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ORIGINAL ARTICLE

The Impact of Percutaneous Coronary Intervention of Right Coronary Artery on Right Ventricular Function after Acute Inferior Myocardial Infarction

Tarek A. Abd-elaziz [1], Nader T. Kandeel [1], Ahmed Helal Mohammed [1,*], Mohamed Maher Allam [1]
[1] Cardiology Department, Faculty of Medicine, Zagazig University, Zagazig, Egypt.

*** Corresponding author:**
Ahmed Helal Mohammed

Email:
a.helal22@medicine.zu.edu.eg

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ABSTRACT

Background: Globally, myocardial infarction (AMI) is a leading cause of mortality and disability. Early detection of ischemic myocardium has consequences for prognosis and treatment. It is still challenging to evaluate right heart function in spite of rapid advances in technologies.
Objective: This study aimed to evaluate the improving right ventricle function (RV) in patients with AMI.
Patients and methods: This prospective study included 50 patients who were admitted with inferior wall myocardial infarction (IWMI). Patients were subjected to resting 12-lead standard surface electrocardiogram, transthoracic echocardiography (TTE), coronary angiography and primary percutaneous coronary intervention (PCI).
Results: 74% of studied cases were males with mean age of 62.1 years, 42% of them had positive family history. Risk factor found among studied cases was diabetes mellitus (60%), 54% had hypertension, 52% with dyslipidemia and 50% were obese. Only one stent used for 90% of studied cases during PCI, while 10% of them had two stents. There was a high significant improvement in RV function parameters (RVDD, PASP, TAPSE, RVFAC and TR), myocardial performance index and S wave post PCI. There was a high statistically significant improvement in RV diastolic function grading, as 50% of studied cases had impaired function pre-operative changed to 8% only and 74% of the cases become normal after PCI. Also, 62% of studied lesions were proximal, 24% proximal to mid and 8% proximal para-osteal. **Conclusion:** Primary PCI of proximal right coronary artery can improve right ventricular systolic and diastolic dysfunction in patients with acute inferior wall myocardial infarction.
Keywords: Myocardial Infarction; Percutaneous Coronary Intervention; Right Ventricular Function

INTRODUCTION

A coronary artery occlusion that results in reduced perfusion to that area of the myocardium causes inferior wall myocardial infarction (IWMI). The posterior descending coronary artery is supplied by the left circumflex in approximately 6–10% of the population due to left dominance. Compared to MIs in other areas, such the anterior wall of the heart, inferior MIs have a better prognosis. Less than 10% of MIs to the inferior wall result in death. Nonetheless, a number of exacerbating variables that raise mortality, such as hypotension, bradycardia heart block, cardiogenic shock, and right ventricular infarction **[1]**.

The right ventricle (RV) has historically been disregarded since it is thought to be unimportant to cardiac function. The RV didn't receive much attention again until the latter half of the 20th century, when researchers realized how crucial it was in a number of physiological and clinical situations. Heart failure, RV myocardial infarction, congenital heart disease, and pulmonary hypertension have all been linked to the importance of RV function. Novel techniques for the investigation of RV anatomy and physiology have been made possible by developments in magnetic resonance imaging (MRI) and echocardiography **[2]**.

A nonsurgical method for treating obstructive coronary artery disease, such as unstable angina, acute myocardial infarction (MI), and multivessel coronary artery disease (CAD), is percutaneous coronary intervention (PCI), sometimes referred to as coronary angioplasty **[3]**.

In most cases, RV dysfunction can be corrected, and four months after acute MI treated with primary PCI, persistent RV ischemia injury is extremely rare [4]. Because of its thin wall construction and complicated anatomy, quantitative evaluation of RV function is still difficult and is not used in routine clinical practice **[5]**.

Therefore, this study aimed to evaluate the impact of percutaneous coronary intervention on right ventricle function after inferior wall myocardial infarction using different modalities of echocardiography at Cardiology Department at Zagazig University Hospital.

