is important to carefully assess presence and extent of viable myocardium. Some studies have indicated that the amount of viable myocardium is an important determinant of survival and have shown that a contractile reserve of >40% predicts improvement in LV function and survival^[3]. Some of these studies have used thallium-201 imaging where >7/15 segments, if viable, led to an improvement in LV function and survival^[4]. In others, low-dose dobutamine stress echocardiography (LDDE) with >5/12 viable segments detected had similar results^[6]. Several studies have demonstrated the prognostic value of SPECT and stress echocardiography in patients with prior MI^[5].

Despite advances in modern medicine, the treatment of patients with coronary artery disease (CAD) and severe left ventricular (LV) dysfunction still represents a serious problem.

These patients have high mortality and morbidity and their treatment is expensive with only suboptimal results. During the last decade, many authors have demonstrated that ventricular dysfunction may not always be an irreversible process but, in a relatively large proportion of patients, it represents an adaptation to chronic hypoperfusion—so-called myocardial hibernation [6]. Such a myocardium has the potential for functional recovery after coronary revascularization resulting in the improvement of the patients' functional class as well as prognosis. Dobutamine echocardiography, which exhibits a good sensitivity (84%) and specificity (81%) in predicting functional recovery after coronary revascularization, has become one of the established methods to identify viability in dysfunctional myocardium. The assessment of viability may identify a large cohort of patients with heart failure to whom coronary revascularization offers a large benefit. On the other hand, the risk of bypass surgery significantly increases with decrease in LV ejection fraction (EF) and with signs of heart failure and some patients with refractory heart failure may benefit more from heart transplantation [7, 8].

The non-invasive assessment of myocardial viability has proved clinically useful for distinguishing hibernating myocardium from irreversibly damaged myocardium in patients with chronic ischemic heart disease who exhibit marked regional and global LV dysfunction. The accurate non-invasive determination of myocardial viability is critically important for clinical decision-making. Viability testing enables physicians to identify those patients with coronary artery disease (CAD) and severe LV dysfunction at rest who would benefit most from revascularization strategies.

Materials and methods

This is prospective and descriptive study conducted at tertiary care teaching hospital over a period of 1 year.

Inclusion Criteria: Patients with CAD and severe LV dysfunction (with EF <35%) with demonstrable viability on nuclear scan (rest gated MIBI) were included in the study.

Exclusion Criteria

- (i) Patients who were not candidates for revascularization
- (ii) Patients who did not have demonstrable viability on nuclear scan.
- (iii) Patients who were not willing for revascularisation
- (iv) Patients who did not have significant CAD on angiogram

Procedure

The patients with coronary artery disease and severe LV dysfunction (with EF <35%) underwent nuclear scan (rest gated MIBI) to assess viability. Those patients in whom viability was detected underwent revascularization procedure either PTCA or CABG. The choice of revascularization was dependent on the nature of lesions. The echocardiograms were analyzed in terms of LVEF and wall thickening in a 17-segment model using a 4-grade scoring system:

- 1. =normal at rest, hyperkinetic with dobutamine;
- 2. =hypokinetic;
- 3. =akinetic
- 4. =dyskinetic.

Wall motion score index (WMSI) was determined by dividing the sum of individual segment scores by the

number of segments scored. Ejection fraction was assessed from apical views by the modified Simpson's method. The severity of MR and degree of PAH were noted.

Nuclear scan (rest gated MIBI)

^{99m}Tc –Sestamibi (740 MBq) was injected intravenously and SPECT was performed 60 min later. SPECT data was acquired using a rotating single head gamma camera equipped with low energy all-purpose parallel hole collimator and connected with a computer system. Extent of perfusion defect, percentage of uptake, thickening in systole, viability score in LAD, LCX and RCA territories were noted. Extent of perfusion defect was assessed using warm metal color coding scale. Yellowish color indicating normal perfusion, black indicating severe perfusion defect. Tracer uptake was assessed using the SPECTRUM 10 color scale, where each color represents 10% incremental uptake. Black color indicating 10% uptake and orange colour indicating 100% uptake. Uptake less than 40% of maximally perfused segments was deemed nonviable. Thickening in systole also indicates viable myocardium.

For convenience LAD territory was divided into 7 segments, and LCX & RCA each territory was divided into 5 segments. Viability was assessed in each segment separately.

Follow up

Follow up was done at 1 month, 6 months and 12 months interval. At each visit 2D ECHO was performed to assess RWMA, improvement in segmental wall motion score, LVEF (Modified Simpson's method), improvement in MR and decrease in PA pressure.

