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CLINICO-ECHOCARDIOGRAPHIC ASSESSMENT OF RIGHT VENTRICULAR FUNCTION IN INFERIOR WALL MYOCARDIAL INFARCTION AND IT'S ANGIOGRAPHIC CORRELATION IN TERTIARY CARE CENTRE: A CROSS SECTIONAL STUDY

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Abstract

Background: Occlusion of proximal dominant right coronary artery (RCA) is usually responsible for Right ventricular (RV) infarction in inferior wall Myocardial Infarction (MI). RV dysfunction after MI is associated with an increased risk of shock, arrhythmias, and death. Therefore, RV involvement is a major determinant of the prognosis and of the treatment strategy in patients with inferior wall MI. **Materials and Methods:** This cross-sectional study was carried out among 100 patients admitted to coronary care unit of the Dept. of Cardiology, government Medical College, Coimbatore with first episode of acute inferior wall myocardial infarction presenting within 24 hours of symptom onset were recruited for the study. Patient's age and gender noted and examined to identify signs of RV failure. ECG and ECHO assessment of RV infarction was performed as early as possible within 24hours of symptom onset. Coronary angiogram was performed to assess the presence of a significant stenosis in RCA and LCx artery. **Result:** In the present study, the mean age of the patients was 55.22 ± 8.45 and 72% of them were male. Among the study participants, stenosis in Proximal RCA was seen among 52% (n=52) of the samples, while stenosis in distal RCA was observed in 36% of them, and only 12 patients were diagnosed with LCx Artery stenosis. The presence of hypotension (p value 0.001), Kussmaul sign (p value 0.001) and Raised JVP (p value 0.004) has the higher risk of proximal RCA stenosis. In the present study there is an association between the incidence of Proximal RCA stenosis and the following echocardiographic parameters that assessed RV dysfunction: TAPSE (p value 0.001), RVFAC (p value 0.001), tricuspid annular S' (p value 0.001), Sm (p value 0.001), Em (p value 0.001), Am (p value 0.001), IVRT (p value 0.001), IVCT (p value 0.001), ET (p value 0.001), MPI (p value 0.001). **Conclusion:** Impaired RV function in patients presenting with acute IWMI can be predicted by different echocardiographic parameters and can be confirmed by angiographic findings. Proximal RCA total occlusion being commonest infarction related artery associated with impaired RV function.

INTRODUCTION

The greatest cause of mortality globally is myocardial infarction (MI).[1] Inferior wall MI are estimated to be 40% to 50% of all MIs.[3] Inferior wall myocardial infarctions (IWMI) are due to ischemia and infarction to the inferior region of the heart. In 80% of patients, the inferior wall of the heart is supplied by the right coronary artery (RCA) via the posterior descending artery (PDA). In the

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other 20% of patients, the posterior descending coronary artery is a branch of the circumflex artery.

Inferior wall myocardial infarctions have a better prognosis than other myocardial infarctions, with a mortality of 2% to 9%. However, up to 40% of inferior wall MIs have associated right ventricular involvement (RVI) that portends a worse outcome.[4] Occlusion of proximal dominant RCA is usually responsible for RV infarction in inferior wall MI.[3] Right ventricular dysfunction (RVD) after MI is associated with an increased risk of shock, arrhythmias, and death.[5]

ST-segment elevation in the right precordial lead, V4 R, was considered as one of the reliable ECG signs of acute RV infarction.[7] ECG changes are transient and disappear in 48% of cases within 10 hours making it a less dependable tool.[8] A hypokinetic or akinetic segment of the RV observed by echocardiography also could be used to detect RVD after RV infarction. However, quantitative assessment of RV function is still challenging due to its complex anatomy and thin wall structure, and therefore is not incorporated into daily clinical practice.[9]

