Research Journal of

Cardiology

ISSN 1819-3404

Academic Journals Inc.

www.academicjournals.com

OPEN ACCESS
Research Journal of Cardiology
ISSN 1819-3404
DOI: 10.3923/rjc.2016.8.16

Research Article
Assessment of Right Ventricular Function in Acute Inferior Wall Myocardial Infarction in Patients Treated with Primary Percutaneous Coronary Intervention

Medhat M. Ashmawy, Yasser H. El-Barbary, Wael A. Hassib and Christine G. Naguib

Department of Cardiology, Faculty of Medicine, Tanta University, Egypt

Abstract
Background and Objective: Since there is a difficulty in the assessment of RV function by 2D echocardiography, a noninvasive, practical, bedside and cost effective method is desirable. Tissue doppler technique enables to visualize systolic and diastolic velocities of the tissue through sample volume replacement. The aim of the study is to evaluate right ventricular function using tissue doppler study in patients with inferior myocardial infarction treated with primary PCI. **Methodology:** Patients with first, acute, inferior STEMI treated with PPCI were prospectively assessed. The RVMI was defined as an ST-segment elevation $\geq$0.1 mV in lead V4R. Echocardiography with TDI was performed after PPCI within 24-48 h of the onset of symptoms. Follow up including in-hospital events was performed. **Results:** Receiver Operating Characteristics (ROC) revealed high diagnostic significance of MPI (Area under the curve was 0.91) with a cut off value >0.51 for a diagnosis of RVMI had a 83.3% sensitivity and a 80% specificity and for SmRV area under the curve was 0.90 with cut off value was (13.5 cm sec^{-1}) with sensitivity 83.3% and specificity 70%. In multivariate stepwise logestic analysis, peak systolic RV velocity (SmRV) with odd's ratio (OR = 0.419) was independent predictors of in-hospital prognosis. **Conclusion:** Tissue Doppler Imaging (TDI) is a relatively new echocardiographic technique that uses doppler principles to measure the velocity of myocardial motion. It has been found a high diagnostic significance of myocardial performance index MPI and systolic myocardial velocity (Sm) in predicting RVMI in inferior MI patients.

Key words: Tissue doppler imaging, right ventricular myocardial infarction, inferior myocardial infarction, systolic myocardial velocity, ROC

Received: May 18, 2016 Accepted: May 31, 2016 Published: June 15, 2016

Citation: Medhat M. Ashmawy, Yasser H. El-Barbary, Wael A. Hassib and Christine G. Naguib, 2016. Assessment of right ventricular function in acute inferior wall myocardial infarction in patients treated with primary percutaneous coronary intervention. Res. J. Cardiol., 9: 8-16.

Corresponding Author: Christine G. Naguib, Department of Cardiology, Faculty of Medicine, Tanta University, Egypt Tel: 01227569870

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Of all Acute Myocardial Infarction (AMI) and Inferior Myocardial Infarction (IMI) is estimated to form 40-50%. The culprit lesion is often esoteric to be in the Right Coronary Artery (RCA) or left circumflex coronary artery (LCX)[1].

It is assessed that 30% of all acute inferior myocardial infarction of the left ventricle is associated with Right Ventricular Infarction (RVI). The RVI is frequently caused by proximal occlusion of the dominant RCA. The term RVI which is used widely to refer to acute RV dysfunction resulting from free wall motion abnormalities and/or dilation of right ventricle while ischaemic but viable myocardium is existed[2].

Patients with right ventricular involvement have worse outcome and moreover risk of major complications has been increased so significantly that in hospital death of these patients has been reported without reperfusion therapy. Therefore, right ventricular involvement is a major determinant of the prognosis and of the treatement strategy in patients with inferior MI[3].

Thus, Left Ventricle (LV) function may be affected by Right Ventricle (RV) dysfunction by limiting LV preload, as well as by adverse systolic and diastolic interaction via the interventricular septum and the pericardium (ventricular interdependence).

