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# Right Atrial Volume Index as a Predictor of Persistent Right Ventricular Dysfunction in Patients with Acute Inferior Myocardial Infarction and Proximal Right Coronary Artery Occlusion Treated with Primary Percutaneous Coronary Intervention

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## Abstract

**Objectives:** Patients with right ventricular (RV) infarctions associated with inferior infarctions have higher rates of adverse events than isolated inferior infarctions. Right atrial volume index (RAVI) has recently been described as a predictor of clinical outcome in patients with chronic systolic heart failure and pulmonary hypertension. The aim of this study is to assess the ability of RAVI to predict the persistent RV dysfunction after acute inferior STEMI due to occlusion of proximal RCA. To the best of our knowledge, this is the first study to investigate the relation between RAVI and persistent RV dysfunction in such group of patients.

**Patients and methods:** Sixty-five consecutive patients with recent first acute inferior STEMI who underwent primary percutaneous coronary intervention (PPCI) were prospectively included in the study. Echocardiographic evaluation was performed at the time of discharge and at 3 months. All the patients underwent standard echocardiographic assessment using conventional 2D and tissue Doppler imaging (TDI).

**Results:** Patients were divided into two groups according to right ventricular function (RVF) 3 months after acute myocardial infarction (AMI). The normal RVF group included 41 (63%) patients and the impaired RVF group included 24 (37%) patients. RAVI was significantly higher in patients with impaired RVF ( $p < 0.001$ ). RAVI was a predictor of persistently impaired RV function (odds ratio = 1.786, 95% confidence interval, 1.367–2.335,  $p$  value =  $< 0.001$ ) and (odds ratio = 1.829, 95% confidence interval, 1.358–2.462,  $p$  value =  $< 0.001$ ) in univariate and multivariable logistic regression analyses respectively. In receiving operator characteristics (ROC) curve analysis, RAVI with a cutoff value  $\geq 30$  ml/m<sup>2</sup> had a 87.5% sensitivity, a 92.24% specificity area under Receiving operator characteristics (ROC) curve = 0.964 for predicting persistently impaired RVF.

**Conclusion:** In patients with inferior STEMI with proximal RCA occlusion, RAVI is an independent predictor of persistently impaired RVF with a cut-off value  $\geq 30$  ml/m<sup>2</sup>.

**Keywords:** Right atrial volume index, inferior STEMI, RV function

## 1. Introduction

In nearly half of acute inferior STEMI patients, the right ventricle is affected by acute myocardial infarction (AMI) mostly due to

occlusion of the right coronary artery (RCA) proximal to the right ventricular (RV) branch[1]. Due to multiple factors the right ventricle is less affected by ischemia than the left ventricle (LV) [2], however when acute RV ischemia complicates

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acute inferior STEMI, it leads to poor clinical outcome especially short term one due to increased risk of arrhythmias and hemodynamic instability [3].

Successful revascularization by primary percutaneous coronary intervention (PPCI) usually improve the RV systolic function [4]. Patients who could pass the acute phase of ischemic RV dysfunction usually regain normal RV function over a period of weeks or months. Echocardiography remains the most commonly used technique to assess RV function due to its availability and its nature as non-invasive real time method. Multiple 2D parameters and tissue Doppler imaging (TDI) are used to assess RV function. However, the complex shape of the RV makes these measurements a real challenge in routine clinical practice. In contrast, the right atrium (RA) can be visualized clearly using 2D echocardiography allowing accurate and reproducible measurement of the RA volume. RA volume indexed to body surface area (RAVI) has recently been described as an echocardiographic parameter that is linked to adverse outcome in patients with heart failure (HF)[5,6] and pulmonary hypertension[7]. In contrast, no studies have explored relationship between RAVI and RV dysfunction in patients with acute inferior STEMI due to occlusion of proximal RCA. We hypothesized that RAVI can serve as a marker of RV dysfunction to predict the persistent of RV dysfunction after acute inferior STEMI due to occlusion of proximal RCA.

## 2. Materials and Methods

### 2.1. Study population

Sixty-five consecutive patients with recent first acute inferior STEMI who underwent PPCI in Tanta University, Cardiology department were prospectively included in the study during the period from July 2018 till April 2019.

Informed consent was taken from all patients and the study was approved by the local ethical committee.

During the enrollment period, 80 consecutive patients screened for admission to the study.