Numerous studies have shown the value of several echocardiographic parameters, including TAPSE, fractional area change (FAC), tissue Doppler imaging of the lateral tricuspid annulus (S′), right ventricular myocardial performance index (RIMP), and more recently RV free wall global longitudinal strain (RVGLS) for the evaluation of RV systolic function.[9–14] The reliability of the Myocardial Perfusion Index (MPI) is well established. This MPI also assists researchers in their comprehension of recreational vehicle dynamics.[10] But there are only limited studies validating the usefulness of these echocardiographic parameters of RV function in predicting proximal RCA stenosis and many lacked angiographic correlation. The objective of the present research was to evaluate RV function in patients with acute IWMI using echocardiography and correlate these findings with the degree of stenosis in the RCA and Left circumflex (LCx) artery observed in angiography.

MATERIALS AND METHODS

Study design and study duration: This cross-sectional study was carried out for one year between January 2023 and December 2023.

Study Population: All patients admitted to coronary care unit of the Dept. of Cardiology, government teaching Medical College, Coimbatore in South India with first episode of acute IWMI presenting within 24 hours of symptom onset were recruited for the study.

Patient Selection

Inclusion Criteria

Patients were included if they had an acute IWMI, at least 30 minutes of chest pain, and an ECG taken within 6 hours of onset of symptoms. IWMI was considered if ECG recorded an ST-segment elevation of ≥0.2 mV in the inferior leads and reciprocal changes in lateral leads. The presence of a right ventricle myocardial infarction (RVMI) associated with an IWMI was also considered, which was defined by an ST segment elevation of ≥0.1 mV in V4 through V6R lead.

ECG assessment of IWMI with RV infarction:

A standard 12-lead ECG and a right precordial ECG (lead V4 R) were recorded immediately after arrival to the coronary care unit. IWMI was defined as ST-segment elevation at least 2 mm in inferior leads (leads II, III, and aVF) and reciprocal changes in lateral leads. The presence of RV infarction in association with an IWMI was defined by an ST-segment elevation of 0.1 mV in lead V4 R through V6R lead.[7]

RV assessment by ECHO:

Following initial stabilization all patients underwent a comprehensive conventional echocardiographic evaluation. Standard views recommended by the American Society of Echocardiography (ASE) were utilized during the examination. The measurement of TAPSE was obtained by positioning an M-mode cursor across the tricuspid lateral annulus in an apical four-chamber view. The pulsed-tissue Doppler imaging technique was utilized to evaluate cardiac dynamics. The images were captured through the apical four-chamber window, utilizing the tissue Doppler mode, and focusing on the RV-free wall. At the end of expiration, the pulsed Doppler sample volume was placed at the tricuspid annulus of the basal RV free wall segment.

Comprehensive velocity profiles which included a significant positive peak systolic velocity (Sm), which indicated that the annulus was moving toward the apex during systole. In addition, negative early diastolic myocardial velocity (Em) measurements were recorded as the annulus ascended away from the apex. Following that, negative late diastolic myocardial velocity (Am) readings were recorded. The dynamic behaviour of Sm, Em, and Am waves was effectively characterized by this analysis. The duration of Sm was calculated using the ejection time (ET). Isovolumic relaxation time (IVRT) data was obtained by calculating the time elapsed between the end of Sm and the start of Em. The duration of the interval between the end of Am and the beginning of Sm also provided insight into the isovolumic contraction time (IVCT). The MPI, a key indicator of cardiac function, was calculated using the following formula: MPI = [(IVRT + IVCT) / ET].

Lesion localisation by Coronary Angiogram:

Coronary angiogram performed as a part of primary PCI or as a Pharmacoinvasive procedure to assess presence of a significant stenosis in RCA and LCx artery. The presence of total or subtotal occlusion of the coronary artery supplying the asynergic field was a crucial criterion for identifying the culprit lesion. The angiography results divided the patients

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who met these criteria into two groups: 88 with RCA stenosis and 12 with LCx artery stenosis.

