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Assessment of Right Ventricular Function after Acute Myocardial Infarction Treated With Primary Percutaneous Coronary Intervention

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Abstract

Background: The effect of the different sites of acute ST-elevation myocardial infarction (STEMI) and left ventricular (LV) dysfunction on systolic and diastolic right ventricular (RV) function is still unclear. In this study, we aimed to assess the effect of primary percutaneous coronary intervention (PPCI) on RV function using echocardiography.

Methods: One hundred and seven consecutive patients with first episode of acute STEMI were enrolled in this study with echocardiographic imaging obtained both within 24 hours and 6 months after successful PPCI. Patients were divided into two groups, anterior (45%) and non-anterior STEMI (55%) based on significant ST-segment elevation.

Results: At presentation, TAPSE (tricuspid annular plane systolic excursion) and FAC (Fractional area change) were significantly lower in non-anterior vs. anterior group (1.9 ± 0.44 vs. 1.57 ± 0.47cm, p=0.005), (40.4 ± 7.5 vs. 34.6 ± 9%, p=0.001). No significant differences of tricuspid E/A, E/é ratio between both groups were detected while a negative correlation between LV-EF (ejection fraction) and TAPSE was recorded (r=0.24). At follow up, the anterior group showed significant improvement of RV-MPI (myocardial performance index) and LV-EF (p value=< 0.01 and 0.08, consecutively) but not of RV-DF (diastolic function). In non-anterior group, RV recovered significantly regarding FAC, TAPSE, RV-MPI and tricuspid E/é (p value=< 0.01 for all) with no improvement of LV-DF or LV-EF irrelevant of the infarction site. LV-EF showed negative correlation with LV-DF at baseline (r=0.22) and follow up (r=0.4), and with tricuspid E/é at follow up (r=0.4). Additionally, positive correlation between LV-DF and both tricuspid E/é and grades of mitral regurgitation (MR) at baseline and follow up (r=0.37, 0.28 respectively).

Conclusion: RV dysfunction can be detected in both anterior and non-anterior STEMI patients at presentation which is more prominent in the non-anterior group. At follow up successful primary PCI patients exhibited recovery of RV systolic function in both groups, while impairment of LV-DF was noted irrelevant of the infarction site. 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.

Keywords: ST-Elevation Myocardial Infarction • RV Function Assessment • Left Ventricular Function • Echocardiography • Primary Percutaneous Coronary Intervention

Introduction

RV function is an important predictor of outcome in a various cardiovascular diseases and therefore, accurate evaluation of RV function is essential issue [1]. There is no debate on the effect of different sites of myocardial infarction (MI) on the RV function but the debate is to which extent it is affected, systolic or diastolic function only or both. RV dysfunction may be secondary to LV dysfunction, as a consequence of "ventricular Interdependence" [2]. Additionally, affection of RV contractility, with interventricular septum being supplied by left coronary artery, supported that acute anterior wall MI can also lead to RV dysfunction [3].

The actual effect of different LV infarct locations on RV function in absence of RV infarction is not well known, especially in the modern era of primary PCI. However, little is known about the pattern of RV functional recovery, its relation to global and regional LV function, and the determinants of RV function change, as assessed by serial echocardiographic studies, in patients with low-risk acute MI. Recently, conventional echocardiographic evaluation is proven very beneficial with multiple studies evaluating the accuracy of different 2D parameters by comparing them with CMR-derived RV measurements which is the gold standard nowadays [4]. However, they mostly focused only on a single parameter of RV functional assessment and many lacked angiographic correlation [5] with limited sample size in plenty of others [4]. In most studies, the results are based on echocardiographic evaluation early after acute STEMI, whereas RV frequently recovers from ischemic injury in the post-STEMI period [6]. In our study, we aimed to assess the effect of first episode of acute MI and primary PCI on RV function by various echocardiographic parameters after acute STEMI.

Patients and Methods

We conducted a prospective study in the Assiut University Heart Hospital (AUHH). It included 107 patients who presented to AUHH with their first episode of STEMI, Killip class I and underwent successful primary PCI to the culprit vessel with TIMI (Thrombolysis in myocardial infarction) grade-III flow in final angiography within the first 12 hrs. of symptoms onset. Recruitment of patients started from the beginning of March 2018 till the end of November 2018 after obtaining approval from the Local Ethical Committee and written consent from all participants. All procedures performed in our study were in accordance with the ethical standards of the institutional and/or national research committee