Statistical Analysis

All values were expressed as mean± standard deviation. The demographic data and risk factors were compared between the groups. Paired *t*-test was used for comparing LVEF, WMSI and PA pressure within the same group. *p*-value of <0.05 was considered statistically significant.

Results

A total of 37 patients were included in the study. Of them, 35 were male. Age range was between 30 to 74. Majority of patients were diabetic (56%), and dyslipidemic (75%). Youngest patient was 30-year-old and oldest was 74-year-old. Positive family history was seen in 29 % patients and hypertension was present in 45%.

Table 1: Demography data

Total	37
Male	35
Female	2
Age	30-74 (mean 57±11)
HTN	17 (45%)
DM	21(56%)
Smoker	17 (45%)
DLP	28 (75%)
Positive family history of CAD	11 (29%)

Table 2: Viability Score

In LAD territory	3.0 to 7 (Mean 5.16±1.51)
In LCX territory	2.5 to 5.0(Mean 4.81±0.59)
In RCA territory	1.0 to 5.0 (Mean 4.24 ± 1.12)

Table 3: Baseline ECHO data

EF%	WMSI	Mean PA pressure
29.24±2.94	1.91 ±0.19	20.3±14.3

At baseline mean EF was 29.24±2.94, wall motion score index was 1.91 ±0.19 and mean PA pressure was 20.3±14.3.

Table 4: Treatment for the patients

CABG	24
PTCA	13

Out of 37, 24 had CABG (64%) and only 13 (36 %) patients had PTCA.

Table 5: Follow-up Assessment at baseline, after 1 months, after 6 months and after 12 months.

	EF%	WMSI	Mean PA pressure
Baseline	29.24±2.94	1.91 ±0.19	20.3±14.3
After 1month	31.0 ±3.74 (p=0.06)	1.87 ±0.19 (p=0.36)	18.6 ± 13.3 (p=0.5)
After 6 Months	34.9 ± 3.23 (p <0.01)	1.76± 0.18 (p <0.01)	17.9±11.5 (p =0.42)
After 12 months	38.0± 3.40 (p <0.01)	1.67± 0.18 (p <0.01)	15.9±9.21 (p=0.12)

Mean EF improved from 29.2% from baseline to 31% after 1 month (p=NS). At the end of 6 months EF improved to 34.9% (p<0.01) and after 12 months improved to 38%, again p<0.01. Similarly, WMSI improved from 1.91 from baseline to 1.87 at the end of 6 months (p=NS) and 1.76 at the end of 6months (p<0.01). After 12 months WMSI improved further to 1.67 (p<0.01). PA pressure improvement was non-significant at 1, 6 and 12 months.

Table 6: Improvement in MR at baseline

Trivial	7
Mild	16
Moderate	8
Severe	0

At 1 month

Trivial	8
Mild	17
Moderate	7
Severe	0

After 6 months

Trivial	10
Mild	16
moderate	2
Severe	0

After 12 months

Trivial	16
Mild	12
Moderate	0
Severe	0

At baseline 8 had moderate MR, but the end of 1 month only 7 were found to have moderate MR. At the end 6 months 2 had moderate MR, but none after 12 months. At baseline 16 had mild MR, at one month 17 and after 6months 16 had mild MR. At the end of 12 months, 12 were found to have mild MR. Overall improvement in MR was not found to be significant.

Discussion

In the present study, most of the patients underwent CABG (64%) as compared to PTCA (34%). Those patients who had at least 40% tracer uptake underwent revascularisation, either PTCA or CABG. Mean viability score in LAD was 5.16 and at other territories were 4.81(in LCX) and 4.24 (in RCA) respectively.

Mean EF improved from 29.2% from baseline to 31% after 1 month (p=NS). At the end of 6 months EF improved to

34.9% (p<0.01) and after 12 months improved to 38%, again p<0.01. Similarly, WMSI improved from 1.91 from baseline to 1.87 at the end of 6 months (p=NS) and 1.76 at the end of 6months (p<0.01). After 12 months WMSI improved further to 1.67 (p<0.01). PA pressure improvement was non-significant at 1, 6 and 12 months even though mild improvement was observed.

At baseline 8 had moderate MR, but the end of 1 month only 7 were found to have moderate MR. At the end 6 months 2 had moderate MR, but none after 12 months. At baseline 16 had mild MR, at one month 17 and after 6months 16 had mild MR. At the end of 12 months 12 were found to have mild MR. Overall improvement in MR was not found to be so significant.