Statistical Analysis

The collected data was entered in MS excel and analysed using IBM SPSS version 21. Categorical data were expressed as frequencies and percentages. To determine the relationship between the culprit vessel and risk factors, Fisher's exact test was performed. Continuous variables were expressed as means and standard deviations. To determine the relationship between the culprit vessel and RV parameters, independent t-test was utilized. A p value of <0.05 accepted as statistically significant.

RESULTS

In the present study, the mean age of the patients was 55.22 ± 8.45 and 72% of them were male. Within the age range of 46-60 years, there were 52 (52%) participants. Out of these, 37 were males and 15 were females. Additionally, 30 (30%) patients were over 60. Among this older age group, 22 were males and 8 were females. [Table 1] shows the age and gender distribution of patients.

[Table 1] shows the relationship between clinical parameters and the occurrence of culprit lesion in the RCA and LCx. Nearly 94.9% of the patients with hypotension was diagnosed to have stenosis in proximal RCA on comparison to non-hypotensive patients and this difference was statistically significant by fisher's exact test (p value – 0.001). Those patients who presented with Kussmaul sign (n = 12) and Raised Jugular Venous pressure (n = 8) clinically were diagnosed to have stenosis only in proximal RCA.

[Table 2] shows the comparison of echocardiographic parameters between RCA stenosis and LCx stenosis groups. TAPSE stands out with a value of 14.86 ± 2.374 and 16.83 ± 0.718 in the RCA stenosis group and the LCx stenosis group, respectively, with a significant difference (p value = 0.005). The Right Ventricular Fractional Area Change (RVFAC) exhibits 41.60 ± 8.489 and 49.25 ± 3.33% in the RCA stenosis and the LCx stenosis, respectively, signifying a noteworthy distinction (p value = 0.0001). There was no significant difference (p value = 1.2) in left ventricular ejection fraction (LVEF) between patients with RCA stenosis (46.13 ± 2.5%) and those with LCx stenosis (47.33 ± 1.8%). The Sm was significantly lower in the RCA stenosis group (13.04 ± 2.76 cm/s) compared to the LCx group (16.10 ± 0.83 cm/s), with a p-value of 0.0001. This suggests that RCA stenosis patients have impaired systolic function. The RCA stenosis group had an Em of 8.853 ± 1.14 cm/s, while the LCx group had 10.108 ± 0.53cm/s, and significant difference was found in Em between groups with a p-value of 0.0001. The RCA stenosis group had a tricuspid annular S' of 9.782 ± 1.41, while the LCx group had 11.08 ± 0.99 cm/s, and significant difference was found in tricuspid annular S' between groups with a p-value of 0.003. The RCA stenosis group had an Am of 13.688 ± 1.83 cm/s, while the LCx group had 15.525 ± 0.62 cm/s and Am also showed significant variation between groups with a p-value of 0.001. The RCA stenosis group had a ratio of 0.647 ± 0.04, while the LCx group had 0.651 ± 0.04 and showed no significant variation between groups. The RCA stenosis group had a significantly (p value = 0.0001) longer IVRT (100.15 ± 14.56 ms) than the LCx group (81.25 ± 4.77 ms), indicating delayed relaxation. The IVCT showed a significant difference between groups (p value = 0.0001). The RCA stenosis group had an IVCT of 81.03 ± 9.13 ms, while the LCx group had 71.25 ± 3.98 ms. The ET was significantly (p value = 0.0001) shorter in the RCA stenosis group (269.81 ± 21.12 ms) compared to the Lcx group (288.5 ± 8.96 ms). The MPI, a measure of cardiac function, was significantly (p value = 0.002) higher in the RCA stenosis group (0.656 ± 0.09) than in the Lcx group (0.567 ± 0.01).