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Abbreviations

Items	Abbreviations	Items	Abbreviations
2D	Two-Dimensional	*LCx*	Left Circumflex Artery
A	Late Diastolic Filling	*LV*	Left Ventricle
ACC/AHA	American College Of Cardiology/ American Heart Association	*LVEDD*	LV End-Diastolic Diameter
		LVESD	LV End-Systolic Diameter
ASE	American Society Of Echocardiography	*MI*	Myocardial Infarction
AUHH	Assiut University Heart Hospital	*MPI*	Myocardial Performance Index
CMR	Cardiac Magnetic Resonance Imaging	*MR*	Mitral Regurgitation
Diag.	Diagonal Arterial Branches	*MRI*	Magnetic Resonance Imaging
DF	Diastolic Function	*OM*	Obtuse Marginal Branches
DM	Diabetes Mellitus	*p*	Probability
DT	Deceleration Time	*PCI*	Percutaneous Coronary Intervention
E	Peak Early Filling	*PW*	Pulsed Wave
é	Early Diastolic Annular Velocity	*r*	Pearson's Correlation Coefficient
ECG	Electrocardiogram	*RCA*	Right Coronary Artery
Echo	Echocardiography	*RV*	Right Ventricle
EF	Ejection Fraction	*RVAd*	Right Ventricular Diastolic Area
ESC	European Society Of Cardiology	*RVAs*	Right Ventricular Systolic Area
ET	Ejection Time	*SD*	Standard Deviation
FAC	Fractional Area Change	*STEMI*	ST-Segment Elevation Myocardial Infarction
GISSI-3	Gruppo Italiano Per Lo Studio Della Sopravvivenza Nell'infartomiocardico-3	*TAPSE*	Tricuspid Annular Plane Systolic Excursion
		TCO	Tricuspid Valve Closure-Opening Time
IRA	Infarct-Related Artery	*TIMI*	Thrombolysis In Myocardial Infarction
LAD	Left Anterior Descending Artery		
LBBB	Left Bundle Branch Block		

and the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. We excluded patients with; diabetes, hypertension, previously known ischemic heart disease, previously documented ventricular dysfunction, atrial fibrillation, paced rhythm, LBBB or cardiomyopathy. Also, patients who had valvular heart disease more than mild as per ACC/AHA criteria, pulmonary hypertension with RV systolic pressure by echo >40mmHg or pulmonary embolism were excluded.

Initial evaluation

All enrolled patients were subjected to full history taking, thorough clinical evaluation and ECG recordings. The diagnosis of STEMI was based on the presence of chest pain lasting ≥ 20 mins associated with typical ECG changes, as defined in the 2018 ESC guidelines as new ST-elevation at the J-point in two contiguous leads with cut-point of: ≥ 1 mm in all leads except V2–V3 where cut-points are: ≥ 2 mm in men ≥ 40 years, ≥ 2.5 mm in men<40 years, or ≥ 1.5 mm in women regardless of age. Patients were pretreated with oral ticagrelor 180 mg and aspirin 300 mg and underwent coronary angiography and primary PCI (performed within 12 hrs of symptoms onset and within 120 mins of STEMI diagnosis). Procedures were performed via femoral or radial artery using 6-French guiding catheters with an intra-arterial bolus of 100 IU/kg heparin administered after establishment of arterial access. The PCI procedure was confined only to the infarct related artery (IRA), target lesions were initially treated with appropriate balloon predilatation if necessary and intracoronary stenting was done using DESs for all patients. Successful primary coronary angioplasty was defined as TIMI-III flow with<30% residual stenosis in the IRA.

Echocardiography for RV function assessment

Early after primary PCI i.e., within 24 hrs, echocardiographic assessment of RV along with LV function was performed to our selected cases by a cardiologist who was blind to patients' coronary anatomy using *GE Vivid S5* device using a 3.5-MHz transducer. All 2D and M-mode (obtained during breath-hold) plus conventional doppler measurements were acquired, repeated thrice and mean values were taken. Reference limits were defined according to guidelines of the American Society of Echocardiography (ASE).

Apical 4-chamber view was obtained to measure

1. FAC, which is a measure of RV systolic function that has been correlated with RV-EF by MRI. Tracing of RV endocardium in systole and diastole from tricuspid annulus along free wall to apex then back to annulus along interventricular septum was done to measure RV diastolic area (RVAd) and systolic area (RVAs) then FAC was calculated as [(RVAd - RVAs) / RVAd x 100].
2. TAPSE, which reflects the longitudinal RV systolic contraction (represented in the amount of longitudinal motion of tricuspid annulus at peak systole expressed in millimeter). It was measured by placing M-mode cursor through tricuspid annulus at lateral RV free wall in such a way that the annulus moved along the cursor.
3. RV-MPI, by placing the sample volume of pulsed-wave (PW) Doppler between the leaflets tips in the center of trans-tricuspid flow stream, velocities were recorded. Measurements were taken at end expiration in beats with<5% R-R interval variation. The time interval from tricuspid valve closure marked at the end of a wave to its opening marked at the beginning of E wave in the next cardiac cycle was measured as TCO. The sample volume of PW doppler was placed at RV-outflow tract in parasternal long-axis view to calculate ejection time (ET) as the time from onset to cessation of flow. RV-MPI was calculated as TCO - ET divided by ET.