In addition, it has been proved that RV function is a main factor to determine clinical outcome that's why it is considerable during clinical management and treatment. Therefore, it's evidently needed to have diagnosis of RV dysfunction[4].

The regional myocardial function can be quantified with the help of TDI, which is a recent ultrasound technique by measuring myocardial velocities. There are 3 available TDI modes: Pulsed wave mode, 2D color mode and color M-mode by each of which the specific analysis of radial and longitudinal myocardial motion is allowed. The TDI can also be used in the analysis of both phase and amplitude of regional myocardial motion. That's why TDI is considered the precise non-invasive method for assessing myocardial dysfunction[5].

The aim of the study was to evaluate right ventricular function using tissue doppler study in patients with inferior myocardial infarction treated with primary PCI.

MATERIALS AND METHODS

Study population: This study has included 30 patients who presented with ST elevation MI in Cardiololgy Department of Tanta University Hospital from March, 2014 till February, 2016. The study has recruited also 10 healthy volunteers as a control group. Patients included in the study fulfilled the following inclusion criteria: First acute ST-inferior segment elevation myocardial infarction (STEMI) legible for primary PCI.

The diagnosis of inferior STEMI will be based on: Chest pain for more than 30 min, ST-segment elevation of more than 1 mm in at least 2 of 3 inferior leads and typical increase in cardiac enzymes and the ST-segment elevation of $\geq$0.1 mV in the right precordial leads V4R is readily available electrocardiographic sign for diagnosis of right ventricular infarction. Exclusion criteria in this study were patients with anterior wall myocardial infarction is to be documented by the presence of ST. Segment elevation in leads other than the inferior leads in 12 lead ECG, patients with old inferior myocardial infarction, patients with history of triple vessel disease and patients with history of stenting of RCA or LCX and patients with history of Coronary Artery Bypass Graft (CABG).

Study design: Subjects included in this study were classified into 2 groups. The first group was the control group that consisted of 10 healthy individuals with no evidence of coronary artery disease, pulmonary disease or any cardiac diseases and with a normal echocardiogram. The second group consisted of 30 patients with the diagnosis of STEMI inferior myocardial infarction with evidence of right ventricular infarction.

Patients included in this study were subjected to the following:

History taking: Full history was taken including age, sex, history of risk factors for CAD which are DM, hypertension, dyslipidemia, smoking and family history of CAD.

Clinical examination: All patients underwent through a clinical examination including:

- General examination with special regards to the patient appearance, decubitus, blood pressure and pulse
- Local cardiac examination for evaluation of abnormal pulsations, heart sounds, murmurs and KILLIP classification will be assessed
- Electrocardiogram (ECG): Standard resting 12 leads ECG was performed to diagnose and localize the site of ST-segment elevation MI for all patients on admission. The ECG was recorded at paper speed of 25 mm sec^{-1} at calibration of 1 mV equals to 10 mm. The ST-segment elevation more than 1 mm was considered significant

Laboratory investigation:

- Total cholesterol, LDL-cholesterol, HDL-cholesterol and serum triglycerides
- Cardiac enzymes including serum treponin
- Random blood sugar

Primary percutaneous coronary intervention for Infarct Related Artery (IRA): In this study, it was selected that cases with inferior infarction with right ventricular involvement. A loading dose of dual anti-platelet (Aspirin and clopidogerl) and unfractionated heparin will be given to all patient before the procedure (600 mg clopidogrel and 300 mg of aspirin), GPIIb/IIIa (Eptifipatide or tirofiban) was used before or during the procedure.

Arterial access: Local anesthetic is introduced into an area 3-4 cm in diameter, 3-4 cm below the inguinal. The anticipated puncture site should overlie bone, thus allowing for adequate vessel compression when the sheaths are removed.

An 18-gauge needle is introduced through the skin and tunnel into the lumen of the femoral artery. Once pulsatile blood flows freely through the needle, a teflon-coated guide wire is advanced into the lumen of the punctured vessel.

