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Original Article

Right ventricular function in patients presenting with non-ST-segment elevation myocardial infarction undergoing an invasive approach

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ABSTRACT

Background: Right ventricular involvement in ST segment elevation myocardial infarction (STEMI) entails an increased morbidity and mortality. However, very scarce data is present on its affection in the setting of non-ST segment elevation myocardial infarction (NSTEMI).

Aim: To assess the affection of right ventricular function in patients presenting with NSTEMI undergoing an invasive procedure.

Subjects and methods: One hundred and fifty patients admitted with a first NSTEMI and eligible for reperfusion therapy via invasive percutaneous coronary intervention. These patients were divided in two groups; group A including patients with normal RV function, and group B including patients with impaired RV function as diagnosed by tricuspid annular plane systolic excursion (TAPSE) cutoff value < 17 mm. All patients underwent angioplasty and were followed up in-hospital and for 3 months.

Results: RV dysfunction occurred in ninety-five (61.3%) patients of the study population. Significant improvement occurred to TAPSE after 3 months in comparison to TAPSE at baseline (15.45 ± 3.21 versus 17.09 ± 4.17 mm). Those with impaired RV function showed improvement of TAPSE after three months as compared to baseline (13.62 ± 2.58 vs 17.16 ± 3.64 p = 0.008). Multivariate analysis determined the independent predictors of RV dysfunction as RVEDD > 26 mm, RVFAC < 35%, RAA > 20 cm^2, and TAPSE < 17 mm.

Conclusion: RV dysfunction is not uncommon in NSTEMI when using the definition of TAPSE < 17 mm. Following up RV function by TAPSE, showed significant improvement after 3 months with successful PCI as compared to baseline. We recommend assessing and following up RV function in all patients admitted with a NSTEMI.

1. Introduction

Right ventricular (RV) dysfunction is a powerful risk marker after acute myocardial infarction (MI).[1] Non–ST-segment elevation myocardial infarction (NSTEMI) is distinguished from unstable angina by elevated levels of cardiac enzymes and biomarkers of myocyte necrosis. Right ventricular (RV) involvement after an acute myocardial infarction (MI) has been shown to be associated with higher morbidity and mortality.[2] The prevalence of RV involvement in acute MI has been reported to range from 50% to 80% in postmortem and animal studies but is frequently underestimated in the clinical setting owing to the diagnostic limitations of the electrocardiogram (ECG) and echocardiography.[3]

Echocardiography remains the most commonly used technique for RV function assessment in clinical practice because of its widespread availability.[3] To differentiate normal RV structure and function from abnormal and to assess RV size, volume, and contractility, a complete set of standardized views must be obtained.[4] Quantitative assessment of RV function is often difficult using the various noninvasive imaging modalities owing to the inherently complex geometry of the right ventricle.[4] The assessment of the right ventricle is in a continuous state of "work in progress"[4]. Due to complex RV morphology, a quantitative assessment of systolic RV function is different with established methods, since a required cylindrical form is not available.[4] Therefore, systolic RV function is better assessed qualitatively. A regional or global RV dilatation must be documented, as well as the diameter.[4] It is not known if available parameters to assess diastolic LV function would have the same value when assessing diastolic RV function. However, others have found its place, e.g. parameters for

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assessment of global function (Tei-index) or longitudinal systolic function (tricuspid annular plane systolic excursion (TAPSE), RV-strain).[4]

2. Aim of the work

The aim of the study is to assess the affection of right ventricular function in patients presenting with Non-ST-segment elevation myocardial infarction (NSTEMI) who undergo an invasive procedure.

3. Patients and methods

This study included 150 patients who were admitted to the coronary catheter lab in Ain Shams University Hospitals with a first NSTEMI, eligible for reperfusion therapy via invasive percutaneous coronary intervention (PCI) during the period from December 2013 till June 2015. After approval of the ethics committee and signed consents, the patients were divided in two groups:

Group A: including patients with normal RV function.
Group B: including patients with impaired RV function as diagnosed by TAPSE cutoff value <17 mm which yields a high specificity, though low sensitivity to distinguish abnormal from normal subjects.[5]