RV diastolic function was assessed through PW and tissue doppler beam. Then, E/A ratio, E/é ratio and E wave-deceleration time (DT) were measured for grading of RV diastolic dysfunction. Impaired relaxation (grade-I) was considered when E/A ratio<0.8, pseudo-normal (grade-II) when E/A ratio 0.8 to 2.1 with E/é ratio>6 and restrictive filling (grade-III, IV) when E/A ratio>2.1 with DT<120 msec. We also took in consideration assessment of LV systolic function using M-mode EF calculation and assessment of LV diastolic function using the same parameters of RV diastolic function in addition to MR grading. Six months after hospital discharge, follow up echo was done to all surviving patients to assess the changes in RV and LV systolic and diastolic function using the same previously mentioned echocardiographic parameters.

Statistical analysis

All data were collected and analyzed using SPSS (Statistical Package for the Social Science, version 20, IBM, and Armonk, New York). Categorical variables and continuous variables were analyzed using Fisher's exact test, student's t-test and chi-square test. Correlations were analyzed using Pearson's correlation coefficient (r). A probability (p) value ≤ 0.05 was considered statistically significant.

Results

Patients' mean age was 58 years, 75 (70%) of them were males, 48 (45%) had anterior and 59 (55%) had non-anterior STEMI, Table (1a). At presentation, 40 patients (37%) had impaired FAC, 35 patients (33%) had impaired TAPSE and 77 patients (72%) had different degrees of MR, Table (1b). Echocardiographic data showed that LV–EF=51.5 ± 7.6%, FAC=37.2 ± 8.9%, RV–MPI=0.44 ± 0.09, E/é ratio=7.7 ± 3.8, Table (2a). At six months, 6 patients died before follow up time and the remaining 101 patients had LV-EF=54.3 ± 6.4%, FAC=39.4 ± 5.5%, TAPSE=1.83 ± 0.19cm, RV - MPI=0.36 ± 0.06 and tricuspid E/é ratio=5.7 ± 3.5, Table (2b).

Anterior vs. non-anterior STEMI groups at baseline and follow up

Patients were divided into two groups, according to significant ST-segment elevation in pre-primary PCI ECG, anterior (48 patients) and non-anterior (59 patients) groups. As shown by coronary angiography, 17% of the 48 anterior STEMI patients had the diagonal branch as the culprit artery (anteroseptal MI) vs. 3% of the non-anterior STEMI patients (lateral MI), Table (3a). On the other hand, 55% of the 59 patients with non-anterior STEMI had RCA, 39% had LCx and 3% had the OM branch as the culprit artery.

Echocardiographic data showed that 19% vs. 44% had impaired TAPSE, 52% vs. 58% had impaired RV-MPI, 73% vs. 64% had impaired RV E/é ratio, 93% vs. 97% had different degrees of LV diastolic dysfunction and 63% vs. only 3% had LV systolic dysfunction (defined as LV-EF<40%) of anterior vs. non-anterior group, respectively, Table (3b).

Also, echocardiographic numbers showed that TAPSE and FAC were significantly lower in non-anterior compared to anterior group (1.91 ± 0.44 vs. 1.57 ± 0.47cm, p=0.005), (40.41 ± 7.51 vs. 34.62 ± 9.05%, p=0.001). On the other hand, anterior group had lower LV-EF (45.76 ± 7.13 vs. 56.1 ± 3.82%, p=0.001). Nevertheless, no differences were found between both groups

Table (1a). Baseline characteristic data of the study group.

Parameters		N	%
Age (mean ± SD)		57.7 ± 9.6	
Gender	Male	75	70
	Female	32	30
Site of infarction by ECG	Anterior	48	45
	Non anterior	59	55
Culprit artery	LAD	38	36
	RCA	34	32
	LCx	23	21
	Diag.	10	9
	OM.	2	2
Affected segment	Proximal	48	45
	Midsegment	45	42
	Distal	14	13
Dominance	LCx	25	23
	RCA	67	63
	Co-dominant	15	14
Multi-vessel affection	Yes	22	21
	No	85	79
Site of other lesion (s)	LAD	6	6
	RCA	3	3
	LCx	3	3
	Diag.	7	6
	OM	3	3

SD: Standard Deviation; **N**: Number; **LAD**: Left Anterior Descending; **RCA**: Right Coronary Artery; **LCx**: Left Circumflex Artery; **Diag:** Diagonal Branches; **OM**: Obtuse Marginal Branches.

