

Assessment of different indices of RV functions by Echocardiography in acute Inferior wall Myocardial Infarction and its coronary angiographic correlation

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Abstract

Background: Cardiovascular diseases (CVD) are the top most cause of death in the world. As per world health organization (WHO), greater number of people die of CVDs than any other cause. Out of the CVDs predominant mortality is attributed to coronary artery disease (CAD) which includes stable CAD and unstable CAD (which can manifest as unstable angina, NSTEMI or STEMI). Hence the present study was undertaken at our tertiary care centre to assess different indices of RV function by Echocardiography within 48 hours of onset of symptoms in 1st episode of acute IWMi and to correlate it with the site of lesion in CAG.

Materials & methods: A hospital-based study was conducted with 100 patients of acute IWMi (1st episode) who had presented within 48 hours of symptoms. Patients were divided into two groups depending on the ST elevation in leads V4R or V3R (whether elevated or not): Group I: subjects showing ST elevation in V4R or V3R (IWMi with RVMI), and

Group II: subjects showing isoelectric ST in V4R or V3R (IWMI without RVMI). The following parameters were used for RV functional assessment-- 1. TAPSE (tricuspid annular plane systolic excursion) , 2. RVFAC (right ventricular fractional area change), 3. Pulsed wave tissue Doppler imaging (assess S',ie, tricuspid annular velocity and MPI ,ie, myocardial performance index).

These patients had undergone CAG to assess the site of lesion and its results was correlated with the RV indices. Statistical testing was conducted with the statistical package for the social science system version SPSS 20.0.

Results:TAPSE (12.88±1.7 Vs 21.48±3.96),S'(9.14±1.14 Vs 16.14±2.40), RV-FAC(30.86±3.6 Vs 47.18±7.2) were substantially low in patients in group I as compared to group II whereas Myocardial Performance Index - Tissue Doppler Imaging (MPI-TDI) (0.62±0.16 vs. 0.32±0.10; p<0.05) values was substantially more in Group I as compared to Group II according to the Student t-test.The TAPSE (13.95±3.16 cm vs. 20.98±4.5 cm; p<0.05), S' (9.53±1.9 m/s vs. 15.9±2.6 m/s; p<0.05) and RV-FAC (30.96±3.3 vs. 47.12±7.4; p<0.05) values were compellingly lesser in cases with Proximal RCA Lesion whereas the MPI-TDI (0.66±0.11 vs. 0.31±0.07; p<0.05) values were higher in patients with Proximal RCA Lesion when compared to those without Proximal RCA Lesion as per Student t-test.For predicting proximal RCA lesion the cut off value of TAPSE < 16 showed Sensitivity of 87.5%, Specificity of 91.1%, Positive Predictive Value (PPV) of 82.3% and Negative Predictive Value (NPV) of 93.9%,the cut off value of S' <10 cm/sec showed Sensitivity of 81.25%, Specificity of 92.6%, PPV of 83.8% and NPV of 91.3%,the cut off value of MPI-TDI >0.55 showed Sensitivity of 84.3%, Specificity of 92.6%, PPV of 84.3% and NPV of 92.6% and the cut off value of RV-FAC <35% showed Sensitivity of 87.5%, Specificity of 91.1%, PPV of 82.3% and NPV of 93.9%.

Conclusion- Echocardiography is a valuable tool to assess right ventricular function and to diagnose RVMI with IWMI. Assessment of different echocardiographic parameters of RV function showed substantial difference amongst groups with or without Proximal RCA lesion proven by coronary angiography.

Key words: Echocardiography, RV function

Introduction

Cardiovascular diseases (CVD) are the top most cause of death in the world. As per world health organization (WHO), greater number of people die of CVDs than any other cause.¹ Over the last two decades, the incidence and prevalence of CVDs have increased. This has had a multi-fold impact on the global health and economic scene. Most of the burden, a huge 80% is borne by the low and middle countries of the world.²

CAD can present as---Stable CAD and Unstable CAD which can manifest as--Unstable angina, NSTEMI (Non- ST elevation myocardial infarction), STEMI (ST elevation myocardial infarction).^{3, 4}