3.1. Inclusion criteria

The diagnosis of NSTEMI was defined as detection of rise and or fall of cardiac biomarker values (we used troponin) with at least one value above the 99th percentile of the upper reference limit and with ischemic symptoms, and ECG changes such as ST-segment depression or T wave inversion or any dynamic changes at the 12 leads ECG. Eligibility for invasive PCI was based on risk stratification and the recent ESC guidelines for the management of NSTEMI.[6]

We enrolled patients with successful invasive PCI defined as successful deployment of stent in culprit infarct- related artery (IRA) with final TIMI flow grade 3, no residual dissection, and less than 30% residual stenosis in IRA.[7]

3.1.1. Exclusion criteria

Patients with any of the following criteria were excluded from the study including; NSTEMI with the presence of RV infarction, STEMI, previous coronary revascularization including PCI or CABG, presence of a coexisting clinical condition that might affect RV function, including pericardial disease, chronic lung disease, pulmonary hypertension, or connective tissue disorder. Those with moderate or severe valvular heart disease, and atrial fibrillation were also excluded.

After an informed consent, all patients had a history taken, a thorough physical examination, 12 lead ECG, and laboratory investigations including Troponin, liver and kidney function tests, blood sugar, and blood lipid profile, we assessed the urgency for coronary intervention.

Diabetes mellitus was diagnosed as having a history of intake of glucose lowering therapy or a HgA1c above 6.5 g%. Dyslipidemia was diagnosed as those taking lipid lowering therapy, hypertension was in those with previous anti-hypertensive treatment and obesity was diagnosed in those with a body mass index above 30 kg/m^2 on admission. Premature coronary artery disease was diagnosed at a cut off age of 55 years in males and 60 years in females.

After a femoral or radial artery approach according to the preference of the operator, angiography and intervention was done to lesion(s). An echocardiographic examination was conducted using a General Electric Vivid 3 as follows:

1. The tricuspid annular plane systolic excursion (TAPSE) was measured from the apical 4-chamber view at the RV free wall level by using an M-mode cursor passed through the tricuspid lateral annulus and measuring the amount of longitudinal displacement of the annulus at peak-systole[8]
2. The RV end-diastolic dimension was assessed at the mid-cavity of the right ventricle in the apical 4 chamber view.[9]
3. The transmitral and transtricuspid Doppler flow velocities was recorded from an apical 4-chamber view with the sample volume placed between the tips of the mitral and tricuspid valves, respectively, and the peak early filling velocity (E), peak atrial velocity (A), E/A ratio
4. The LV dimensional measurements were routinely obtained from an M-mode recording, the LV ejection fraction (LVEF) was estimated using the modified Simpson method.[10]

3.2. Follow up

Follow up of the patients included in-hospital and short term (3 months) for M.A.C.E.; including myocardial infarction, stroke, revascularization and death.

3.3. Data management and statistical analysis

Statistical analyses were performed by using SPSS system for Windows (version 20 Chicago, IL, USA), Continuous variables were presented as mean ± SD and categorical variables were expressed as percentages. Wilcoxon signed ranks test for comparing between results before and after PCI. The receiver operational characteristic (ROC) analyses was performed and best cut off value was determined and at that point sensitivity and specificity were determined, the results were considered significant when the p value was less than 0.05.

4. Results

4.1. Baseline demographic data

The mean age was 51.88 ± 11.18 years. Eighty-six (57.3%) were males, sixty-four (42.7%) were smokers, ninety-four (62.7%) were diabetic, and one hundred and seven (71.3%) were hypertensive, forty-eight (32%) were dyslipidemic, and forty-four (29.3%) had positive family history premature CAD (see Table 1).

During PCI predilatation was done in forty-three patients (28.7%), a single stent was performed in ninety-nine patients (66%), and two stents were used in fifty patients (33.3%), and three stents in one patient.

Laboratory investigations revealed that the mean CK total was (2216.92 ± 651.10) U/L, CK MB was (192.19 ± 59.10) U/L.

Table 1
Baseline characteristics of the study population.

	Number of patients	%
Smoker	77	51.3%
DM	94	62.7%
HTN	107	71.3%
Dyslipidemia	48	32.0%
Obese	80	53.3%
FH of CAD	44	29.3%

DM = Diabetes mellitus; HTN = Hypertension; FH of CAD = Family history of premature coronary artery disease.