Table (1b). Echocardiographic baseline data.

	Parameters	N	%
FAC	Impaired	40	37
	Normal	67	63
TAPSE	Impaired	35	33
	Normal	72	67
MR	No	30	28
	Mild	33	31
	Moderate	35	33
	Severe	9	8

FAC: Fractional Area Change; **TAPSE**: Tricuspid Annular Plane Systolic Excursion; **MR**: Mitral Regurgitation; **N**: Number.

Table (2a). Echocardiographic numerical baseline data.

Parameters		Mean	SD
RV	RVAd	17.6	± 3.7
	RVAs	10.97	± 2.5
	FAC	37.2	± 8.9
	TAPSE	1.73	± 0.49
	TCO	359	± 55.7
	ET	250	± 42.6
	MPI	0.44	± 0.09
	E/A	1.1	± 0.57
	E/é	7.7	± 3.8
	DT	147.8	± 48
LV	LVEDd	5.31	± 0.42
	LVEDs	3.71	± 0.5
	LVEF	51.5	± 7.6

RV: Right Ventricle; **Rvad**: Right Ventricular Diastolic Area; **Rvas**: Right Ventricular Systolic Area; **FAC**: Fractional Area Change; **TAPSE**: Tricuspid Annular Plane Systolic Excursion; **TCO**: Tricuspid Valve Closure-Opening Time; **ET**: Ejection Time; **MPI**: Myocardial Performance Index: **E**: Peak Early Filling; **A**: Late Diastolic Filling; **E**: Early Diastolic Annular Velocity; **DT**: Deceleration Time; **LV**: Left Ventricle; **LVEDd**: Left Ventricular End-Diastolic Diameter; **LVEDs**: Left Ventricular End-Systolic Diameter; **LVEF**: Left Ventricular Ejection Fraction; **SD**: Standard Deviation.

Table (2b). Echocardiographic follow up data.

Parameters		Mean	SD
RV	**RVAd**	17.7	±3.4
	RVAs	10.7	±2.2
	FAC	39.4	± 5.5
	TAPSE	1.83	± 0.19
	TCO	364	± 44.2
	ET	269.4	± 35.5
	MPI	0.36	± 0.06
	E/A	0.9	± 0.3
	E/é	5.7	± 3.5
	DT	136.8	± 26
LV	**LVEDd**	5.33	± 0.41
	LVEDs	3.62	± 0.46
	EF	54.3	± 6.4

RV: Right Ventricle; **RVAd**: Right Ventricular Diastolic Area; **RVAs**: Right Ventricular Systolic Area; **FAC**: Fractional Area Change; **TAPSE**: Tricuspid Annular Plane Systolic Excursion; **TCO**: Tricuspid Valve Closure-Opening Time; **ET**: Ejection Time; **MPI**: Myocardial Performance Index: **E**: Peak Early Filling; **A**: Late Diastolic Filling; **e**: Early Diastolic Annular Velocity; **DT**: Deceleration Time; **LV**: Left Ventricle; **LVEDd**: Left Ventricular End-Diastolic Diameter; **LVEDs**: Left Ventricular End-Systolic Diameter; **LVEF**: Left Ventricular Ejection Fraction; **SD**: Standard Deviation.

Table (3a). Anterior and non-anterior STEMI groups regarding the demographic data.

Parameters		Anterior (48 pts.)	Non-anterior (59 pts.)	P value
Age (mean ± SD)		57 ± 9	58 ± 10	0.546
Gender	Male	39 (81%)	36 (61%)	0.01
	Female	9 (19%	23 (39%)	
Culprit	LAD	40 (83%)	0%	0.0001
	RCA	0%	32 (55%)	
	LCx	0%	23 (39%)	
	Diag.	8 (17%)	2 (3%)	
	OM	0%	2 (3%)	
Affected segment	Proximal	17 (35%)	31 (53%)	0.312
	Midsegment	27 (57%)	18 (30%)	
	Distal	4 (8%)	10 (17%)	
Dominance	LCx	14 (29%)	11 (19%)	0.26
	RCA	27 (56%)	40 (68%)	
	Co-dominant	7 (15%)	8 (13%)	
Multivessel affection		10 (21%)	12 (20%)	0.001**
Site of other lesion (s)	LAD	0%	6 (10%)	0.25
	RCA	2 (4%)	1 (2%)	
	LCx	2 (4%)	1 (2%)	
	Diag.	5 (11%)	2 (3%)	
	OM	1 (2%)	2 (3%)	

SD: Standard Deviation; **LAD**: Left Anterior Descending; **RCA**: Right Coronary Artery; **LCx**: Left Circumflex Artery; **Diag**.: Diagonal Branches; **OM**: Obtuse Marginal Branches; **SD**: Standard Deviation; **p**: Probability.