Acute ST segment elevation MI (STEMI) generally happens when thrombus develops on a ruptured atheromatous plaque and blocks an epicardial coronary vessel. Survival of the person is dependent on many components, the major one being reclamation of brisk

antegrade coronary blood flow, the time required to attain this, and the maintained patency of the involved artery.⁵

The infarct in acute cases of Inferior Myocardial Infarction is commonly due to RCA involvement and less likely due to circumflex involvement. The fatality and complication rates are increased in cases of acute inferior wall MI that also involve the right ventricle. When a patient presents with complications like cardiogenic shock and arrhythmias, RCA territory is most commonly involved.^{6, 7}

Area and volume measurement via conventional methods have restricted usefulness in understanding RV function because of its complicated structure. Many ECHO parameters have come up which helps in assessing the RV functions which is based on the contraction of longitudinal fibres, which brings tricuspid annulus close to apex. Various Tissue Doppler parameters have justified their need in assessing RV function.^{8, 9}

Hence present study was undertaken at our tertiary care centre to assess different indices of RV function by Echocardiography within 48 hours of onset of symptoms in 1st episode of acute IWMI and correlating it with the site of lesion in angiography.

Materials & methods

A hospital-based study was conducted with 100 patients of acute IWMI (1st episode) who had presented within 48 hours of symptoms. These patients had undergone Echocardiography for RV function assessment which was further co-related with the site of lesion in coronary angiogram. Patients were divided into two groups depending on the ST elevation in leads V4R or V3R (whether elevated or not):

- Group I: 32 subjects showed ST elevation in V4R or V3R (IWMI with RVMI).
- Group II: 68 subjects showed isoelectric ST in V4R or V3R (IWMI without RVMI)

First episode of acute inferior wall myocardial infarction patients attending OPD/IPD of Tertiary care Hospital who fulfilled the inclusion criteria were recruited. A detailed past and present history along with clinical examination of patients was done and the data were registered in a pre-designed form. Patient profile (Age, sex, weight, height), Clinical status (blood pressure, pulse rate, NYHA functional class), Complications like cardiogenic shock, arrhythmia, heart block, Risk-factors (diabetes, dyslipidaemia, hypertension, Smoking & family history of coronary artery disease), Drug History, ECG with right sided ECG on presentation were registered.

Echocardiographic assessment of RV function was performed as early as possible, within 48 hours of symptom onset and coronary angiogram was performed in all patients to assess for presence of a significant proximal RCA stenosis.

The following parameters were used for RV functional assessment--

1) TAPSE

In apical 4-chamber view, M-mode cursor was placed through tricuspid annulus at lateral RV free wall in such a way that the annulus move along M-mode cursor. From M-mode tracing the amount of longitudinal motion of annulus at peak systole was measured. Total displacement was measured by leading edge of echoes and expressed in millimeter.

2. RVFAC

RVFAC is defined as $(RV \text{ end diastolic area} - RV \text{ end systolic area}) / \text{end diastolic area} \times 100$. Right ventricular area in diastole and systole were obtained by tracing the RV endocardium in

both phases from the annulus along free wall to apex and then back to annulus along interventricular septum in apical 4 chamber view.

3. Pulsed wave tissue Doppler imaging

A major positive velocity (S') was recorded with the movement of annulus towards apex during systole. With the movement of annulus towards base during diastole, two major negative waves were recorded—one during early diastole (E') and one during late diastole (A'). S' duration was measured as ejection time (ET), the time between the end of S' and the beginning of E' as isovolumic relaxation time (IRT), time between end of A0 and beginning of S' as isovolumic contraction time (ICT). Right ventricular MPI is calculated as $(IRT + ICT)/ET$.

Coronary Angiography

Significant proximal RCA stenosis is defined in the coronary angiogram by the presence of occlusion, $\geq 70\%$ stenosis, acute thrombosis or dissected plaque in RCA before the origin of first major RV branch. The patients were divided into two groups according to the level of the right coronary artery lesion when the IRA was the right coronary artery. The patients with the lesion proximal to the major RV branch of the right coronary artery were defined as proximal RCA group, whereas those with the lesion distal to the major RV branch of right coronary artery were defined as without proximal RCA group.