Echocardiography data showed that the mean LVEF was (51.81 ± 7.19%), LVEF% at follow up after 3 months (52.77 ± 7.27), LVESD was (35.2 ± 4.8) mm, LVEDD was (44.71 ± 8.66) mm, while the mean WMSI was (1.84 ± 0.39).

Regarding the RV function, we found that the mean RV EDD was (26.15 ± 5.33) mm, right ventricular fractional area change (RVFAC) was (36.49 ± 8.15), RA area was (16.00 ± 5.22) cm^2, TAPSE (mm) baseline was (15.45 ± 3.21) mm while TAPSE (mm) after 3 months (17.09 ± 4.17),

According to RV function assessment based on TAPSE, the patients were classified into two groups:

Group 1: Patients with normal RV function if TAPSE >17 mm including fifty-nine (38.7%) patients.

Group 2: Patients with abnormal RV function if TAPSE >17 including ninety-five (61.3%) patients.

When comparing the 2 groups: as regards demographic criteria, baseline characteristics (age, gender, smoking, DM, HTN, dyslipidemia, obesity, positive family history premature CAD) showed no statistically significant difference between the 2 groups (p > 0. 05); these data were shown in (see Table 2).

Regarding peri-procedural data, patients with normal TAPSE who underwent predilatation were twenty-four (41.4%), patients with abnormal TAPSE who underwent predilatation were ninteen (20.7%). In all cases, complete revascularization was attempted with only small vessels not amenable to intervention spared (see Table 3).

Patients with normal RV function had a smaller RVEDD (24.19 ± 4.57 mm versus 50.8 mm, p = 0.00), a higher RVFAC (39.39 ± 7.96 versus 31.90 ± 6.10, p = 0.000), lower RA area (14.32 ± 4.64 versus 18.67 ± 4.99, p = 0.00), and a higher TAPSE (18.34 ± 1.57 versus 13.62 ± 2.58 mm p = 0.00). They were statistically significant as shown in (Table 4).

A significant increase in LVEF when comparing LVEF at baseline versus after 3 months (51.81 ± 7.19% versus 52.77 ± 7.2% P = 0.02). Also, a highly significant improvement occurred to the TAPSE at 3 months (15.45 ± 3.21 versus 17.09 ± 4.17 mm p = 0.00) (see Table 5).

Patients with abnormal RV function had a statistically higher TAPSE after 3 months (13.62 ± 2.58 versus 17.16 ± 3.64 mm P- = 0.008). On the other hand, LVEF also showed a significant LVEF improvement after 3 months (51.52 ± 6.86 versus 52.32 ± 6.46% P = 0.00) (see Table 6).

Patients with normal RV function had a higher TAPSE after 3 months (18.34 ± 1.57 versus 20.16 ± 2.97 mm P- = 0.07). On the other hand, LVEF also showed significant higher LVEF after 3 months (52.26 ± 7.72 versus 53.50 ± 8.41% P = 0.00) (see Table 7).

Multivariable analysis was used to determine the independent predictors of RV dysfunction. The patient will be considered to have RV dysfunction if the patients had a combination of RV EDD >26 mm, RV FAC <35%, RAA >20 cm^2, and TAPSE <17 mm.

5. Discussion

RV involvement after an acute MI is associated with higher morbidity and mortality.[2] The prevalence of RV involvement in acute myocardial infarction is reported to range from 50% to 80% in postmortem and animal studies but is frequently underestimated in the clinical setting owing to the diagnostic limitations of the ECG and echocardiography.[3] Although the importance of the right ventricle has been well known for many years in patients with ST-elevation myocardial infarction (STEMI), the importance of right ventricle in NSTEMI is less known.[11] Many studies have showed that reperfusion therapy especially primary PCI restores the right ventricular systolic function in patients with STEMI. However, the effects of urgent PCI on RV systolic functions in NSTEMI patients are less known.[12] Quantitative assessment of the RV function is often difficult using the various noninvasive imaging modalities owing to its complex geometry.[4] Echocardiography remains the most commonly used technique for RV function assessment in clinical practice because of its widespread availability.[13]

Table 2
Comparison between patients with and without RV dysfunction regarding baseline characteristics.