#### 2.1.1. Inclusion criteria

(1) Confirmed first inferior STEMI based on the presence of typical angina pain more than 20 minutes, new ST-segment elevation at J point  $\geq 0.1$  mv in two or more inferior leads. The diagnosis was confirmed by the elevation in troponin levels. The presence of associated right

#### List of abbreviations

RV	Right ventricular
RAVI	Right atrial volume index
STEMI	ST segment elevation myocardial infarction
RCA	Right coronary artery
PPCI	Primary percutaneous coronary intervention
NYHA	New York Heart Association
TDI	Tissue Doppler imaging
RVF	Right ventricular function
AMI	Acute myocardial infarction
ROC	Receiving operator characteristics
LV	Left ventricle
RA	Right atrium
HF	Heart failure
RV-MI	Right ventricular myocardial infarction
COPD	Chronic obstructive pulmonary disease
TIMI	Thrombolysis in Myocardial Infarction flow
MBG	Myocardial blush grade
EF	Ejection fractions
LAVI	Left atrial volume index
TAPSE	Tricuspid annular plane systolic excursion
RVFAC	Right ventricular fractional area change
MPI	Myocardial performance index
IVRT	Isovolumetric relaxation time
IVCT	Isovolumetric contraction time
PCI	Percutaneous coronary intervention
LVESV	LV end-systolic volume
LVEDV	LV end diastolic volume
PASP	pulmonary artery systolic pressure
IVC	inferior vena cava
IWMI	Inferior wall myocardial infarction
CMR	Cardiac magnetic resonance

ventricular myocardial infarction (RV-MI) was defined as ST-segment elevation  $\geq 0.1$  mv in lead V4R [8].

- (2) Onset of symptoms <12 h before hospital admission.
- (3) Patients with culprit proximal right coronary artery (RCA) at coronary angiography.

#### 2.1.2. Exclusion criteria

- (1) Patients with poor echogenic window.
- (2) Prior STMI.
- (3) Documented pulmonary hypertension.
- (4) Documented LV dysfunction.
- (5) Atrial fibrillation.
- (6) Significant valvular regurgitation or stenosis (moderate or severe).
- (7) Chronic obstructive pulmonary disease (COPD).
- (8) History of coronary artery bypass grafting.

For various reasons, 15 were not considered eligible: 5 patients had poor echocardiographic views, 2 patients had prior STEMI, 1 patient had atrial fibrillation, 2 patients had history of coronary

artery bypass grafting, 1 patient had (COPD) and 4 others refused to take part in the research (Fig. 1).

## 2.2. Angiographic Procedure

Coronary angiography and percutaneous coronary intervention were done through the femoral or radial approach. All patients received the following regimen: (1) Ticagrelor 180 mg initial dose followed by a maintenance dose of 90 mg twice daily or clopidogrel 600 mg loading dose orally followed by maintenance dose of 75 mg/day if ticagrelor is contraindicated; (2) Aspirin 300 mg followed by 75-100 mg/day and (3) During the procedure patients received unfractionated heparin (100 IU/kg), the dose was reduced to (70 IU/kg) in case of administration of glycoprotein IIb/IIIa inhibitor (eptifibatide).

Thrombolysis in Myocardial Infarction flow (TIMI) rate [9] was assessed before and at the end

PPCI also myocardial blush grade (MBG) [10] was assessed at the end of the procedure.

The use of manual thrombus aspiration was left upon the operator discretion.

On coronary angiography the site of occlusion of the RCA was defined based on the origin of first major (>1 mm) RV branch [11].

## 2.3. Echocardiographic evaluation

All patients underwent two dimensional transthoracic echocardiographic and Doppler studies using the commercially available GE Vivid 7 echocardiograph with 2.5 MHz transducer. Echocardiographic evaluation was performed at the time of discharge and at 3 months interval. LV ejection fractions (EF), LV end-systolic volume (LVESV), LV end diastolic volume (LVEDV) were evaluated (using biplane method of discs) [12].

Right atrial volume indexed to body surface area (RAVI) using the 4-chamber single-plane Simpson