Table (3b). Comparison between both groups regarding the echo data.

Parameters		Anterior (48 pts)	Non-anterior (59 pts)	P value
MR baseline	No	14 (28%)	16 (27%)	0.218
	Mild	16 (34%)	17 (29%)	
	Moderate	16 (34%)	19 (32%)	
	Severe	2 (4%)	7 (12%)	
MR follow up	No	19 (43%)	31 (54%)	0.13
	Mild	20 (46%)	21 (37%)	
	Moderate	3 (7%)	5 (9%)	
	Severe	2 (4%)	0%	
LVDF baseline	No	3 (7%)	2 (3%)	0.326
	Grade-I	23 (52%)	31 (55%)	
	Grade-II	15 (33%)	23 (40%)	
	Grade-III	2 (4%)	1 (2%)	
	Grade-IV	2 (4%)	0%	
LVDF follow up	No	6 (13%)	25 (44%)	0.001**
	Grade-I	21 (48%)	30 (53%)	
	Grade-II	17 (39%)	2 (3%)	
Abnormal echocardiographic data				
LV dysfunction baseline		30 (63%)	2 (3%)	0.001**
LV dysfunction follow up		4 (9%)	0	0.001**
Impaired FAC baseline		11 (23%)	29 (49%)	0.004**
Impaired FAC follow up		4 (9%)	10 (17%)	0.177
Impaired TAPSE baseline		9 (19%)	26 (44%)	0.005**
Impaired TAPSE follow up		5 (11%)	7 (12%)	0.571
Impaired RV MPI baseline		25 (52%)	34 (58%)	0.438
Impaired RV MPI follow up		4 (9%)	9 (16%)	0.001**
Abnormal RV E/é baseline		35 (73%)	38 (64%)	0.041*
Abnormal RV E/é follow up		33 (75%)	18 (32%)	0.278

MR: Mitral Regurgitation; **LVDF**: Left Ventricular Diastolic Function; **LV**: Left Ventricle; **FAC**: Fractional Area Change; **TAPSE**: Tricuspid Annular Plane Systolic Excursion; **RV**: Right Ventricle; **MPI**: Myocardial Performance Index; **E**: Peak Early filling; **é**: Early Diastolic Annular Velocity; **p**: Probability

regarding tricuspid E/A ratio (0.93 ± 0.55 vs. 1.23 ± 0.55), tricuspid E/é ratio (7.98 ± 3.29 vs. 7.5 ± 4.22) which implied impaired DF in both groups and a quite difference was found in RV-MPI (0.42 ± 0.07 vs. 0.45 ± 0.09) which was lower in anterior STEMI group, Table (4a).

At six months, there were significant differences between the two groups regarding the following: LV-EF (49 ± 5.79 vs. 58.39 ± 2.77%, p=0.001), TAPSE (1.88 ± 0.22 vs. 1.79 ± 0.13cm, p=0.013) and RV E/é ratio (7.21 ± 2.66 vs. 4.28 ± 3.55, p=0.0001) in anterior vs. non-anterior groups, respectively, Table

Table (4a). Anterior vs. non-anterior patients' baseline echocardiographic data.

Parameters		Anterior (48 pts)		Non anterior (59 pts)		P value
		Mean	SD	Mean	SD	
RV	**RVAd**	17.63	± 3.41	17.49	± 3.95	0.846
	RVAs	10.4	± 2.05	11.38	± 2.76	0.056
	FAC	40.41	± 7.51	34.62	± 9.05	0.001**
	TAPSE	1.91	± 0.44	1.57	± 0.47	0.005**
	TCO	363	± 52	355	± 58	0.439
	ET	254	± 36	246	± 47	0.287
	MPI	0.42	± 0.07	0.45	± 0.09	0.146
	E/A	0.93	± 0.55	1.23	± 0.55	0.06
	E/é	7.98	± 3.29	7.5	± 4.22	0.519
	DT	163	± 46	135	± 46.5	0.003**
LV	**LVEDd**	5.46	± 0.37	5.17	± 0.36	0.002**
	LVEDs	4.02	± 0.46	3.43	± 0.31	0.001**
	LVEF	45.76	± 7.13	56.1	± 3.82	0.001**

RV: Right Ventricle; **RVAd**: Right Ventricular Diastolic Area; **RVAs**: Right Ventricular Systolic Area; **FAC**: Fractional Area Change; **TAPSE**: Tricuspid Annular Plane Systolic Excursion; **TCO**: Tricuspid Valve Closure-Opening Time; **ET**: Ejection Time; **MPI**: Myocardial Performance Index; **E**: Peak Early Filling; **A**: Late Diastolic Filling; **é**: Early Diastolic Annular Velocity; **DT**: Deceleration Time; **LV**: Left Ventricle; **LVEDd**: Left Ventricular End-Diastolic Diameter; **LVEDs**: Left Ventricular End-Systolic Diameter; **LVEF**: Left Ventricular Ejection Fraction.