PATIENTS AND METHODS

This prospective cohort study included 50 patients who were admitted with inferior wall myocardial infarction (IWMI) at Cardiology department, Zagazig University Hospital.

Inclusion criteria:

Inclusion criteria for the PCI of RCA comprised patients with IWMI and dominant RCA with ST-elevation in the inferior leads (II, III, aVF). In order to rule out individuals with right ventricular infarction, a right precordial ECG (leads V3R and V4R) and a routine 12-lead ECG were recorded as soon as the patient arrived at the coronary care unit. Characteristic chest discomfort, ECG abnormalities, and diagnostic serial changes in cardiac enzymes were used to make the diagnosis of MI. ST-segment elevation in inferior leads (leads II, III, and aVF) of at least 1 mm was considered indicative of inferior wall myocardial infarction **[6]**.

Exclusion criteria:

Patients with failed PCI, previous IWMI, pulmonary embolism, rheumatic heart disease, pericardial disorders, renal impairment, malignancy, chronic obstructive pulmonary disease or pulmonary hypertension, history of open heart surgery or PCI, cardiomyopathy, rhythm disturbance other than sinus rhythm, bundle branch block (BBB), previous revascularization, hemodynamic instability, and poor echogenic window were excluded.

Ethical Consideration:

An approval of the study was obtained from Zagazig University Academic and Ethical Committee (ZU-IRB#9349/2-3-2022). Written informed consent of all the participants was obtained. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Clinical assessment

All patients included in the study were subjected to the following full history taking and complete clinical examination including vital signs (pulse and systolic and diastolic blood pressure) and local cardiac examination.

i. Resting 12-lead standard surface electrocardiogram:

To identify and locate STEMI. At the emergency room triage, an ECG was performed upon admission with an amplification of 10 mm/mv and a paper speed of 25 mm/second. STEMI was identified based on the following information: In at least two continuous leads, the new ST segment elevation at the J-point is > 2 mm in leads V1, V2, or V3 and ≥ 1 mm in the other leads. A posterior STEMI is associated with leads V1 through V3 having an ST-segment depression of ≥ 1mm. elevation of the ST section measured 20 ms after the J point. For inferior infarction, leads II, III, and aVF were used to measure the height (in mm) of ST segment elevations. Leads V3R and V4R of the right precordial ECG were also documented **[7]**.

ii. Transthoracic echocardiography (TTE):

Using aharmonic M5S variable-frequency (1.7–4 MHz) phased-array transducer, transthoracic echocardiography was performed 48 hours after admission using a Vivid 6s from General Electric Healthcare (GE Vingmed, Norway). In accordance with the guidelines of the American Society of Echocardiography and RV, all individuals were assessed in the left lateral decubitus position. Utilising the focused apical 4C image, right ventricular measures were obtained **[8]**.

iii. Left Ventricular Assessment:

- ***Systolic function assessment:***

To assess LV systolic function, measurements of the ejection fraction (EF%) and fractional shortening (FS%) were made. Using a modified biplane Simpson's approach, the LVEDV and LVESV were computed by 2D echo from the apical 2- and 4-chamber views. As a percentage of LV chamber volumes between diastole and systole, EF% was computed. The following formula for the LV ejection fraction was generated automatically: (EF %) = (EDV−ESV)/EDV×100 **[8]**.

- ***Diastolic Function assessment:***

The LV diastolic function was assessed using pulsed wave Doppler (PW) echocardiography.

The Doppler studies were recorded from an apical 4-chamber view, and a sample volume was placed inside the LV's inflow region, halfway between the mitral valve's annular borders **[9].**

iv. Right ventricular Assessment:

- **2D and tissue Doppler:**

1- ***RV end diastolic dimension*** (RVEDD) was evaluated at mid RV level.

2- ***Pulmonary artery systolic pressure*** (PASP) was measured using tricuspid regurge velocity.