The vessel is held firmly in place as the needle is and the wire is wiped to remove blood and thrombi. There is sheath with a side arm port is advanced over the wire into the vessel lumen and the wire is removed. The side arm port allows continuous pressure monitoring and infusion as catheters are advanced through the sheath to the heart.

Assessment of perfusion: Coronary angiogram was done by interventional cardiologist who identify the culprit lesion on the basis of the infarct location on the admission ECG and the angiographic finding (Target vessel, lesion and its characteristics) and Bare Metal Stent (BMS) was used after doing pre-stenting balloon dilatation for indicated cases and thrombus aspiration using aspiration catheter was used for indicated cases and then analyzed to determine the extent of flow which was graded according to the Thrombolysis in Myocardial Infarction (TIMI) classification.

Echocardiography and tissue doppler imaging: Standard echocardiographic examination with TDI was performed after Primary Percutaneous Coronary Intervention (PPCI) within 24-48 h of the onest of symptoms in all patients. Examinations were performed using a GE vivid seven dimension cardiac ultrasound phased array system with tissue doppler imaging using M4S transducer 4 MHz. Echocardiographers were blinded to clinical, ECG and angiographic parameters.

2D doppler echocardiography: While patient lying in partial left lateral decubitus position to assess the following:

- The RV systolic function was measured by the fractional area change (RVFAC), which is done by tracing the RV end diastolic area (RVDA) and the end systolic area (RVSA) in the apical 4-chamber view using the equation[6]:

$$\text{RVFAC} = \frac{\text{RVDA-RVSA}}{\text{RVDA}} \times 100$$

- The normal values for RVFAC according to the American society of echocardiography guide lines for chamber quantification ranges[7] from 40-50
- Assessment of wall motion abnormalities was included in the standard echocardiographic examination: The presence or absence of RV wall motion abnormality was assessed qualitatively from different views. In the parasternal view of RV inflow, wall motion of anterior and inferior wall of RV was assessed. Parasternal short axis view of RVOT was used to assess RWMA of RVOT and parasternal short axis view at papillary muscle level used to assess anterior, lateral and inferior walls of RV. From apical 4-chamber view wall motion abnormality of lateral wall of RV was assessed
- Left Ventricular Ejection Fraction (LVEF) was calculated according to modified Simpson's rule in the apical 4 view
- Tricuspid Annular Plane Systolic Excursion (TAPSE) was measured. It is usually measured with 2-dimensional M-mode echocardiograms from the 4-chamber view, positioning the cursor on the lateral tricuspid annulus near the free RV wall and aligning it as close as possible to the apex of the heart[8]. The TAPSE is easily obtainable and is a measure of RV longitudinal function TAPSE<16 mm indicates RV systolic dysfunction[9]

Tissue doppler imaging: The TDI was recorded during shallow respiration or end expiratory apnea with doppler velocity range -20 to 20 cm sec^{-1} with 0.57 cm sample volume at a sweep of 50 cm sec^{-1}.

Guided by 2D 4-chamber view, a sample volume was placed at the lateral tricuspid annulus. Special care was taken to obtain an ultra-sound beam parallel to the direction of RV and tricuspid annular motion:

- The peak systolic myocardial velocity (Sm) was obtained. Mean values for Sm in normal populations are approximately 15 cm sec^{-1} at the annulus, a lower reference limit of normal controls[9] was 10 cm sec^{-1}

- The E/A ratio at lateral tricuspid annulus was obtained
- The myocardial performance index (Tei index) was obtained

The time interval between the end of once cycle (A) and the onset of the next cycle (E) is denoted by "A" which is equal to the sum of Isovolumic Contraction Time (ICT), Ejection Time (ET) and Isovolumic Relaxation Time (IRT) [a = ICT+ET+IRT]. The left and right ventricular outflow velocities pattern will be recorded from the parasternal short-axis view with doppler sampling site positioned just below the aortic or pulmonary valve, respectively. The left and right ventricular ejection time is represented by "B".