Table (4b). Anterior vs. non-anterior patients' follow up echocardiographic data.

Parameters		Anterior (44 pts)		Non-anterior (57 pts)		P value
		Mean	SD	Mean	SD	
RV	RVAd	17.86	± 3.3	17.54	± 3.45	0.642
	RVAs	10.62	± 2.05	10.76	± 2.28	0.753
	FAC	40.41	± 5.16	38.6	± 5.64	0.1
	TAPSE	1.88	± 0.22	1.79	± 0.13	0.013*
	TCO	360.5	± 41.4	367	± 46.4	0.441
	ET	266	± 33	272	± 37	0.433
	MPI	0.35	± 0.04	0.35	± 0.06	0.886
	E/A	0.9	± 0.32	0.92	± 0.27	0.677
	E/é	7.21	± 2.66	4.28	± 3.55	0.0001***
	DT	140	± 33.5	134	± 18.6	0.233
LV	LVEDd	5.49	± 0.4	5.2	± 0.34	0.002**
	LVEDs	3.9	± 0.44	3.35	± 0.28	0.002**
	LVEF	49	± 5.79	58.39	± 2.77	0.001**

RV: Right Ventricle; **RVAd**: Right Ventricular Diastolic Area; **RVAs**: Right Ventricular Systolic Area; **FAC**: Fractional Area Change; **TAPSE**: Tricuspid Annular Plane Systolic Excursion; **TCO**: Tricuspid Valve Closure-Opening Time; **ET**: Ejection Time; **MPI**: Myocardial Performance Index; **E**: Peak Early Filling; **A**: Late Diastolic Filling; **é**: Early Diastolic Annular Velocity; **DT**: Deceleration Time; **LV**: Left Ventricle; **LVEDd**: Left Ventricular End-Diastolic Diameter; **LVEDs**: Left Ventricular End-Systolic Diameter; **LVEF**: Left Ventricular Ejection Fraction; **SD**: Standard Deviation; **p**: Probability.

Table (5a). Comparison between baseline and follow up echocardiographic data of anterior STEMI group.

Parameters		Baseline (48 pts)		Follow up (44 pts)		P-value
		Mean	SD	Mean	SD	
RV	RVAd	17.78	± 3.5	17.86	± 3.3	0.918
	RVAs	10.38	± 2.12	10.62	± 2.05	0.579
	FAC	41.43	± 6.74	40.41	± 5.16	0.428
	TAPSE	1.96	± 0.43	1.88	± 0.22	0.33
	TCO	363.6	± 53.75	360.5	± 41.43	0.763
	ET	255.5	± 37.1	266	± 32.9	0.159
	MPI	0.42	± 0.07	0.35	± 0.04	0.0001***
	E/A	0.93	± 0.55	0.9	± 0.32	0.772
	E/é	7.89	± 3.36	7.22	± 2.66	0.297
	DT	166	± 46.44	140	± 33.5	0.004**
LV	LVEDd	5.49	± 0.37	5.49	± 0.4	0.956
	LVEDs	4.01	± 0.48	3.92	± 0.44	0.385
	LVEF	46.81	± 6.33	49.08	± 5.79	0.082

RV: right ventricle; **RVAd**: right ventricular diastolic area; **RVAs**: right ventricular systolic area; **FAC**: fractional area change; **TAPSE**: tricuspid annular plane systolic excursion; **TCO**: tricuspid valve closure-opening time; **ET**: ejection time; **MPI**: myocardial performance index; **E**: peak early filling; **A**: late diastolic filling; **é**: early diastolic annular velocity; **DT**: deceleration time; **LV**: left ventricle; **LVEDd**: left ventricular end-diastolic diameter; **LVEDs**: left ventricular end-systolic diameter; **LVEF**: left ventricular ejection fraction; **SD**: standard deviation; **p**: probability.

(4b), while there were no significant differences between both groups in FAC or RV-MPI which turned to be around normal values implying improvement and RV functional recovery.

Paired samples statistics of each group separately

Among the 44 anterior STEMI patients there were no significant differences between baseline and follow up regarding LV-EF, FAC, TAPSE and E/é. However, RV-MPI improved significantly at follow up (0.42 ± 0.07 and 0.35 ± 0.04, p=0.0001), Table (5a). Out of the 57 non-anterior STEMI patients, FAC, TAPSE and RV-MPI improved significantly at follow up (34.7 ± 9.2 vs. 38.6 ± 5.64%, p=0.008), (1.57 ± 0.47 vs. 1.79 ± 0.14cm, p=0.001) and (0.45 ± 0.1 vs. 0.35 ± 0.06, p=0.001), respectively, it was also noted that tricuspid E/e' decreased significantly (7.5 ± 4.3 vs. 4.3 ± 3.5, p=0.0001), Table (5b).