3- ***Tricuspid Annular Plane Systolic Excursion (TAPSE):***

The tricuspid annulus was positioned through the M-mode cursor at the lateral RV free wall in the apical 4-chamber image so that the annulus travelled along the cursor. The amount of annulus longitudinal motion at peak systole was assessed using M-mode tracing. Leading edges of echoes were used to calculate the total displacement, which was reported in millimetres (n > 17 mm) **[10].**

4- ***Right ventricular fractional area change (RVFAC):*** The value was calculated using the following formula: (normal RVFAC > 35%) / (RV end-diastolic area – RV end-systolic area) **[10].**

5- Tricuspid annular plane systolic velocity (S')"

Using a TDI cursor placed at the level of the tricuspid annulus on the right ventricular free wall, pulsed TDI pictures were obtained. During systole, the annulus moved towards the apex at a large positive velocity (S') (abnormal S'< 9.5 cm/second) **[10].**

- **Grading of RV diastolic dysfunction:**

E/A ratio >0.8 (impaired relaxing); E/A ratio 0.8-2.1 (pseudo-normal filling); and E/A ratio <2.1 (restrictive filling) when the deceleration time is more than 120 ms.

- **Myocardial performance index (MPI) by pulsed wave Doppler method:**

In the apical 4-chamber view, pulsed wave Doppler trans-tricuspid flow velocities are measured. Peak atrial filling velocity (A), transtricuspid early rapid filling velocity (E), E/A ratio, and E wave deceleration time were the characteristics that were measured. The tricuspid valve closure opening time (TCO), which is the amount of time between the tricuspid valve closure seen at the conclusion of the A wave and the tricuspid valve opening noticed at the start of the E wave in the subsequent cardiac cycle, was measured using the pulse wave Doppler tracing. An outflow pulsed Doppler was obtained by introducing the sample volume into the RV outflow tract. Ejection time (ET) was calculated as the duration from the start of the flow until its termination. By dividing TCO-ET by ET (N < 0.44), MPI was calculated **[11].**

- **Coronary angiography and primary PCI:**

Patients received transradial approach or retrograde percutaneous transfemoral procedure (Judkins technique) for coronary angiography. For right coronary angiography, the Judkins or Amplatz right catheter was utilised. Multiple projections of coronary angiography were carried out to ensure sufficient investigation of the target lesions. The treating physician was left with the final say over revascularization options **[12].**

Two approaches were used to identify the severity of an infarct-related artery (IRA): subtotal, when there was penetration but no perfusion, and total, when there was no antegrade flow across the lesion. Contrast material travels beyond the point of obstruction during the cine angiographic filming session and the ECG data, however it is unable to opacify the entire coronary bed distal to the obstruction (the supplied territory corresponding to ST-elevation region on ECG). The Thrombolysis in Myocardial Infarction (TIMI) flow grading method is used to evaluate the myocardial perfusion in the artery connected to the infarct both before and after PCI. TIMI-1 indicates partial distal filling from antegrade contrast penetration beyond the blockage; TIMI-2 indicates a slow antegrade flow that fills the distal segments; TIMI-0 indicates no antegrade flow beyond the occlusion; TIMI-3 normal coronary flow **[13].**

It was estimated that there were lesions in a large number of vessels overall. For coronary lesions other than the culprit one, stenosis of ≥ 70% in at least one major epicardial coronary artery was considered severe. For left major (LM), a lesion of 50% or more was considered significant **[14].**

Follow up:

Two months following the PCI revascularization operation, all echocardiography tests were performed again, and the outcomes were compared to those obtained at baseline.

STATISTICAL ANALYSIS

Data collected and analyzed using Microsoft Excel software. Data were then imported into Statistical Package for the Social Sciences (SPSS version 20.0) software for analysis. According to the type of data qualitative represent as number and percentage, quantitative continues group represented by mean± SD. Differences between quantitative independent multiple by ANOVA. P value was set at <0.05 for significant results &<0.001 for high significant result.