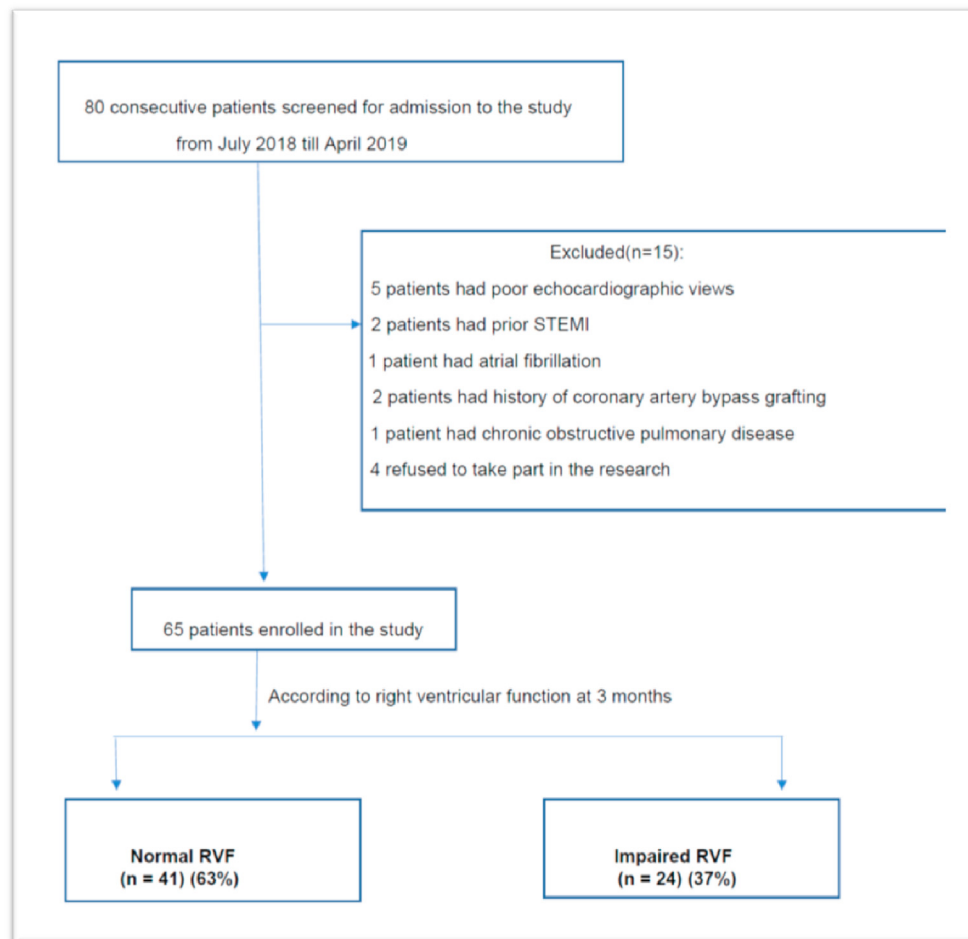


Fig. 1. Flow chart of patient selection.

method averaged over 5 consecutive cardiac cycles. An Apical 4 chamber view that includes the entire RA was used. The RA contours were traced on sequential images at end-ventricular systole. Fore-shortening of the RA was carefully avoided. The RA appendage, coronary sinus, and the confluence of inferior vena cava were excluded [13] (Fig. 2).

From the trans-mitral flow profile, the E and A waves peak velocities were calculated. TDI of the mitral annulus was performed in the apical 4 chamber view using 1- to 2- mm sample volume placed in the septal mitral valve annulus. The value of  $\dot{e}$  was measured and  $E/\dot{e}$  was obtained [12].

#### 2.4. Evaluation of RV function

Tricuspid annular plane systolic excursion (TAPSE) was measured in the apical 4-chamber view by M-mode echocardiography with the cursor placed through the tricuspid lateral annulus and measuring the amount of longitudinal motion of the annulus at peak systole [12].

Right ventricular fractional area change (RVFAC) was defined as  $(RV \text{ end-diastolic area} - RV \text{ end-systolic area}) / RV \text{ end-diastolic area}$ . The RV endocardium was traced both in systole and diastole along the free wall to the apex and then back to annulus along the inter-ventricular septum in the apical 4-chamber view [12].

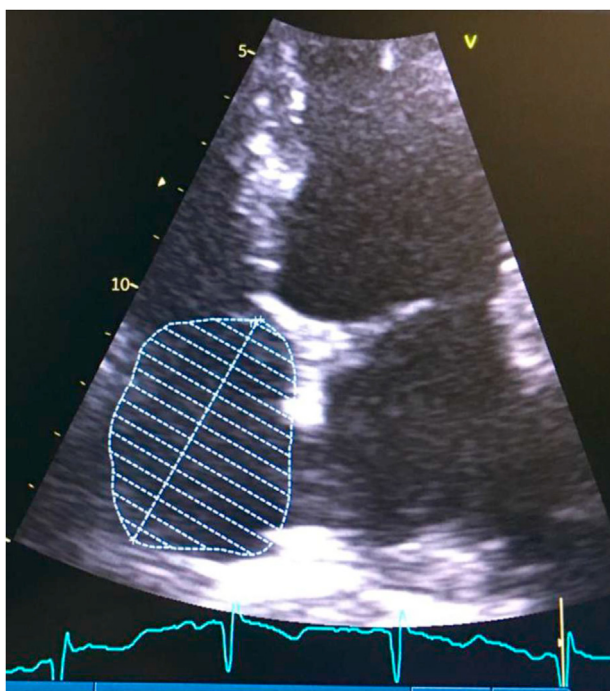


Fig. 2. Measurement of right atrial volume in apical 4 chamber view.