Tei index is defined as the sum of Isovolumic Contraction Time (ICT) and Isovolumic Relaxation Time (IRT) divided by ventricular Ejection Time (ET)[10]:

$$\text{Tei index} = \frac{\text{ICT+IRT}}{\text{ET}} = \frac{\text{a-b}}{\text{b}}$$

By 2-dimensional 4-chamber view, a sample volume was placed at the septal tricuspid annulus with pulsed wave and the E/A ratio at the septal tricuspid annulus was obtained.

Statistical analysis: Data were tabulated, coded then analyzed using the computer program SPSS (Statistical package for social science) version 17.0 to obtain.

Descriptive data: Descriptive statistics were calculated for the anthropometric measurements and laboratory data in the form of:

- Mean±Standard Deviation (SD)
- Frequency (Number-percent)

Analytical statistics: In the statistical comparison between the different groups, the significance of difference was tested using one of the following tests:

- Student's t-test: Used to compare between mean of two groups of numerical (parametric) data
- Inter-group comparison of categorical data was performed by using chi square test (χ^2-value)
- Pearson's correlation coefficient test was used correlating different parameters

Some investigated parameters were entered into a logistic regression model to determine which of these factors is considered as a significant risk factor and identify its odds ratio. The sensitivity and specificity of Sm, Em, TAPSE and MPI to discriminate between control and cases with right ventricular infarction were examined at different cut off points using ROC curve analysis to determine the best cutoff point as well as the diagnostic power of each test. A p-value<0.05 was considered statistically significant.

RESULTS

As regard to coronary artery risk factors; patient group showed a higher incidence of dyslipidemia (p = 0.006), smoking (p = 0.001) but no significant difference in BMI, DM and HTN. About 20% of cases in patient group showed positive family history of CAD (Table 1).

Clinical status and laboratory findings in both groups: Patients in group II showed significant increase in serum blood glucose (p = 0.04), serum total cholesterol (p = 0.001), LDL-cholesterol (p = <0.001), TG (p = 0.03) and significant decrease in HDL-cholesterol (p = <0.001) but no significant difference in the heart rate, systolic and diastolic blood pressure and all patient group showed positive treponin test and grade I killip classification (Table 2).

Table 1: Demographic characteristics of control group (N = 10) and patient group (N = 30)

Parameters		Control groups		Inferior with right group		p-value
Age		54.60±12.49		57.27±10.68		0.5
Sex						
Male		7	70.0%	26	86.7%	0.23
Female		3	30.0%	4	13.3%	
BMI		32.95±5.48		31.44±7.57		0.56
DM	Y	1	10.0%	8	26.7%	0.27
HTN	Y	1	10.0%	12	40.0%	0.08
Dyslipidemia	Y	1	10.0%	18	60.0%	0.006*
Smoker	Y	1	10.0%	21	70.0%	0.001*
Family history of CAD	Y			6	20.0%	-

Data expressed either in Mean±SD or frequency (No-%), *Significance <0.05, Test used: Student's t-test for data expressed as Mean±SD and chi-square for data expressed as frequency, BMI: Body mass index, DM: Diabetes mellitus, HTN: Hypertension and CAD: Coronary artery disease

Table 2: Clinical and laboratory findings in control group (N = 10) and patient group (N = 30)

Parameters	Control groups Mean±SD	Inferior with right groups Mean±SD	p-value
HR	75.20±5.87	74.50±8.84	0.8
SBP	118.00±8.23	119.17±22.05	0.87
DBP	76.00±5.68	74.50±14.64	0.75
RBS	96.20±28.26	143.90±68.40	0.04*
Cholesterol	149.80±37.82	199.77±40.00	0.001*
HDL	43.30±2.5	32.27±3.70	<0.001**
LDL	92.3±29.20	141.40±37.84	0.001*
TG	93.40±37.72	130.30±46.55	0.03*