RESULTS

The present study showed 74% of studied cases were males with mean age of 62.1 years, 42% of them had positive family history and 86% presented with TIMI flow of grade III. Also, the commonest risk factor found among studied cases was diabetes mellitus among 60% of them, then 54% had hypertension, 52% with dyslipidemia and 50% were obese **(Table 1).**

Only one stent used for 90% of studied cases during PCI, while 10% of them had two stents, with stent diameter ranged from 2.75 up to 3.5 and mean length of 31.1 ± 3.5 **(Table 2).**

A change in LVDD, LVSD and EFpost PCI, but not statistically significant **(Table 3).**

A high statistically significant improvement in RV function parameters (RVDD, PASP, TAPSE, RVFAC and TR) post PCI **(Table 4).**

A high statistically significant improvement in myocardial performance index and S wave post PCI **(Table 5).**

A high statistically significant improvement in RV diastolic function grading, as 50% of studied cases had impaired function pre-operative changed to 8% only and 74% of the cases become normal after PCI **(Table 6).**

Coronary angiography results, as 62% of studied lesions were proximal, 24% proximal to mid and 8% proximal para-osteal **(Table 7).**

Table (1): Basic characteristics of the studied group

		Group (N=50)	
Age\ years **Mean ±SD**		**62.1 ± 6.66** **46 – 60**	
		N	**%**
Gender	**Male**	37	74.0
	Female	13	26.0
Positive family history		21	42.0
TIMI flow	**II**	7	14.0
	III	43	86.0
Smoking		24	48.0
DM		30	60.0
Hypertension		27	54.0
Obesity		25	50.0
Dyslipidemia		26	52.0

Table (2): Data of operative stent used among studied group

		Group (N=50)	
		N	**%**
Stent number	**1**	45	90.0
	2	5	10.0
Stent diameter (mm) Mean ± SD Range		3.31 ± 0.27 2.75 – 3.5	
Stent length (mm) Mean ± SD Range		31.1 ± 8.28 16 – 48	

Table (3): Assessment of LV functions data pre- & post-operative among studied group

	Studied group (N=50)		Paired t-test\ KW#	P value
	Pre PCT	**Post-PCI**		
LVDD (mm) Mean ± SD	**48.5 ±2.51**	**48.1 ± 2.27**	1.44	0.156 NS
LVSD (mm) Mean ± SD	**29.7±4.44**	**29.1 ±4.42**	1.45	0.153 NS
LVEF (%) Mean ± SD	**63.9 ± 4.17**	**64.2 ±3.59**	0.976	0.335 NS

LVDD: left ventricular diastolic diameter ; LVSD:left ventricular systolic dysfunction
HS: P-value<0.001 is high significant

Table (4): Assessment of RV functions data pre- & post-operative among studied group

	Studied group N=50		Paired t-test\ KW#	P value
	Pre PCT	Post-PCI		
RVDD (mm) Mean ± SD	34.6 ±3.84	30.1 ± 2.92	8.62	<0.001 HS
PASP (mmHG) Mean ± SD	25.5± 9.47	17.2 ± 7.49	4.97#	<0.001 HS
TAPSE (mm) Mean ± SD	14.2 ±1.37	28.2 ±7.71	12.81	<0.001 HS
RVFAC (%) Mean ± SD	29.8 ± 2.87	53.2 ±10.53	14.6	<0.001 HS
TR	**N (%)**	**N (%)**	Freidman test 24.6	<0.001 HS
0	8 (16%)	26 (52%)		
1	29 (58%)	24 (48%)		
2	13 (26%)	0 (0.0%)		

RVEDD: RV end diastolic dimension; PASP: Pulmonary artery systolic pressure; TAPSE: Tricuspid Annular Plane Systolic Excursion; RVFAC: Right ventricular fractional area change; HS: P-value<0.001 is high significant

Table (5): Myocardial performance index pre- and post-operative among studied group