There was negative correlation between LV-EF and TAPSE at presentation (r=0.237), RV-E/é at follow up (r=0.414) and grades of LV-DF at presentation and follow up (r=0.22, 0.401 respectively). Additionally, we found positive correlation between LV-DF and RV-E/é at baseline and follow up (r=0.369) and grades of MR (r=0.279), Tables (6a and 6b).

Discussion

In our study, at presentation, patients with non-anterior STEMI had more RV systolic but less LV systolic dysfunction and both anterior and non-anterior STEMI groups had more RV and LV diastolic dysfunction. These results are compatible with the findings reported by Hsu *et al.* who studied the effect of different infarction sites on RV functional changes using conventional echo in patients with a first acute STEMI without concomitant RV infarction after successful primary PCI [7]. In Hsu et al. study, LV-EF was also lower in anterior group (43 ± 8.7 vs. 55 ± 8% with p<0.05) as well as tricuspid E/A ratio (1.1 ± 0.3 vs. 1.5 ± 0.4), as our study reported, with lower tricuspid E/é ratio but not significant (5.6 ± 1.9 vs. 6.1 ± 1.37). On contrary, they stated that TAPSE was similar in magnitude in both groups (20 ± 3.8 and 21 ± 2.8cm) and RV-MPI was significantly higher in anterior than in non-anterior group (0.48 ± 0.25 vs. 0.32 ± 0.1, p<0.05). However, the lower sample size (60 patients only) in Hsu *et al*. study and the difference in patient number with higher number of non-anterior patients in our study along with inclusion of patients with significant multivessel affection (14 patients (40%) of anterior group and 18 (72%) of the

Table (5b). Comparison between baseline and follow up echocardiographic data of non-anterior STEMI group.

Parameters		Baseline (59 pts)		Follow up (57 pts)		P-value
		Mean	SD	Mean	SD	
RV	RVAd	17.49	± 4	17.54	± 3.45	0.944
	RVAs	11.35	± 2.8	10.76	± 2.28	0.223
	FAC	34.7	± 9.2	38.6	± 5.64	0.008**
	TAPSE	1.57	± 0.47	1.79	± 0.14	0.001**
	TCO	352	± 56.2	367	± 46.4	0.114
	ET	244	± 46.3	272	± 37.3	0.001**
	MPI	0.45	± 0.1	0.35	± 0.06	0.0001***
	E/A	1.25	± 0.55	0.92	± 0.27	0.0001***
	E/é	7.5	± 4.3	4.3	± 3.5	0.0001***
	DT	136	± 47	134	± 18.6	0.762
LV	LVEDd	5.18	± 0.37	5.21	± 0.34	0.736
	LVEDs	3.42	± 0.31	3.35	± 0.28	0.238
	LVEF	56.3	± 3.75	58.4	± 2.77	0.001**

RV: Right Ventricle; **RVAd**: Right Ventricular Diastolic Area; **RVAs**: Right Ventricular Systolic Area; **FAC**: Fractional Area Change; **TAPSE**: Tricuspid Annular Plane Systolic Excursion; **TCO**: Tricuspid Valve Closure-Opening Time; **ET**: Ejection Time; **MPI**: Myocardial Performance Index; **E**: Peak Early Filling; **A**: Late Diastolic Filling; **é**: Early Diastolic Annular Velocity; **DT**: Deceleration Time; **LV**: left Ventricle; **LVEDd**: Left Ventricular End-Diastolic Diameter; **LVEDs**: Left Ventricular End-Systolic Diameter; **LVEF**: Left Ventricular Ejection Fraction; **SD**: Standard Deviation; **p**: Probability.

Table (6a). Correlation between LVEF and RV function.

Parameter		LVEF-baseline	LVEF-follow up
		r	r
RV	**FAC**	-0.07	0.053
	TAPSE	-0.237	0.009
	MPI	0.053	0.051
	E/é	-0.056	-0.414

RV: Right Ventricle; **FAC**: Fractional Area Change; **TAPSE**: Tricuspid Annular Plane Systolic Excursion; **MPI**: Myocardial Performance Index; **E**: Peak Early Filling; **e** Early Diastolic Annular Velocity; **LVEF**: Left Ventricular Ejection Fraction: **r**: Correlation Coefficient; **p**: Probability.

Table (6b). Correlation between LVDF and RV function.