SD: Standard deviation, *Significance <0.05, **High significance <0.001, Test used: Student's t-test, HR: Heart rate, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, RBS: Random blood sugar, HDL: High density lipoprotein, LDL: Low density lipoprotein and TG: Triglycerides

Table 3: Echocardiographic findings in patient group (N = 30) and control group (N = 10)

Parameters	Control group	Inferior with right group	p-value
LVEF (%)	66.70±8.38	59.03±6.80	0.006*
RVFAC	48.90±7.40	31.00±7.14	<0.001**
Sm (cm sec^{-1})	14.90±1.73	11.57±2.03	<0.001**
Em (cm sec^{-1})	14.10±3.18	9.70±3.14	<0.001**
Am (cm sec^{-1})	12.30±3.40	14.17±3.21	0.12
E/A lateral	1.18±0.29	0.69±0.19	<0.001**
E/A septal	1.21±0.49	0.80±0.26	0.001*
TAPSE	2.49±0.36	1.97±0.35	<0.001**
MPI	0.40±0.11	0.60±0.12	<0.001**

*Significance <0.05, **High significance <0.001, Test used: Student's t-test, LVEF: Left ventricular ejection fraction, RVFAC: Right ventricular fractional area change, Sm: Systolic myocardial velocity, Em: Early diastolic myocardial velocity, Am: Late diastolic myocardial velocity, E/A lateral: E/A ratio at lateral tricuspid annulus, E/A septal: E/A ratio at septal tricuspid annulus, TAPSE: Tricuspid annular plane systolic excursion and MPI: Myocardial performance index

Echocar diographic findings after PCI: Patients in group II had significant impairment in left ventricular ejection fraction mean 59.03±6.80 compared to control group 66.70±8.38 (p = 0.006), significant impairment in right ventricular fractional area change mean 31.00±7.14 compared to control group 48.9±7.4 (p = <0.001), in systolic myocardial velocity at lateral tricuspid annulus mean 11.57±2.03 cm sec^{-1} compared to control group 14.90±1.73 cm sec^{-1} (p = <0.001), in early diastolic myocardial velocity at lateral tricuspid annulus 9.70±3.14 cm sec^{-1} compared to control group 14.10±3.18 cm sec^{-1} (p = <0.001), in E/A ratio at lateral tricuspid annulus mean 0.69±0.19 compared to control group 1.18±0.29 (p = <0.001), in E/A ratio at septal tricuspid annulus mean 0.80 compared to control group 1.21 (p = 0.001), in tricuspid annular plane systolic excursion mean 1.97±0.35 compared to control group 2.49±0.36 (p = <0.001) and myocardial performance index mean 0.6±0.12 compared to control group 0.40±0.11 (p = <0.001) but no significant difference in late diastolic myocardial velocity at lateral tricuspid annulus between control and patient group (Table 3).

Table 4: Echocardiographic findings in patient group (N = 30)

Inferior with right group	No.	%
RWMA hypokinesia	24	80.0
RWMA akinesia	2	6.7
TR	4	13.3

RWMA: Resting wall motion abnormalities and TR: Tricuspid regurgitation

Table 5: Coronary angiographic characteristics of patient group (N = 30)

Characteristics	Groups	No.	%
Culprit infarcted artery	Subtotal	11	36.7
	Total	19	63.3
Culprit infarcted artery	LCX	1	3.3
	RCA	29	96.7
Site of occlusion in related artery	Distal	1	3.3
	Mid	12	40.0
	Proximal	17	56.7
TIMI	2.0	1	3.3
	3.0	29	96.7
Stent No.	0.0	1	3.3
	1.0	21	70.0
	2.0	8	26.7
Type	BMS	24	80.0
	DES	5	16.7
	NO	1	3.3

LCX: Left circumflex coronary artery, RCA: Right coronary artery TIMI: Thrombolysis in myocardial infarction, BMS: Bare-metal stent and DES: Drug-eluting stent

There was resting wall motion abnormalities RWMA in the form hypokinesia in about 80% of patient group and akinesia in 6.7% of patient group. Tricuspid valve regurgitation occurred in 13.3% of patient group (Table 4).