TDI derived RV- myocardial performance index (MPI) was calculated. Pulsed TDI analysis was obtained from apical 4-chamber view with TDI cursor placed at the level of tricuspid annulus. One major positive velocity ( $S'$ ) was recorded with movement of the annulus towards the apex during systole. Two major negative waves were recorded, one during early diastole ( $E'$ ) and one during late diastole ( $A'$ ). ( $S'$ ) duration was measured as ejection time. The time between the end of ( $S'$ ) and beginning of ( $E'$ ) was measured as isovolumetric relaxation time (IVRT). The time between the end of ( $A'$ ) and beginning of ( $S'$ ) was measured as isovolumetric contraction time (IVCT). MPI was calculated as  $(IVRT + IVCT) / ET$  [12].

Impaired right ventricular systolic function defined as presence of these three parameters together FAC  $< 35\%$ , TAPSE  $< 17$  mm and TDI derived RV- (MPI)  $> 0.54$  [12].

The pulmonary artery systolic pressure (PSAP) was assessed by measuring the difference in pressures between the right ventricle and the right atrium using the peak velocity ( $V_{max}$ ) of the tricuspid regurgitation Continuous wave Doppler trace. The simplified Bernoulli equation ( $PSAP = 4(V_{max})^2 + \text{right atrial pressure}$ ) was used [14]. Right atrial pressure (RAP) is assumed by the size and distensibility of inferior vena cava (IVC) during respiration. IVC diameter  $> 2.1$  cm that collapsed  $> 50\%$  with a sniff indicated normal RA pressure of 3 mmHg, whereas IVC diameter  $> 2.1$  cm that collapsed  $< 50\%$  with a sniff suggested high RA pressure of 15 mmHg. If IVC diameter and collapse did not fit this paradigm, an intermediate value of 8 mmHg was used. Pulsed wave Doppler recordings of flow velocities of the hepatic vein flow was done using a sample volume placed in the hepatic vein 1 cm proximal to junction of IVC and hepatic veins and hepatic vein systolic/diastolic (S/D) ratio was calculated [5].

#### 2.5. Reproducibility

All measurements were performed by an experienced echo cardiographer. Intraobserver and inter-observer variability was assessed using intraclass correlation coefficients in 15 randomly selected patients by repeated analysis on the same cine loop by the same investigator (S.S) or independently by two separate investigators (M.N and S.S).

##### 2.5.1. Study endpoint definition

The primary end point was persistent of RV dysfunction (defined as presence of the following parameters together FAC  $< 35\%$ , TAPSE  $< 17$  mm

and TDI derived RV- (MPI) > 0.54) after acute inferior STEMI due to occlusion of proximal RCA at 3- month.

### 2.6. Statistical study

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). The Kolmogorov- Smirnov test was used to verify the normality of distribution of variables; Comparisons between groups for categorical variables were assessed using Chi-square test (Fisher). Student t-test was used to compare two groups for normally distributed quantitative variables. Mann Whitney test was used to compare between two groups for not normally distributed quantitative variables. Univariate and multivariable logistic regression analyses were performed to identify predictors for persistently impaired RV function. Receiving operator characteristics (ROC) curve is used to detect optimal cut-off values of RAVI in predicting persistently impaired RV function. A p value < 0.05 is considered as statistically significant. In addition, power of the sample size was calculated by G Power tool (Franz Faul, University of Kiel, Germany, version 3.1.9.4) with 0.05 alpha and 0.8 effect size. The calculated power value was 0.86 according to post hoc-type power analysis.

## 3. Results

Sixty-five patients with first acute inferior wall STEMI, who were treated with PPCI, were included in the study.

In the 3 months after AMI, 41 of the 65 patients (63%) had normal right ventricular function (RVF) and were included in the normal RVF group. The remaining 24 (37%) patients had persistent RV dysfunction and were assigned to the impaired RVF group.