Parameters		LVDF-baseline	LVDF-follow up
		r	r
RV	FAC	-0.152	-0.052
	TAPSE	-0.088	-0.201
	MPI	0.121	0.108
	E/e'	0.091	0.369
LV	LVEF	-0.22	-0.401
	MR	0.04	0.279

RV: Right Ventricle; **FAC**: Fractional Area Change; **TAPSE**: Tricuspid Annular Plane Systolic Excursion; **MPI**: Myocardial Performance Index; **E**: Peak Early Filling; **e**: Early Diastolic Annular Velocity; **LV**: Left Ventricle; **LVEF**: Left Ventricular Ejection Fraction; **MR**: Mitral Regurgitation; **LVDF**: Left Ventricular Diastolic Function; **r**: Correlation Coefficient; **p**: Probability.

non-anterior group), diabetes (14 patients) and hypertension (31 patients) in their study must alter the results accuracy. In addition, their echocardiographic examinations were performed within 72 hrs after patients have undergone primary PCI (i.e., delayed) and it is possible that RV function have already recovered by then in some of their patients.

In another low sample size study by Abtahi et al., they compared RV function in patients with inferior and anterior MI using conventional echo 48 hrs after starting the standard reperfusion therapy (either PCI or fibrinolysis). That study suggested that RV function was extremely affected in patients with first acute STEMI and RV involvement was more pronounced in anterior MI than in inferior MI patients. Moreover, LV-EF declined irrespective of the site of infarction or affection of RV function. LV-EF was lower in the patients with anterior infarction, but the difference was not statistically significant. Additionally, no significant difference was observed between both groups regarding the measurements of tricuspid E/A ratio (1.2 ± 0.4 vs. 1.2 ± 0.5) and TAPSE (17.4 ± 2 vs. 17.3 ± 1.7cm) [8].

On the other hand, patients with anterior infarction in Abtahi *et al.* study had a significantly higher mean tricuspid E/é ratio in comparison to those with inferior infarction (6.73 ± 1.6 vs. 5.7 ± 1.3, p=0.01) and RV-MPI (measured by TDI) was also significantly higher in the anterior infarction group compared to the inferior infarction group (p=0.02). However, Abtahi, *et al.* study had lower sample size (60 patients) and higher number of anterior STEMI group (35 patients), diabetic & hypertensive patients were not excluded and also only 21 patients were treated with primary PCI while 39 patients were treated with streptokinase. All these factors make the affection on LV and RV function not purely attributed to the recent episode of acute STEMI while our results are more specific. Additionally, the lack of clinical follow-up data in their study makes it difficult to address the long-term clinical implications. Our additional data of follow up showed improvement in RV systolic and diastolic function regarding RV-MPI and LV systolic function regarding M-mode LV-EF in anterior STEMI group while RV-DF still did not improve regarding tricuspid E/é ratio. Moreover, RV systolic and diastolic function improved regarding FAC, RV-MPI and tricuspid E/é in non-anterior STEMI group.

On the other hand, we noticed a reverse fit between RV and LV systolic functions represented in TAPSE and LV-EF at presentation and between RV diastolic and LV systolic functions represented in RV E/é and LV-EF at baseline and follow up. A reverse relation was also found between grades of LV-DF and LV-EF at baseline and follow up. Besides, a direct proportion was noted between RV and LV diastolic dysfuction at baseline and follow up and also between LV-DF and grades of MR with improvement of both at follow up. These follow up and correlation data denote that RV function recovers to a greater extent than LV function.

Popescu *et al*. from GISSI-3 echo substudy agreed with us that out of 500 low-risk patients who underwent serial echocardiograms 24–48 hrs after symptoms onset and six months after acute STEMI, RV functional recovery did occur after acute MI, keeping in mind that GISSI-3 study excluded those who underwent revascularization procedures which is an important determenant [9]. Likewise, these results confirm the previous data by Moller *et al.* that in a larger population, study RV systolic function recovery occurred early after acute MI and continued to improve up to six months after infarction [10].

Although it is a large sample size trial, but it excluded patients who underwent coronary intervention and did not exclude diabetics and those with history of previous MI, therein lays the difference in our study, they also focus on TAPSE as the most reliable parameter for measurement of RV systolic function. Finally, based on all previous studies, our study gives more definitive results that excluded interfering factors such as multivessel affection and diabetes that would influence cardiac function irrespective of the recent MI. In addition, all of our patients were treated with primary PCI and full echocardiographic assessment at follow up was done using reliable comparative parameters.

Conclusion

RV dysfunction can be detected in both anterior and non-anterior STEMI patients at presentation which is more prominent in the non-anterior group. At follow up successful primary PCI patients exhibited recovery of RV systolic function in both groups, while impairment of LV-DF was noted irrelevant of the infarction site. 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.

Conflict of Interest

The authors report no conflicts of interest associated with this work.

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