Statistical testing was conducted with the statistical package for the social science system version SPSS 20.0. Continuous variables presented as Mean \pm SD or median (IQR) for non-normally distributed data. Categorical variables expressed as frequencies and percentages.

Results

The patients in Group I had a mean age of 55.06 ± 11.53 years. The mean age of cases in Group II was 57.65 ± 11.41 years. There was 25 (78.1%) male and 7 (21.9%) female cases in Group I while this number was 55 (80.9%) male and 13 (19.1%) female cases in Group II. The incidence of Kussmaul's sign (59.4% vs 0%), raised JVP (68.7% vs. 8.8%) and hypotension (75% vs. 14.7%) was significantly more in Group I compared to Group II according to Chi-Square test. The Tricuspid Annular Plane Systolic Excursion (TAPSE) (12.86 ± 1.7 cm vs. 21.48 ± 3.96 cm; $p < 0.05$), Tissue Doppler Peak systolic velocity (S') (9.14 ± 1.14 m/s vs. 16.14 ± 2.40 m/s; $p < 0.05$) and Right Ventricular Fractional area change (RV-FAC) (30.86 ± 3.6 vs. 47.18 ± 7.2 ; $p < 0.05$) values was substantially lesser in Group I compared to Group II as per Student t-test. The Myocardial Performance Index - Tissue Doppler Imaging (MPI-TDI) (0.62 ± 0.16 vs. 0.32 ± 0.10 ; $p < 0.05$) values was substantially more in Group I as compared to Group II according to the Student t-test.

The TAPSE (13.95 ± 3.16 cm vs. 20.98 ± 4.5 cm; $p < 0.05$), S' (9.53 ± 1.9 m/s vs. 15.9 ± 2.6 m/s; $p < 0.05$) and RV-FAC (30.96 ± 3.3 vs. 47.12 ± 7.4 ; $p < 0.05$) values was compellingly lesser in cases with Proximal RCA Lesion whereas the MPI-TDI (0.66 ± 0.11 vs. 0.31 ± 0.07 ; $p < 0.05$) values were higher in patients with Proximal RCA Lesion when compared to those without Proximal RCA Lesion as per Student t-test.

For predicting proximal RCA lesion the cut off value of TAPSE < 16 showed Sensitivity of 87.5%, Specificity of 91.1%, Positive Predictive Value (PPV) of 82.3% and Negative Predictive Value (NPV) of 93.9%, the cut off value of S' < 10 cm/sec showed Sensitivity of

81.25%, Specificity of 92.6%, PPV of 83.8% and NPV of 91.3%, the cut off value of MPI-TDI >0.55 showed Sensitivity of 84.3%, Specificity of 92.6%, PPV of 84.3% and NPV of 92.6% and the cut off value of RV-FAC <35% showed Sensitivity of 87.5%, Specificity of 91.1%, PPV of 82.3% and NPV of 93.9%.

To predict proximal RCA lesions in patients with RVMI, the cut off values of TAPSE, S', MPI-TDI and RV-FAC showed good sensitivity (87.5%, 81.25%, 84.3% and 87.5% respectively) and good specificity (91.1%, 92.6%, 92.6% and 91.1% respectively). The association of all 4 parameters with proximal RCA lesion was statistically significant.

Table 1: Distribution of patients in accordance with Clinical Parameters

Clinical Parameters		Group I		Group II		p Value
		N	%	N	%	
Kussmaul's sign	Yes	19	59.4%	0	-	<0.05
	No	13	40.6%	68	100%	
	Total	32	100%	68	100%	
Raised JVP	Yes	22	68.7%	6	8.8%	<0.05
	No	10	31.3%	62	91.2%	
	Total	32	100%	68	100%	
Hypotension	Yes	24	75%	10	14.7%	<0.05
	No	8	25%	58	85.3%	
	Total	32	100%	68	100%	

Table 2: Echocardiographic parameters of Right Ventricular Systolic Function in the two groups--

Parameters	Group I		Group II		p Value
	Mean	SD	Mean	SD	
TAPSE (cm)	12.88	1.7	21.48	3.96	<0.05
S' (m/s)	9.14	1.14	16.14	2.40	<0.05
MPI-TDI	0.62	0.16	0.32	0.10	<0.05
RV-FAC (%)	30.86	3.6	47.18	7.2	<0.05