Coronary angiographic characteristics in the patient group: Total occlusion in the culprit infracted artery occurred in 19 cases (63.3%) and subtotal occlusion in 11 cases (36.7%), RCA was the culprit lesion in 29 cases (96.7%) while LCX was the culprit lesion in 1 case (3.3%). Proximal occlusion occurred in 17 cases (56.7%), mid occlusion occurred in 12 cases (40%) while distal occlusion occurred in 1 case (3.3%). The TIMI flow post PCI was 3 in 29 case (96.7%) and 2 in only 1 case (3.3%). For stent implantation two stent were implanted in 8 cases (26.7%) while 1 stent was implanted in 22 cases (70.0%). The BMS was implanted in 24 case (80%), DES was implanted in 5 cases (16.7%) while only 1 case with no stent implantation (3.3%) (Table 5).

Complications: Complication in the form of arrythemia, sinus bradycardia, Premature Ventricular Contractions (PVCs) and bigeminy, Ventricular Fibrillation (VF) occurred in 8 cases 26.7% of cases.

Receiver Operating Characteristics (ROC): differentiate between control and patients: It has been found a high diagnostic significance for both MPI and systolic myocardial velocity at lateral tricuspid annulus (Sm). For myocardial

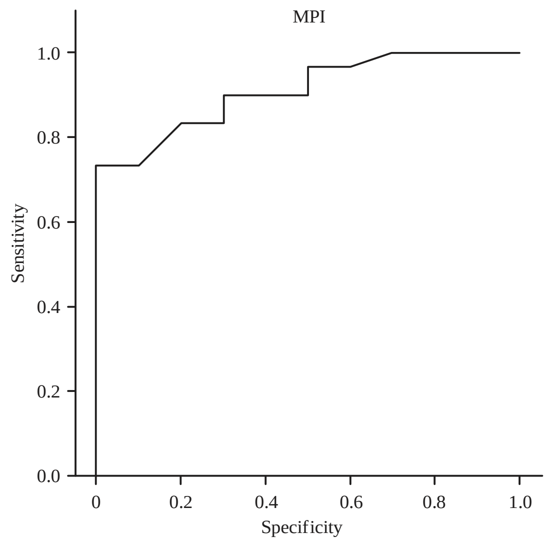

Fig. 1: ROC for Myocardial Performance Index (MPI) in diagnosis of RV myocardial infarction

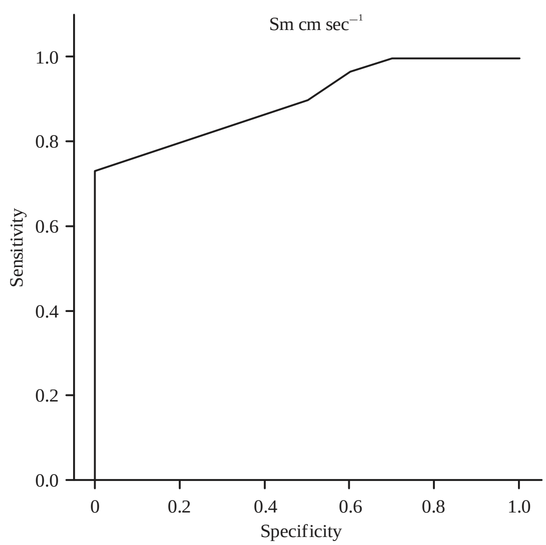

Fig. 2: ROC for systolic myocardial velocity right ventricular (RV) in diagnosis of RV myocardial infarction

performance index area under the curve was 0.91 and the cut off value was >0.51with sensitivity 83.3 and specificity 80 and accuracy 82.5 (Fig. 1).

For systolic myocardial velocity at lateral tricuspid annulus (Sm) area under the curve was 0.90 and the cut off value was <13.5 with sensitivity 83.3 and specificity 70 and accuracy 80 (Fig. 2).