		Normal RV function	Impaired RV function	Independent t-test	
		No. = 58	No. = 92	t/X^{2*}	P value
Age	Mean ± SD	53.45 ± 10.07	50.89 ± 11.78	−1.368	0.173
	Range	33–75	30–73		
Sex	Females	25 (43.1%)	39 (42.4%)	0.007*	0.932
	Males	33 (56.9%)	53 (57.6%)		
Smoker		27 (46.6%)	50 (54.3%)	0.865	0.352
DM		35 (60.3%)	59 (64.1%)	0.218	0.641
HTN		43 (74.1%)	64 (69.6%)	0.364	0.546
Dyslipidemia		16 (27.6%)	32 (34.8%)	0.847	0.358
Obese		29 (50.0%)	51 (55.4%)	0.422	0.516
FH of CAD		18 (31.0%)	26 (28.3%)	0.132	0.716

* Chi-square test; RV = Right ventricle; DM = Diabetes mellitus; HTN = Hypertension; FH of CAD = Family history of premature coronary artery disease.

Table 3
Comparison between patients with and without RV dysfunction regarding PTCA and number of stents.

		Normal RV function		Impaired RV function	
		No.	%	No.	%
PTCA balloon dilatation	Not done	34	58.6%	73	79.3%
	Done	24	41.4%	19	20.7%
Number of stents	One	34	58.6%	65	70.7%
	Two	23	39.7%	27	29.3%
	Three	1	1.7%	0	0.0%

PTCA = Percutaneous transluminal coronary angioplasty

Table 4
Comparison between patients with and without RV dysfunction regarding echocardiographic data.

		Normal RV function	Impaired RV function	Independent *t*-test	
		No. = 58	No. = 92	t	P value
LVESD	Mean ± SD	44.57 ± 10.93	44.97 ± 9.61	−0.229	0.819
	Range	29–61	28–60		
LVEDD	Mean ± SD	43.24 ± 10.02	45.64 ± 7.59	1.663	0.098
	Range	30–60	31–59		
LVEF%	Mean ± SD	52.26 ± 7.72	51.52 ± 6.86	−0.610	0.543
	Range	41–70	38–72		
SWMI	Mean ± SD	1.88 ± 0.41	1.82 ± 0.38	−0.969	0.334
	Range	1–2.3	1–2.5		
RVEDD	Mean ± SD	24.19 ± 4.57	29.26 ± 4.99	6.382	0.000
	Range	15–36	17–38		
RVFAC (%)	Mean ± SD	39.39 ± 7.96	31.90 ± 6.10	−6.121	0.000
	Range	23–54	21–52		
RA area (cm^2)	Mean ± SD	14.32 ± 4.64	18.67 ± 4.99	5.420	0.000
	Range	8–25	7.8–26		
TAPSE (mm) baseline	Mean ± SD	18.34 ± 1.57	13.62 ± 2.58	12.563	0.000
	Range	17–23	9–16		

LVEDD = Left ventricular end diastolic diameter; LVESD = Left ventricular end systolic diameter; LVEF = Left ventricular ejection fraction; SWMI = Segmental wall motion index; RVEDD = Right ventricular end diastolic dimension; RVFAC: Right ventricular fractional area change; RA = Right atrium; TAPSE = Tricuspid annular plane systolic excursion.

Table 5
Comparison between all patients as regard baseline LVEF and TAPSE and after 3 months.

	All patients		Paired *t*-test	
	Baseline	Follow up	t	P value
LVEF% Mean ± SD	51.81 ± 7.19	52.77 ± 7.27	−2.350	0.020
Range	38–72	39–70		
TAPSE (mm) Mean ± SD	15.45 ± 3.21	17.09 ± 4.17	−7.961	0.000
Range	9–23	9–28		

LVEF = Left ventricular ejection fraction; TAPSE = Tricuspid annular plane systolic excursion.

Table 6
Comparison between base line and follow up data for abnormal RV function patients.

	Abnormal RV function patients		Paired *t*-test	
	Baseline	After 3 months	t	P value
TAPSE (mm) Mean ± SD	13.62 ± 2.58	17.16 ± 3.64	−1.579	0.008
	9–16	9–25		
LVEF% Mean ± SD	51.52 ± 6.86	52.32 ± 6.46	−5.810	0.000

LVEF = Left ventricular ejection fraction; TAPSE = Tricuspid annular plane systolic excursion.