### 3.1. Baseline clinical characteristics

There were no statistically significant differences between both groups in respect to age, sex, hypertension, dyslipidemia, diabetes mellitus, smoking status, family history of premature coronary artery disease, HF history, New York Heart Association (NYHA) functional class, creatinine level, heart rate, hypotension at presentation, troponin level nor number of patients with ST-segment elevation in V4R. Both groups did not differ regarding major medications prescribed at discharge (Table 1).

Table 1. Comparison between the studied groups according to baseline clinical characteristics.

	Normal RVF (n = 41) (63%)	Impaired RVF (n = 24) (37%)	p
Age (years)	57.8 ± 8.7	54.6 ± 5.7	0.077
Male	30 (73.2%)	16 (66.7%)	0.578
Hypertension	21 (51.2%)	13 (54.2%)	0.818
Dyslipidemia	22 (53.7%)	11 (45.8%)	0.543
Diabetes mellitus	10 (24.4%)	6 (25%)	0.956
Smoker	24 (58.5%)	15 (62.5%)	0.753
Family history of premature CAD	8 (19.5%)	5 (20.8%)	1.000
NYHA functional class			
NYHA I	6 (14.6%)	4 (16.7%)	0.951
NYHA II	26 (63.4%)	14 (58.3%)	
NYHA III	5 (12.2%)	4 (16.7%)	
NYHA IV	4 (9.8%)	2 (8.3%)	
Creatinine (mg/dl)	1.1 ± 0.2	1.1 ± 0.2	0.502
Heart rate (beat/min)	77.2 ± 8.3	74.7 ± 9.6	0.266
Hypotension—baseline (n %)	9 (22%)	6 (25%)	0.778
Peak troponin (ng/ml)	3.5 ± 2.5	4 ± 2.5	0.138
ST elevation in V4R	26 (63.4%)	14 (58.3%)	0.684
Major medications			
Beta- blocker	31 (75.6%)	20 (83.3%)	0.465
ACEI or ARB	23 (56.1%)	13 (54.2%)	0.880
Statin	38 (92.7%)	22 (91.7%)	1.000
Diuretics	4 (9.8%)	2 (8.3%)	1.000
Mineralocorticoid-receptor antagonist	2 (4.9%)	1 (4.2%)	1.000

RVF = Right ventricular failure. ACEI = angiotensin-converting enzyme inhibitor. ARB = Angiotensin II receptor blocker.

### 3.2. Angiographic characteristics

There were no significant differences between both groups regarding number of diseased vessels, TIMI flow before percutaneous coronary intervention (PCI), TIMI flow after (PCI), reference vessel diameter, stent diameter, stent length, the time from symptom onset to PCI, the rate of use of thrombus aspiration device or rate of use of Glycoprotein IIb/IIIa inhibitors (Table 2).

### 3.3. Echocardiographic characteristics

#### 3.3.1. Acute phase (Table 3)

a. Left ventricle function: both groups did not differ with respect to LVESV, LVEDV, EF%, peak mitral E wave velocity, peak mitral A wave velocity, mitral E/e' ratio and left atrial volume index (LAVI).

b. RV function: there were no significant differences between both groups regarding (PASP), TAPSE, MPI-TDI, RVFAC, peak tricuspid E wave velocity and peak tricuspid A wave velocity, Tricuspid E/e', RV- isovolumic relaxation time (IVRT), deceleration time, Hepatic vein systolic/diastolic ratio.

Table 2. Comparison between the studied groups according to angiographic characteristics.

	Normal RVF (n = 41) (63%)	Impaired RVF (n = 24) (37%)	P
Number of diseased vessels			0.869
1	9 (22%)	4 (16.7%)	
2	17 (41.5%)	11 (45.8%)	
3	15 (36.6%)	9 (37.5%)	
TIMI flow before PCI			0.778
0	32 (78%)	18 (75%)	
1	9 (22%)	6 (25%)	
TIMI flow after PCI			1.000
2	4 (9.8%)	2 (8.3%)	
3	37 (90.2%)	22 (91.7%)	
RD	3.1 ± 0.4	3.2 ± 0.3	0.392
Stent diameter	21.2 ± 5.4	22.2 ± 5.2	0.505
Stent length	3.1 ± 0.4	3.2 ± 0.3	0.681
Time from symptom onset to PCI (mins)	290.1 ± 121.5	240.6 ± 126.2	0.093
Thrombus aspiration	5 (12.2%)	3 (12.5%)	1.000
GPIIb/IIIa	19 (46%)	10 (42%)	0.134

RVF = Right ventricular failure. TIMI = Thrombolysis in Myocardial Infarction. PCI = percutaneous coronary intervention. RD = reference diameter. G IIb/IIIa inhibitors = glycoprotein IIb/IIIa inhibitor.

c. RAVI: patients in the impaired RV function group had higher RAVI (p=<0.001).