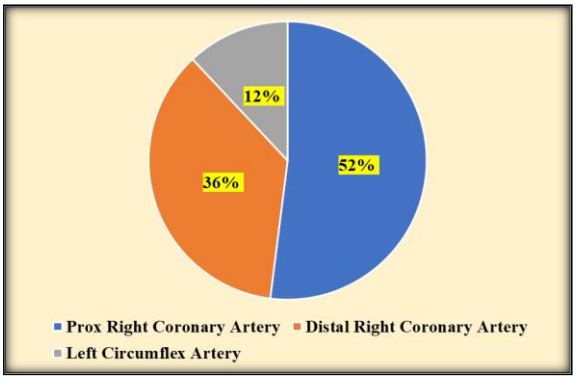

Figure 1: Distribution of culprit lesion among the study participants

[Table 3] shows the comparison of echocardiographic parameters between proximal RCA stenosis and distal RCA stenosis groups. TAPSE stands out with a value of 13.42 ± 2.00 and 16.94 ± 0.79 in the proximal RCA stenosis group and the distal group stenosis group, respectively, with a significant difference (p value = 0.0001). The RVFAC exhibits 35.12 ± 2.77 and 50.97 ± 3.88 % in the proximal RCA stenosis and the distal stenosis, respectively, signifying a noteworthy distinction (p value = 0.0001). There was no significant difference (p value = 0.258) in LVEF between patients with proximal RCA stenosis (45.87 ± 2.95%) and those with distal stenosis (46.50 ± 1.85%). The Sm was significantly lower in the proximal RCA stenosis group (10.835 ± 0.77 cm/s) compared to the distal group (16.225 ± 0.67 cm/s), with a p-value of 0.0001. This suggests that proximal RCA stenosis patients have impaired systolic function. The proximal RCA stenosis group had an Em of 8.025 ± 0.54 cm/s, while the distal group had 10.05 ± 0.57cm/s, and significant difference was found in Em between groups with a p-value of 0.0001. The proximal RCA stenosis group had a tricuspid

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annular S' of 8.9 ± 1.10, while the distal group had 11.056 ± 0.62 cm/s, and significant difference was found in tricuspid annular S' between groups with a p-value of 0.0001. The proximal RCA stenosis group had an Am of 12.26 ± 0.62 cm/s, while the distal group had 15.75 ± 0.64 cm/s and Am also showed significant variation between groups with a p-value of 0.0001. The proximal RCA stenosis group had a ratio of 0.65 ± 0.04, while the distal group had 0.63 ± 0.041 and showed no significant variation between groups. The proximal RCA stenosis group had a significantly (p value = 0.0001) longer IVRT (111.17 ± 6.0 ms) than the distal group (84.22 ± 5.6 ms), indicating delayed relaxation. The IVCT showed a significant difference between groups (p value = 0.0001). The proximal RCA stenosis group had an IVCT of 86.94 ± 5.9 ms, while the distal group had 72.50 ± 5.39 ms. The ET was significantly (p value = 0.0001) shorter in the proximal RCA stenosis group (253.73 ± 9.14 ms) compared to the distal group (293.03 ± 6.97 ms), indicating altered systolic function. The MPI, a measure of cardiac function, was significantly (p value = 0.0001) higher in the proximal RCA stenosis group (0.732 ± 0.02) than in the distal group (0.547 ± 0.02).

Table 1: Relationship between clinical parameters and the occurrence of culprit lesion in the RCA and LCx

Variables		Site of occlusion			Total	Fisher's exact test value	p value
		Proximal RCA, (n = 52)	Distal RCA, (n = 36)	Left circumflex, (n = 12)			
Hypotension	Yes	37 (94.9%)	2 (5.1%)	0 (0%)	39 (39%)	47.196	0.001
	No	15 (24.6%)	34 (55.7%)	12 (19.7%)	61 (61%)		
Kussmaul sign	Yes	12 (100%)	0 (0%)	0 (0%)	12 (12%)	12.587	0.001
	No	40 (45.5%)	36 (40.9%)	12 (13.6%)	88 (88%)		
Raised JVP	Yes	8 (100%	0 (0%)	0 (0%)	8 (8%)	8.027	0.004
	No	44 (47.8%)	36 (39.1%)	12 (3%)	92 (92%)		
	Not done	6 (33.3%)	9 (50%)	3 (16.7%)	18 (18%)		