In our study we found that 61.3% of NSTEMI patients had RV dysfunction (when using the definition of TAPSE <17 mm) while in another study by Shun et al., 17% of the study population presenting with anterior STEMI and underwent primary PCI had RV dysfunction.[14] Also, Ozlem et al. reported that 22% of their study population presenting with anterior STEMI and underwent primary PCI or received thrombolytic therapy had abnormal myocardial performance index (MPI).[15] Our study showed a higher prevalence of RV involvement because of the higher risk profile of our patients such as DM (62.7% in our study), 28.5% in Shun's study and 25.9% in Ozlem's study. This could be explained by the more prevalent affection of the micro vascular integrity and more macrovascular beds affection leading to higher incidence of RV involvement. On the other hand, Kidawa et al.,[16] found that 64% of the patients present with STEMI and underwent primary PCI had RV dysfunction measured by TAPSE, this higher incidence may be explained by the fact that Kidawa et al's study population included all STEMI patients with non-anterior STEMI and possible occurrence of RV infarction in addition to the different assessment parameters.[16]

5.1. Factors affecting RV function

Similar to our results, Shun et al. found no association between the increasing age of the study population and the impaired RV function.[14] Hoogslag et al.[17] investigated determinants of right ventricular remodeling following ST-segment elevation myocardial infarction, and they defined RV systolic dysfunction as TAPSE <16 mm. In our study, ninety-five (61.3%) patients NSTEACS had TAPSE value under 17 mm.

We assessed the right ventricular systolic function by using TAPSE, obtained after PCI and 3 months later. There was a significant improvement was seen after 3 months 15.45 ± 3.21 mm versus 17.09 ± 4.17 mm (p = 0.00). We also noticed that patients with abnormal RV function patients showed improvement after three months (13.62 ± 2.58 vs 17.16 ± 3.64 p = 0.008). Regarding

Table 7
Comparison between base line and follow up data for normal RV function patients.

	All patients		Paired *t*-test	
	Baseline	Follow up	t	P value
TAPSE (mm) Mean ± SD	18.34 ± 1.57	20.16 ± 2.97	−1.750	0.07
Range	17–23	16–28		
LVEF% Mean ± SD	52.26 ± 7.72	53.50 ± 8.41	−5.464	0.000
Range	38–70	40–70		

LVEF = Left ventricular ejection fraction; TAPSE = Tricuspid annular plane systolic excursion.

ejection fraction obtained after urgent PCI in patients with NSTEMI and 3 months later, we found a highly significant improvement of LVEF after 3 months when compared to baseline (51.81 ± 7.19 vs 52.77 ± 7.27 p = 0.020) and we did not find similar studies to compare our results with it. As regards patients with impaired RV function, follow up of LVEF was done and showed a highly significant improvement after 3 months (51.52 ± 6.86 vs 52.32 ± 6.46 p = 0.000) but unfortunately, we did not come across similar studies to compare our results with. When comparing the normal RV function and the impaired RV function groups in our study, we found a highly significant relation between the RV function and other echocardiography measurements which are: RVEDD (24.19 ± 4.57 vs 29.26 ± 4.99 p = 0.000) and RVFAC (39.39 ± 7.96 vs 31.90 ± 6.1 0 p = 0.000) and RA area (cm^2) (14.32 ± 4.64 vs 18.67 ± 4.99 p = 0.000).

6. Conclusion

The affection of RV function in (NSTE-ACS) patients is not well studied although the significant affection of the RV. Echocardiography remains the most commonly used technique for RV function assessment in clinical practice because of its widespread availability. RV dysfunction occurred in large number of population in first NSTEMI using the definition of TAPSE <17 mm. Age, gender, smoking, DM, HTN, dyslipidemia, obesity, positive family history premature CAD were independent predictors of abnormal RV function showed no statistically significant different between normal and abnormal patients according to TAPSE. On following RV function by TAPSE, significant improvement occurred after 3 months follow up after successful PCI comparing with baseline. Also, LVEF follow showed a high significant improvement occurred after 3 months in comparing LVEF at baseline. We would like to recommend assessing RV function in all cases including those presenting with NSTEMI.

Conflict of interest

The authors do not have any conflict of interest pertaining to this manuscript.

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