	Studied group N=50		t-test	P value
	Pre PCI	Post-PCI		
MPI Mean ± SD	0.65 ±0.039	0.48 ± 0.072	14.4	<0.001 HS
S wave Mean ± SD	7.84± 0.82	11.3 ±1.57	13.7	<0.001 HS

MPI: Myocardial performance index; HS: P-value<0.001 is high significant

Table (6): Grading of RV diastolic dysfunction pre- & post-operative among studied group

RV grading	Studied group (N=50)		Friedman test	P value
	Pre PCI	Post-PCI		
	N (%)	***N (%)***	37.4	<0.001 HS
Normal (%)	0 (0.0%)	37 (74.0%)		
Pseudo-normal (%)	25 (50%)	9 (18%)		
Impaired **(%)**	25 (50%)	4 (8.0%)		

HS: P-value<0.001 is high significant

Table (7): Right coronary angiography results among studied group

CA	N	%
Proximal	31	62.0
Proximal-proximal to mid	12	24.0
Proximal para-osteal	4	8.0
Osteal	1	2.0
Proximal-thrombotic	2	4.0

DISCUSSION

Chronic coronary atherosclerosis has phases of stability and instability. Patients may experience a MI during unstable times when the vascular wall is inflamed. MI can range from a little occurrence to a persistent, lifelong illness, and it can even remain untreated. But it can also be a massive, catastrophic event that causes instantaneous death or hemodynamic collapse. Patients with established coronary artery disease may get MI frequently, or it may be the first indication of the disease **[7].**

In humans suffering from acute myocardial ischemia, right ventricular (RV) dysfunction has been proposed as a predictor of mortality. Furthermore, severe RV dysfunction coexisted with considerable right coronary artery (RCA) stenosis at the main blood branches supplying the RV **[15].** Also, chronic myocardial ischemia-related heart failure and long-axis RV function can be studied using the TDI method to identify RV function depletion, **Parcharidou et al. [16]** indicated that patients with prolonged myocardial ischemia have more severe RV impairment. However, It is unknown if RV dysfunction has any clinical significance in that group of post-AMI patients.

Therefore, the aim of this work was to evaluate the impact of percutaneous coronary intervention on right ventricle function after inferior wall myocardial infarction using different modalities of echocardiography at Cardiology Department at Zagazig University Hospital.

This prospective cohort study included 50 patients admitted with inferior wall myocardial infarction (IWMI). All patients included in the study were subjected to full history taking, clinical examination, resting 12-lead standard surface electrocardiogram, transthoracic echocardiography (TTE), coronary angiography and primary PCI.

Our results showed that 74% of studied cases were males with mean age of 62.1 years, 42% of them had positive family history. Also, the commonest risk factor found among studied cases was diabetes mellitus among 60% of them, then 54% had hypertension, 52% with dyslipidemia and 50% were obese. Only one stent used for 90% of studied cases during PCI, while 10% of them had two stents, with stent diameter ranged from 2.75 up to 3.5 and mean length of 31.1 ± 3.5.

Antoni et al. [17] examined the relationship in post-AMI patients receiving primary PCI between RV function and adverse outcomes. The majority of patients (78%), with a mean age of 60 ± 12 years, were males.

Our results showed a high statistically significant improvement in RV function parameters (RVDD, PASP, TAPSE, RVFAC and TR), myocardial performance index and S wave post PCI. **Shah et al. [18]** concluded that individuals with proximal RCA involvement had RV impairment. Furthermore, among the patients who received primary PCI after AMI, RVFAC, TAPSE, and MPI were highly predictive of the composite end point all-cause death, reinfection, and hospitalisation for heart failure. Also, **Louisa Antoni et al. [17]** determined the mean RV strain, 45 ± 8%, 37 ± 9%, 1.7 ± 0.2 cm, and -22 ± 7% for the RVFAC, RVEF, TAPSE, and RV. RV strain, RVFAC, and TAPSE did not differ between patients with and without inferior AMI.