TAPSE - Tricuspid Annular Plane Systolic Excursion; S' - Tissue Doppler Peak systolic velocity; MPI-TDI - Myocardial Performance Index - Tissue Doppler Imaging; RV-FAC - Right Ventricular Fractional area change

Table 3: Comparing Echocardiographic parameters of Right Ventricular Systolic Function with the site of Culprit lesion on Angiography

Parameters	Proximal RCA Lesion		Without Proximal RCA Lesion		p Value
	Mean	SD	Mean	SD	
TAPSE (cm)	13.95	3.16	20.98	4.5	<0.05
S' (m/s)	9.53	1.9	15.9	2.6	<0.05
MPI-TDI	0.66	0.11	0.31	0.07	<0.05

RV-FAC (%)	30.96	3.3	47.12	7.4	<0.05
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Table 4: Sensitivity and specificity of ECG parameters in predicting RCA lesion

Parameters	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	p Value
TAPSE(<16mm)	87.5%	91.1%	82.3%	93.9%	<0.05
S' (<10 cm/sec)	81.25%	92.6%	83.8%	91.3%	<0.05
MPI-TDI (>0.55)	84.3%	92.6%	84.3%	92.6%	<0.05
RV-FAC (<35%)	87.5%	91.1%	82.3%	93.9%	<0.05

DISCUSSION

In the present study, the patients in Group I had a mean age of 55.06 ± 11.53 years. The mean age of cases in Group II was 57.65 ± 11.41 years. There was 25 (78.1%) male and 7 (21.9%) female cases in Group I while this number was 55 (80.9%) male and 13 (19.1%) female cases in Group II. The incidence of Kussmaul's sign (59.4%vs 0%), raised JVP (68.7%vs. 8.8%) and hypotension (75%vs.14.7%) was significantly more in Group I compared to Group II according to Chi-Square test. The Tricuspid Annular Plane Systolic Excursion (TAPSE)(12.86 ± 1.7 cm vs. 21.48 ± 3.96 cm; $p < 0.05$), Tissue Doppler Peak systolic velocity (S') (9.14 ± 1.14 m/s vs. 16.14 ± 2.40 m/s; $p < 0.05$) and Right Ventricular Fractional area change (RV-FAC) (30.86 ± 3.6 vs. 47.18 ± 7.2 ; $p < 0.05$) values was substantially lesser in Group I compared to Group II as per Student t-test. The Myocardial Performance Index - Tissue Doppler Imaging (MPI-TDI) (0.62 ± 0.16 vs. 0.32 ± 0.10 ; $p < 0.05$) values was substantially more in Group I as compared to Group II according to the Student t-test.

The TAPSE (13.95 ± 3.16 cm vs. 20.98 ± 4.5 cm; $p < 0.05$), S' (9.53 ± 1.9 m/s vs. 15.9 ± 2.6 m/s; $p < 0.05$) and RV-FAC (30.96 ± 3.3 vs. 47.12 ± 7.4 ; $p < 0.05$) values was compellingly lesser in cases with Proximal RCA Lesion whereas the MPI-TDI (0.66 ± 0.11 vs. 0.31 ± 0.07 ; $p < 0.05$) values were higher in patients with Proximal RCA Lesion when compared to those without Proximal RCA Lesion as per Student t-test.

The cut off value of <16mm for TAPSE showed Sensitivity of 87.5%, Specificity of 91.1%, Positive Predictive Value (PPV) of 82.3% and Negative Predictive Value (NPV) of 93.9%. The cut off value of <10 cm/sec for S' showed Sensitivity of 81.25%, Specificity of 92.6%, PPV of 83.8% and NPV of 91.3%. The cut off value of >0.55 for MPI-TDI showed Sensitivity of 84.3%, Specificity of 92.6%, PPV of 84.3% and NPV of 92.6%. The cut off value of <35% for RV-FAC showed Sensitivity of 87.5%, Specificity of 91.1%, PPV of 82.3% and NPV of 93.9%. In the present study, to predict proximal RCA lesions in patients with RVMI, the cut off values of TAPSE, S', MPI-TDI and RV-FAC showed good sensitivity (87.5%, 81.25%, 84.3% and 87.5% respectively) and good specificity (91.1%, 92.6%, 92.6% and 91.1% respectively). The association of all 4 parameters with proximal RCA lesion was statistically significant.