3.3.2. 3-months follow up (Table 4)

a) Left ventricle function: both groups did not differ with respect to LVESV, LVEDV, EF%, peak mitral E wave velocity, peak mitral A wave velocity, mitral E/e' ratio and LAVI.

Table 4. Comparison between the studied groups according to echocardiographic characteristics at 3-month follow up.

	Normal RVF (n = 41) (63%)	Impaired RVF (n = 24) (37%)	p
LVESV (ml)	50.4 ± 15.5	44.5 ± 13.7	0.073
LVEDV (ml)	125.4 ± 24	115.7 ± 19.8	0.051
EF %	59.2 ± 5.4	61.2 ± 6.4	0.192
LAVI	28.3 ± 3.1	29.6 ± 2.9	0.100
Peak E (m/s)	0.7 ± 0.1	0.7 ± 0.1	0.665
Peak A (m/s)	0.8 ± 0.1	0.8 ± 0.1	0.628
E/e' ratio	11.9 ± 1.8	11.3 ± 1.6	0.163
PASP (mmhg)	26.4 ± 6.6	29.1 ± 5.2	0.093
TAPSE (mm)	22 ± 4.7	14.8 ± 2.8	<0.001*
MPI-TDI	0.4 ± 0.1	0.6 ± 0.1	<0.001*
RVFAC%	38 ± 2.5	30 ± 3.1	<0.001*
Tricuspid E (m/s)	0.5 ± 0.1	0.5 ± 0.1	0.933
Tricuspid A (m/s)	0.4 ± 0.1	0.4 ± 0.1	0.190
Tricuspid E/e'	4.2 ± 0.8	4.3 ± 0.7	0.704
RV-IVRT (ms)	82.99 ± 7.32	86.01 ± 3.47	0.063
Deceleration time (ms)	197.96 ± 5.85	200.47 ± 10.59	0.222
Hepatic vein systolic/diastolic ratio	1.3 ± 0.5	1.55 ± 0.6	0.076

RVF = Right ventricular failure. LVESV = Left ventricular end-systolic volume. LVEDV = Left ventricular end-diastolic volume. EF%, Ejection fraction; E: peak flow velocity during the early rapid filling phase; A: peak flow velocity during atrial contraction. E/e', the ratio of early flow velocity to the early annular velocity. PASP = pulmonary artery systolic pressure. TAPSE = Tricuspid annular plane systolic excursion. MPI = Myocardial performance index. TDI = Tissue Doppler imaging. RVFAC = Right ventricular fractional area change. IVRT= Isovolumetric relaxation time.

b) RV function: there was no significant difference between both groups regarding PASP, peak tricuspid E wave velocity, peak tricuspid A wave velocity and RV- isovolumic relaxation time (IVRT),

Table 3. Comparison between the studied groups according to echocardiographic characteristics acute phase.

	Normal RVF (n = 41) (63%)	Impaired RVF (n = 24) (37%)	p
LVESV (ml)	47.4 ± 11.2	42.5 ± 10	0.078
LVEDV (ml)	120.9 ± 18.6	113.5 ± 12.3	0.086
EF %	60.8 ± 6.2	62 ± 6.4	0.467
LAVI	26.8 ± 2.1	27.9 ± 2.7	0.072
Peak E (m/s)	0.7 ± 0.1	0.7 ± 0.1	0.928
Peak A (m/s)	0.8 ± 0.1	0.8 ± 0.1	0.821
E/e' ratio	11.4 ± 1.6	12.2 ± 2.2	0.078
PASP (mmhg)	29.7 ± 5.3	27.3 ± 5.2	0.078
TAPSE (mm)	18 ± 3.5	17 ± 3.5	0.291
MPI-TDI	0.5 ± 0.1	0.5 ± 0.2	0.995
RVFAC %	35.3 ± 5.1	34.2 ± 4.5	0.385
Tricuspid E (m/s)	0.5 ± 0.1	0.5 ± 0.1	0.845
Tricuspid A (m/s)	0.4 ± 0.1	0.4 ± 0.1	0.694
Tricuspid E/e'	4.5 ± 0.8	4.1 ± 0.9	0.055
RV-IVRT (ms)	95.25 ± 19.22	97.31 ± 4.37	0.608
Deceleration time (ms)	191.89 ± 8.95	196.22 ± 10.9	0.088
Hepatic vein systolic/diastolic ratio	1.15 ± 0.5	1.4 ± 0.7	0.099
RAVI (ml/m <sup>2</sup> )	25.6 ± 3.2	37 ± 2.2	<0.001*