Table 2: Comparative echocardiographic evaluation between RCA stenosis and LCx stenosis groups

Variables	Site of occlusion		Mean difference	P value
	Right Coronary Artery, (n=88)	Left Circumflex, (n=12)		
TAPSE	14.86 ± 2.374	16.83 ± 0.718	-1.97	0.005
RVFAC (%)	41.60 ± 8.489	49.25 ± 3.334	-7.648	0.0001
LVEF (%)	46.13 ± 2.572	47.33 ± 1.875	-1.208	1.2
Doppler S'	9.782 ± 1.41	11.08 ± 0.996	-1.3015	0.003
Sm (cm/s)	13.04 ± 2.76	16.10 ± 0.8388	-3.06	0.0001
Em (cm/s)	8.853 ± 1.143	10.108 ± 0.538	-1.254	0.0001
Am (cm/s)	13.688 ± 1.836	15.525 ± 0.621	-1.8375	0.001
Em/ Am (ratio)	0.647 ± 0.041	0.651 ± 0.048	-0.004	0.737
IVRT (ms)	100.15 ± 14.567	81.25 ± 4.770	18.89	0.0001
IVCT (ms)	81.03 ± 9.132	71.25 ± 3.98	9.784	0.0001
ET (ms)	269.81 ± 21.124	288.5 ± 8.96	-18.693	0.0001
MPI	0.656 ± 0.094	0.567 ± 0.019	0.0889	0.002

Table 3: Comparative echocardiographic evaluation of proximal RCA stenosis and distal RCA stenosis groups

Variables	Site of occlusion in RCA		Mean difference	P value
	Proximal RCA, (n=52)	Distal RCA, (n=36)		
TAPSE	13.42 ± 2.003	16.94 ± 0.791	-3.521	0.0001
RVFAC (%)	35.12 ± 2.77	50.97 ± 3.88	-15.857	0.0001
LVEF (%)	45.87 ± 2.957	46.50 ± 1.859	-0.0635	0.258
Doppler S'	8.9 ± 1.10	11.056 ± 0.629	-2.1556	0.0001
Sm (cm/s)	10.835 ± 0.773	16.225 ± 0.6789	-5.3904	0.0001
Em (cm/s)	8.025 ± 0.543	10.05 ± 0.573	-2.025	0.0001
Am (cm/s)	12.26 ± 0.62	15.75 ± 0.644	-3.49	0.0001
Em/ Am (ratio)	0.65 ± 0.04	0.63 ± 0.041	0.016	0.075
IVRT (ms)	111.17 ± 6.083	84.22 ± 5.662	26.951	0.0001
IVCT (ms)	86.94 ± 5.942	72.50 ± 5.39	14.442	0.0001
ET (ms)	253.73 ± 9.148	293.03 ± 6.975	-39.297	0.0001
MPI	0.732 ± 0.025	0.547 ± 0.026	0.184	0.0001

DISCUSSION

Acute occlusion of the RCA proximal to the RV branches may result in right ventricle infarction. This identifies a significant subgroup of patients that are associated with considerable immediate morbidity and mortality.[16]

In the present study, the mean age of the patients was 55.22 ± 8.45 and 72% of them were male. More than half of the patients (52%) were above the age of 45 years. Among the study participants, stenosis in Proximal RCA was seen among 52% (n=52) of the samples, while stenosis in distal RCA was observed in 36% of them, and only 12 patients were

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diagnosed with LCx Artery stenosis. Commonest Infarction related Artery (IRA) associated with impaired RV function was proximal RCA in the study by Lotfy et al in Egypt by 2021.[17] Similar findings were noted in the study by Rajesh et al. in India by 2012 in which they reported that 39% of patients had proximal RCA stenosis, and 61% had non-proximal RCA stenosis that includes left coronary artery.[13] El Sebaie and El Khateeb examined 76 patients with inferior wall MIs and reported that 43 (56.5%) had proximal RCA stenosis, while 43.5% had distal RCA stenosis.[13] Remarkably, our findings closely align with their results, reinforcing the consistency of outcomes across different studies. In the present study, there was no statistically significant difference between groups of culprit lesion regarding baseline variables like age, BMI, type 2 diabetes mellitus (T2DM), hypertension, smoking and thrombolysis received. Similar findings were noted in the study by Rajesh et al. in India by 2012.[13] They observed that there was no statistically significant difference between groups regarding baseline variables like age, sex, BMI, T2DM or hypertension.