Coghlan JG et al studied 90 patients with first episode of IWMI of which 67 patients underwent CAG. There was significant difference between group 1 (IWMI + RVMI, n = 26) and group 2 (isolated IWMI, n = 41) in TAPSE (13.5 ± 1.3 vs 21.3 ± 1.7 , $p < 0.001$). There was a good interobserver correlation for TAPSE. TAPSE ≤ 16 (sensitivity 93%, specificity 100%), were useful in predicting presence of proximal RCA stenosis.¹⁰

Gopalan et al in his study with 90 patients with first episode of IWMI of which 67 patients underwent CAG found that there was significant difference between group 1 (IWMI with RVMI, n = 26) and group 2 (IWMI without RVMI, n = 41) in TAPSE (13.5 ± 1.3 vs 21.3 ± 1.7 , $p < 0.001$), MPI by tissue Doppler (0.87 ± 0.1 vs 0.55 ± 0.2 , $p < 0.001$) and in tissue Doppler systolic velocity from RV free wall (S' 9.8 ± 1.1 vs 15.0 ± 1.5 , $p < 0.001$). There was a good interobserver correlation for TAPSE, MPI by TDI, and S' velocity. TAPSE ≤ 16 (sensitivity 93%, specificity 100%), MPI-TDI ≥ 0.69 (sensitivity 94.7%, specificity 93.5%), S ≤ 12.3 (sensitivity 90.3%, specificity 94.3%) were useful in predicting presence of proximal RCA stenosis.¹¹

El Sebaie et al compared the validity of echocardiographic parameters assessing right ventricular (RV) function for the prediction of proximal right coronary artery (RCA) lesion in patients with inferior wall myocardial infarction. Patients with proximal RCA showed significantly lower S' (10.44 ± 2.61 cm/s vs. 12.11 ± 2.94 cm/s, $p = 0.013$) while MPI was significantly higher (0.82 ± 0.222 Vs. 0.47 ± 0.10 , $p = 0.001$) when compared with patients without proximal RCA stenosis. It further concluded that most independent predictors for proximal RCA lesions were MPI ($p = 0.0001$) and a cut-off value of 0.58 for MPI had a sensitivity of 95% and specificity of 97% for the diagnosis proximal RCA.¹²

Shetaya A et al conducted study on 35 cases with 1st episode of IWMI and showed substantial variations between groups in TAPSE (1.28 cm vs 1.98 $p < 0.001$), MPI-TDI (0.69 ± 0.12 vs 0.38 ± 0.05 $p < 0.001$), and in S' velocity from RV free wall (0.09 m/s ± 0.02 vs 0.12 m/s ± 0.02 $p < 0.001$). He noted that S' < 10 cm/s is useful in determining a proximal RCA lesion with sensitivity of 92.86% and specificity of 85.71%, PPV 81.25, NPV 94.7, MPI-TDI > 0.55 had a sensitivity of 92.86 % and a specificity of 100%, 100% PPV and 95.45% NPV, TAPSE < 16 mm had a sensitivity of 93%, and a specificity of 100%.¹³

Roshdy et al in her study found that there was significant difference between IWMI with RVMI and isolated IWMI patients in TAPSE (14.63 ± 3.68 Vs 19.02 ± 3.01), S' (9.29 ± 2.74 Vs 13.61 ± 2.18) MPI-TDI (0.7 ± 0.2 Vs 0.5 ± 0.1) and RVFAC (34.1 ± 6.2 Vs 44.8 ± 8.5).¹⁴

Conclusion

Clinical suspicion of right ventricular involvement in the setting of acute inferior wall myocardial infarction, should arise from the presence of hypotension and shock with clear lung field, engorged neck vein and Kussmaul's sign. 12 lead ECG with right precordial leads further helps in screening patients of Inferior wall myocardial infarction with RV involvement. Echocardiography is a valuable tool to assess right ventricular function and to diagnose RVMI with IWMI. Assessment of different echocardiographic parameters of RV function showed substantial difference amongst groups with or without Proximal RCA lesion proven by coronary angiography.

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