RVF = Right ventricular failure. LVESV = Left ventricular end-systolic volume. LVEDV = Left ventricular end-diastolic volume. EF%, Ejection fraction; E: peak flow velocity during the early rapid filling phase; A: peak flow velocity during atrial contraction. E/e', the ratio of early flow velocity to the early annular velocity. PASP = pulmonary artery systolic pressure. TAPSE = Tricuspid annular plane systolic excursion. MPI = Myocardial performance index. TDI = Tissue Doppler imaging. RVFAC = Right ventricular fractional area change. IVRT= Isovolumetric relaxation time. RAVI = Right atrial volume index.

Table 5. Univariate and multivariate logistic regression analysis for predicting impaired RV function.

	Univariate		Multivariate	
	OR (95% C.I.)	p	OR (95% C.I.)	p
Age (years)	0.113	0.946 (0.883 – 1.013)	0.367	0.931 (0.798 – 1.087)
Male	0.656	0.889 (0.485 – 1.112)	0.789	0.863 (0.474 – 1.101)
Time from symptom onset to PCI (mins)	0.126	0.997 (0.992 – 1.001)	0.191	0.993 (0.982 – 1.004)
EF %	0.461	1.031 (0.951 – 1.118)	0.444	0.933 (0.782 – 1.114)
RAVI (ml/m <sup>2</sup> )	<0.001	1.786 (1.367 – 2.335)	<0.001	1.829 (1.358 – 2.462)

C.I, Confidence interval. OR: Odd's ratio. EF%, Ejection fraction. RAVI = Right atrial volume index.

deceleration time, Hepatic vein systolic/diastolic ratio. TAPSE, MPI-TDI and RVFAC were significantly better in normal RVF group. P value= (<0.001).

Univariate and multivariable logistic regression analyses to assess predictor of persistently impaired RV function included age, sex, time from symptom onset to PCI, EF% and RAVI. The results showed that RAVI was the only factor that predicted persistently impaired RV function (odds ratio = 1.786, 95% confidence interval, 1.367–2.335, p value= <0.001) and (odds ratio = 1.829, 95% confidence interval, 1.358 –2.462, p value= <0.001) in univariate and multivariable logistic regression analyses respectively (Table 5).

In ROC curve analysis, RAVI with a cutoff value  $\geq 30$  ml/m<sup>2</sup> had a 87.5% sensitivity, a 92.24% specificity area under ROC curve = 0.964 for predicting persistently impaired RV function (Fig. 3).

#### 3.4. Reproducibility

Intraobserver and interobserver variability for conventional two-dimensional/Doppler

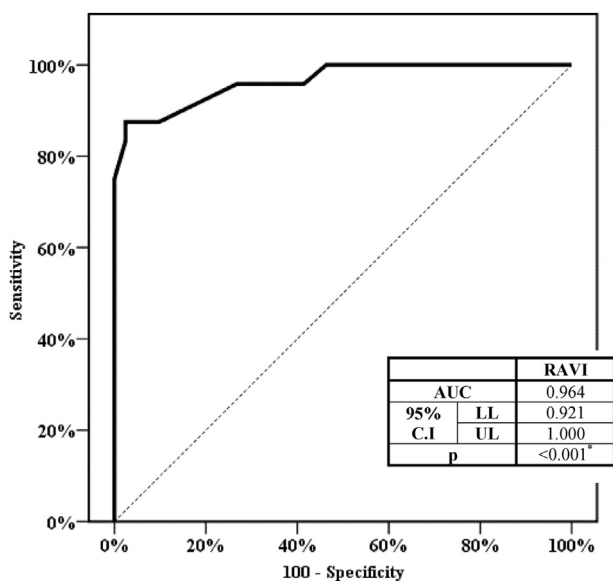


Fig. 3. Receiver operating curve characteristic (Roc) curve analyses for RAVI as predictor for impaired RVF.

measurements and TDI-derived parameters ranged from 0.95 and 0.98 and 0.92 and 0.95 respectively.

#### 4. Discussion

The present study evaluated the ability of RAVI to predict persistent RV dysfunction in patients with inferior STEMI with proximal RCA occlusion.