Stepwise logistic regression: A logistic regression analysis was used to evaluate the predictive value of selected clinical and echocardiographic parameter factors for the presence of ECG changes specific for RVMI diagnosis. In backward stepwise

Table 6: Stepwise logistic regression

	B	p-value	OR	CI 95%
Sm (cm sec^{-1})	-0.869-	0.002	0.419	0.23-0.736

OR: Odd's ratio and CI: Confidence interval

regression analysis systolic myocardial velocity at tricuspid annulus was independent predictors of RV myocardial infarction diagnosis with odd's ratio = 0.419, confidence interval 95% = 0.23-0.736 and p = 0.002 (Table 6).

DISCUSSION

Right ventricular infarction typically occurs when there is an occlusion of the right coronary artery proximal to the acute marginal branches or of the left circumflex artery in patients with a dominant left coronary system. Less commonly, occlusion of the left anterior descending artery can result in infarction of the anterior right ventricle[11].

Assessment of RV function remains challenging because of the complex geometry of the right ventricle, its asynchronous contraction pattern and its mechanical interaction of the LV[12].

These factors limit the validity of simple geometric assumptions required for function analysis and thus limit the use of noninvasive imaging techniques for assessing RV function. Accordingly, the evaluation of right ventricular function by echocardiography has been considered difficult[12].

Tissue Doppler Imaging (TDI) is a relatively new echocardiographic technique that uses doppler principles to measure the velocity of myocardial motion. Echocardiography is less accurate in the evaluation of right ventricular ejection fraction because of the complex right ventricular shape, but it enables us to assess the right ventricular function by determining the tricuspid annular excursions and velocities reflecting the function of longitudinally oriented myocardial fibres[13-17]. It is known that these fibers contribute to the right ventricular ejection more than circularly oriented fibers. Several researcher proved a good correlation of the right ventricular ejection fraction assessed by radionuclide ventriculography with the magnitude of systolic tricuspid annular excursions[16].

Recently, demonstrated a more rapid and easily performable way of evaluating the right ventricular function the measurement of tricuspid annular velocities using pulsed doppler tissue imaging[17].

Accordingly, the aim of this study was to use conventional 2D echocardiography and TDI to evaluate RV systolic and diastolic properties in patients with acute ST segment elevation inferior MI with RV involvement and the changes that occur after coronary angioplasty.

The study included 30 patients, who are presented with acute ST segment elevation inferior MI with RV involvement as well as 10 healthy age and gender matched asymptomatic controls with no evidence of coronary artery disease, pulmonary disease or any cardiac diseases and with a normal echocardiogram.

In this study total cholesterol, low density lipoprotein and triglycerides level showed significant increase, while high density lipoprotein showed lower level in MI patient when compared with healthy control group. Similarly, a study by Kumar *et al*.[18] who studied the significance of lipid profile estimation in patient with acute myocardial infarction found that altered lipid levels play a significant role in the incidence of MI.

For the echocardiographic data in this study, RVFAC in patients with inferior MI with RV infarction showed significant decrease ($p<0.001$) compared to healthy control group.

The systolic myocardial velocity at lateral tricuspid annulus was significantly reduced in patient group compared to control group ($p = <0.001$) and the Tricuspid Annular Plane Systolic Excursion (TAPSE) was significantly reduced compared to control group ($p = <0.001$) which means that systolic function was impaired in inferior MI patient with RV involvement. These data are concordant with Fan *et al*.[19] evaluated right ventricular function by tissue doppler echocardiography and Tei index in right ventricular myocardial infarction and also concordant with Ondrus *et al*.[20] discussed the right ventricular myocardial infarction from pathophysiology to prognosis and RV was assessed using TAPSE in his study.