The assessment of myocardial viability is a potentially important component in the evaluation of patients with coronary artery disease (CAD) and left ventricular (LV) dysfunction. It is well established that myocardial revascularization in such patients may result in an improved survival rate or improvement in LV function (or both). The selection of patients for revascularization is often difficult, however, particularly in those at highest risk (ie, with severe LV systolic dysfunction and history of prior infarction). In these patients, the assessment of myocardial viability may help determine who will most likely benefit from revascularization^[9].

During the last decade, many authors have demonstrated that ventricular dysfunction may not always be an irreversible process but, in a relatively large proportion of patients, it represents an adaptation to chronic hypoperfusion—myocardial hibernation. Such a myocardium has the potential for functional recovery after coronary revascularization resulting in the improvement of the patients' functional class as well as prognosis^[10].

The non-invasive assessment of myocardial viability has proved clinically useful for distinguishing hibernating myocardium from irreversibly damaged myocardium in patients with chronic ischemic heart disease who exhibit marked regional and global LV dysfunction. The accurate non-invasive determination of myocardial viability is critically important for clinical decision-making. Viability testing enables physicians to identify those patients with coronary artery disease (CAD) and severe LV dysfunction at rest who would benefit most from revascularization strategies^[11].

Studies have suggested that patients who have substantial zones of viable but under perfused myocardium identified by a variety of non-invasive cardiac imaging techniques have higher rates of improvements in regional and global LV function, a greater reduction in the symptoms of heart failure and better exercise tolerance after revascularization.

The greater the extent of myocardial viability, the better the outcome. Patients with hibernation as the prominent cause of ischemic cardiomyopathy have a better prognosis with coronary revascularization than after medical therapy^[12].

Other studies

Roberto Sciagra, Marco Pellegrini et al. did a study in 2000. Follow-up data were collected in 105 CAD patients with LV dysfunction who had undergone baseline-nitrate sestamibi perfusion imaging for viability assessment and had been later treated medically (group 1), or submitted to revascularization, which was either complete (group 2A) or incomplete (group 2B). Eighteen had events (cardiac death or nonfatal myocardial infarction) were registered during the follow-up. A significantly worse event-free survival curve was observed in the patients of group 1 ($p < 0.0002$) and group 2B ($p < 0.03$) compared to those of group 2A. Using a Cox proportional hazard model, the most powerful prognostic predictors of events were the number of non-revascularized asynergic segments with viability in sestamibi imaging ($p < 0.003$, risk ratio [RR]= 1.4), and the severity of CAD ($p < 0.02$, RR = 1.28). They concluded that viability detection in sestamibi imaging has important prognostic implications in CAD patients with LV dysfunction. Patients with preserved viability kept on medical therapy or submitted to incomplete revascularization represent high-risk groups^[13].

In 2006, Mario Leoncini, Gabriella Marcucci did a study in which they showed that low dose dobutamine (LDD) sestamibi SPECT appears to be a promising method for detecting myocardial viability, which provides better accuracy than sestamibi SPECT at rest, and achieves predictive values comparable to those of LDD echocardiography. Before revascularization, 23 patients with chronic coronary artery disease and regional left ventricular dysfunction underwent sestamibi SPECT at rest and, on a separate day, LDD echocardiography and sestamibi SPECT with tracer injection during LDD infusion. Echocardiography at rest was repeated after revascularization. Semiquantitative sestamibi uptake results (grading from 0= normal to 4= absent) and wall motion (grading from 1 = normal to 5= dyskinesia) were evaluated with a 16-segment model. The ventricular wall was divided into 3 vascular territories. At follow-up, 20 of 32 asynergic vascular territories showed functional recovery, whereas 12 showed no changes. For prediction of functional recovery, LDD SPECT achieved better accuracy than SPECT at rest (87% vs 65%, $p < 0.05$); positive and negative predictive values of LDD SPECT were 90% and 83%, respectively, which was not significantly different from the related LDD echocardiographic values (84% and 69%)^[14].

The accuracy of echocardiographic and nuclear tests for viability have been compared in the same and different patients. In a major meta-analysis by Bax JJ, Wijns W, Cornel JH they found that of the widely available methodologies, SPECT offers fewest false negatives and echocardiography minimizes false positives^[15].

Conclusion

In this study of 37 patients ---

1. EF and WMSI improved significantly by 6 months and 12 months but not at 1 month. Upward trend towards improvement was noted as days progressed.
2. PA pressures did not improve significantly.

3. MR improved by grade I by 6 months in 50% of patients (which was not significant)
4. No mortality in 12 months follow-up

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