The main findings of the present study were: (1) Persistent RV dysfunction occurred in (37%) patients. (2) RAVI is an independent predictor of persistent RV dysfunction. The cutoff value of RAVI  $\geq 30$  ml/m<sup>2</sup> had a 87.5% sensitivity, a 92.24% specificity for predicting persistently impaired RV function.

The importance of predicting persistence RV dysfunction came from the fact that persistent RV dysfunction is associated with long term poor prognosis irrespective of left ventricle (LV) systolic function[15] [16]. Liao H et al, compared in-hospital outcomes between left ventricular myocardial infarction patients with and without right ventricular myocardial infarction in 458 patients with acute (STEMI) undergoing (PPCI). They reported that patients with concomitant RVMI have higher of in-hospital complications, particularly all-cause mortality and new onset acute HF. [17].

The occlusion of proximal RCA in patients with IWMI is associated with more worse RV function indices compared to patients without proximal RCA occlusion[1]. This raises the importance of precisely assessing the RV function in such patients. For long time the assessment of the cardiac function was all about the left ventricle and the right ventricle was the forgotten chamber. Nowadays the importance of the right ventricle as a prognostic marker in different cardiovascular diseases is well accepted [18].

Although different imaging modalities are available nowadays to assess both RV function and structure, still echocardiography is the most used imaging technique due to its wide availability and cost issues especially in the developing countries. The standard techniques of echocardiography which are recommended by the current guidelines to evaluate RV function, such as 2D, Doppler and M



mode, are faced by the complex geometry of the right ventricle and difficulty in obtaining accurate and clear images in some patients[19]. The new techniques such as speckle tracking and 3D are still limited by many concerns making them difficult to use in every day practice[20]. In comparison to the right ventricle, the right atrium is easy to visualize and assess allowing quantitative and highly reproducible calculation of RAVI.

Sallach et al. evaluated the relationship between (RAVI) and (RV) systolic and diastolic function, as well as long-term prognosis in patients with chronic systolic (HF). RAVI was an independent predictor of long-term adverse clinical events.  $RAVI \geq 30.6$  ml/m<sup>2</sup> (optimal ROC cutoff) had a 78% sensitivity and a 77% specificity ( $p < 0.0001$ ) for predicting RV systolic dysfunction stage  $\geq 3$ . This cutoff is similar to that found in the present study, however we used RAVI as a marker of persistently impaired of RV dysfunction at 3 months follow up and in different patients population which are acute inferior STEMI and RV involvement based on coronary angiographic findings[6].

Ivanov A et al, evaluate the predictive value of RAVI assessed by cardiac magnetic resonance (CMR) for all-cause mortality in 243 patients with HFrEF (LVEF < 35% measured by CMR). They concluded that RAVI measured by CMR imaging is an independent predictor of mortality in patients with heart failure with reduced ejection fraction [21]. Alexandre Altes et al examined the relation between RAVI and long term mortality of patient with systolic HF who received cardiac resynchronization therapy, they included 172 patients and they found that for every 1 mL/m<sup>2</sup> increase in RAVI the risk of death was increasing  $p = (0.042)$  and patients in the highest tertile ( $RAVI > 29$  mL/m<sup>2</sup>) had significantly higher risk of death compared with those with  $RAVI \leq 29$  mL/m<sup>2</sup>  $p = (0.014)$  [22]. The RAVI value in the last 2 studies which predict poor outcome is close to our finding that  $RAVI \geq 30$  ml/m<sup>2</sup> predicts persistent RV dysfunction after acute IWMi due to proximal RCA occlusion.

## 5. Conclusion

The findings of the present study suggest that RAVI may be a useful predictor of persistently impaired RVF in patients with inferior STEMI with proximal RCA occlusion with a cut-off value  $\geq 30$  ml/m<sup>2</sup>. The clinical application of these findings requires larger studies to test drugs that target the RV with the aim of preventing RV dysfunction. Also, further studies are required to

determine the impact of these findings on the clinical outcome e.g.: re-hospitalization and or death.

## Author contributions

Conception and design of Study: Mohamed Naseem, Sameh Samir. Literature review: Mohamed Naseem. Acquisition of data: Sameh Samir. Analysis and interpretation of data: Mohamed Naseem, Sameh Samir. Drafting of manuscript: Mohamed Naseem, Sameh Samir. Revising and editing the manuscript critically for important intellectual contents: Mohamed Naseem, Sameh Samir.

## Disclosure

Authors have nothing to disclose with regard to commercial support

## Conflict of interest

The authors declare that there is no conflict of interest.

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