RV function corrected quickly, according to a comparison of the data. This is consistent with other research showing that RV function recovered almost entirely following NSTEMI. Even though we looked at candidates for elective PCI due to single vessel disease rather than primary PCI patients, this suggests the significance of revascularization of the impacted arteries. LVEF was substantially correlated with TAPSE **[19].**

A study done by **Anavekar et al. [20]** showed that RV strain, RVFAC, and TAPSE were positive predictors of the composite end objective all-cause mortality, reinfarction, and hospitalisation for HF. Moreover, the predictive usefulness of several well-established risk indicators, including multivessel disease, peak cardiac enzymes, Killip class, and LV function, was confirmed once more. Once known risk factors for an adverse outcome after AMI were taken into consideration, RVFAC and RV strain were found to be independent predictors of the composite end goal. However, the RV function did not offer predictive data for the individual prediction of nonfatal reinfarction.

Several techniques for measuring RV function using 2D echocardiography have been published. Whether or not it is done in conjunction with TAPSE or RVFAC, qualitative evaluation of RV function is typically carried out in clinical practice. These parameters are simple to apply and enhance prognosis, particularly in patients with LV failure who have had an AMI **[21]**.

The study findings showed a high statistically significant improvement in RV diastolic function grading, as 50% of studied cases had impaired function pre-operative changed to 8% only and 74% of the cases become normal after PCI. Also, our study showed coronary-angiography results, as 62% of studied lesions were proximal, 24% proximal to mid and 8% proximal para-osteal.

Gorter et al. [22] examined RV function. To determine the RV scar size and RV ejection fraction (RVEF), an MRI was carried out four months later. Prior to discharge and four months later, the RV free wall longitudinal strain (FWLS) and the tricuspid annular plane systolic excursion (TAPSE) were measured by echocardiography. 258 people without diabetes mellitus were included in the study; their mean age was 58 ±11 years, and 79% of them were men. They also had a mean LV ejection percentage of 54 ± 8%. Before being discharged, 5.2% of patients had TAPSE <17mm, 32% had FWLS > 20%, and 11% had FWLS > 15%. Over the course of four months, FWLS went from 22.6 ± 5.8 to 25.9 ± 4.7%, and TAPSE increased from 22.8 ± 3.6 to 25.1 ± 3.9mm. After four months, the average RVEF on MRI was 64.1 ± 5.2%, and 5 patients (2%), showed evidence of RV scarring. The size of the LV scar was not correlated with RVEF or RV FWLS. Four months after acute MI treated with primary PCI, it was found that most patients recover from RV dysfunction and that long-term RV ischemia injury is quite unusual.

The clinical significance of RV function has been misconstrued in the past. Despite evidence that RV dysfunction may marginally improve after AMI, RV function is crucial for predicting long-term prognosis in patients with inferior AMI and LV failure **[23]**.

Mehta et al. [24] showed that RV involvement in inferior AMI is not the result of a more frequent LV infarction, these patients also had a higher risk of serious consequences.

In post-AMI patients with LV dysfunction, **Anavekar et al. (2008)** shown that there was a limited link between LV and RV function and that there was a separate relationship between a higher risk of death and heart failure and RV function as measured by RVFAC.

Rajesh et al. [25] observed a significant difference in the groups with and without proximal RCA lesion in the echocardiographic evaluation of the RV function parameters. This evaluation was conducted within 24 hours of the first episode of acute inferior wall MI. TAPSE, tissue Doppler systolic annular velocity, and myocardial performance index are easy to use and useful tools for determining which artery is associated to the infarct the proximal RCA.

There was some limitation in our results could have been biased by the relatively small number of patients. Our findings could have been more reflective if a larger sample size was recruited. We did not follow up the patients with complications after hospital discharge to assess long term clinical outcome.

Conclusion

Primary PCI of proximal right coronary artery can improve right ventricular systolic and diastolic dysfunction in patients with acute inferior wall myocardial infarction.

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