In the present study there is a strong association that the presence of clinical parameters such as hypotension, Kussmaul sign and elevated JVP will result in development of proximal RCA stenosis than another culprit lesion. This finding suggests a potential association between proximal RCA stenosis and increased JVP, which may reflect RV function and hemodynamic variations. It is important to remember that the decision to undergo thrombolysis was most likely influenced by several factors, including the severity of symptoms, the extent of ischemia, the patient's overall condition, and the length of time since symptoms first appeared.

In the present study there is an association between the incidence of Proximal RCA stenosis and the following echocardiographic parameters that assessed RV dysfunction: TAPSE, RVFAC, tricuspid annular S', Sm, Em, Am, IVRT, IVCT, ET, MPI. Similar finding was observed in the study by Kumar et al in India by 2023 among 200 patients experiencing their first symptoms of acute IWMI.[10] Consequently, a detectable IVRT indicates elevated RV end-systolic pressure.[1] In our study, patients with proximal RCA exhibited significantly longer RV IVRT and shorter ET. This is because proximal RCA patients have a significantly higher incidence of RVMI. Furthermore, our study revealed that the prolongation of IVCT and the decrease in ET were the main factors that contributed to a significantly elevated MPI in patients with stenosis in the RCA. This indicates that patients with proximal RCA stenosis have a higher level of cardiac dysfunction. The MPI has been established as a reliable indicator for identifying proximal RCA lesions because it provides a comprehensive measurement that includes both the systolic and diastolic phases of the cardiac cycle.[15]

Accurate identification of the culprit artery is critical in the risk stratification and optimization of treatment approaches for patients afflicted by acute IWMI. Particularly, the mortality rate for acute IWMI cases accompanied by RV involvement attributable to proximal lesions within the RCA is notably elevated at 16%, in contrast to the 3.5% mortality rate observed in cases of isolated acute IWMI.[16] Echocardiography has become the standard RV evaluation method in routine clinical practice. Nevertheless, the complex RV geometry poses significant challenges to evaluating RV function.[17]

Limitations

The study was performed on relatively small sample size and hence an effect of RV function derangement on prognosis could not be determined. The invasive hemodynamic assessment was not done. Measuring the right atrial pressure could have helped in elucidating the pseudo normalization of the Tei index in severe RV infarction. Strain imaging software was not installed in the echo machine at the time of undertaking the study; hence RV strain imaging could not be performed. we only studied the acute stage of MI and RV functional recovery may occur later after acute MI, so later assessment of RV function could result in different findings. We didn't follow-up patients after discharge to assess improvement of RV function with time and the long-term effects of our findings.

CONCLUSION

The comprehensive echocardiographic evaluation of diverse parameters relating to RV function in the context of acute inferior wall STEMI has revealed substantial differences between groups characterized by proximal and distal RCA lesions. Assessment of RV systolic and diastolic function using echocardiography is useful, rapid, and feasible method that can be done initially and at follow up to all STEMI patients. Impaired RV function in patients presenting with RV infarction can be predicted by angiographic findings. The utility of easily accessible measures such as tissue Doppler systolic annular velocity, MPI, and TAPSE has been underscored in predicting the proximal RCA as the infarct related artery. It is noteworthy that all patients diagnosed with proximal RCA stenosis exhibited RV dysfunction upon echocardiographic analysis. Importantly, the study's findings also emphasize a high incidence of RVMI in patients with proximal RCA stenosis, reinforcing the clinical significance of these observations.

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