In this study, the peak early diastolic tricuspid annular velocity was reduced in patients and the early-to-late diastolic ratio of lateral and septal tricuspid annulus was significantly reduced in patients compared with healthy control group ($p = <0.001$) which might be an expression of diastolic asynchrony and of decreased RV diastolic function. The data go hand in hand with the data of Mukhaini *et al*.[21] who assessed right ventricular diastolic function by tissue doppler imaging in patients with acute right ventricular myocardial infarction.

In this study Tei index was significantly increased in patient group compared to control group ($p = <0.001$) which means that the global function of the RV was impaired and this is concordant with Fan *et al*.[19].

Receiver Operating Characteristics (ROC) revealed a high diagnostic significance of MPI and Sm RV. For MPI (Area under the curve was 0.91) with a cut off value >0.51 for a diagnosis of RVMI had a 83.3% sensitivity and a 80% specificity.

However, Hsiao *et al*.[22] studied the right ventricular infarction and tissue doppler imaging insights from acute inferior myocardial infarction after primary coronary intervention and found cut off value for RV-MPI was >0.41 and this may be explained by that the Right Ventricular Infarction (RVI) was defined as a culprit lesion proximal to the right ventricular branch of Right Coronary Artery (RCA) but in our study RVMI, based on ECG criteria.

For SmRV area under the curve was 0.90 with the cut off value was <13.5 cm sec^{-1} with sensitivity 83.3% and specificity 70%. These data were in agreement with Witt *et al*.[15] assessed tricuspid annular velocity by doppler tissue imaging as a marker of right ventricular involvement in the acute and late phase after a first ST elevation myocardial infarction and found that the cut off value for a tricuspid annular systolic velocity was <13 cm sec^{-1} with sensitivity and specificity for identifying patients with ST elevation in V4R were 89% and 71%, respectively but it had a higher cut off value as every patient was treated by primary PCI.

However, Zaborska *et al*.[23] assessed prognostic and diagnostic value of RV myocardial velocities in inferior myocardial infarction treated with primary PCI found that the ROC revealed a high diagnostic significance of SmRV (C-statistics = 0.90) and EmRV (C-statistics = 0.89). The SmRV was <12 cm sec^{-1} as a cut off for a diagnosis of RVMI with 89% sensitivity and a 83% specificity, whereas EmRV was <10 cm sec^{-1} with 81 and 80%, respectively. In this study inferior MI patients with RV involvement with inferior MI without RV involvement were compared.

A significant positive correlation was noted between RV fractional area change and TAPSE ($p<0.0001$) in inferior wall myocardial infarction and RVMI. Present data were concordant with Lopez-Candales *et al*.[24] found that right ventricular systolic function is not the sole determinant of tricuspid annular motion and that TAPSE is not only determined by RV systolic function but also appears to depend on LV systolic function.

In this study, angiography revealed that RCA was the IRA in 96.7% of RVMI patients and LCX was the IRA in 3.3% of RVMI patients. This is in concordance with Ondrus *et al*.[20]. This means that occlusion of the RCA proximal to the acute marginal branch suggest RVMI, while more proximal occlusions usually suggest more extensive necrosis of the posterior. In patients with left coronary artery dominance, a left circumflex coronary artery (LCX) occlusion may also be found.

In this study, it has been found that proximal RCA occlusion typically compromises RV branch perfusion in 56.7% of cases, resulting in RV ischemic dysfunction, whereas distal RCA occlusions rarely do that. These data go hand in hand with the data of Bowers *et al*.[25] studied the patterns of coronary compromise resulting in acute right ventricular ischemic dysfunction.

In this study complications occurred in only 26.7% in the form of arrhythmia, sinus bradycardia, Premature Ventricular Contractions (PVCs) and bigeminy, Ventricular Fibrillation (VF). Also Bowers *et al*.[26] studied the effect of reperfusion on biventricular function and survival after right ventricular infarction and observational studies had suggested that early reperfusion in inferior wall MI with RV infarction is beneficial. In patients with inferior wall myocardial infarction with RVMI, in whom PCI was successful, persistent hypotension and mortality were less compared to patients in whom PCI was unsuccessful.

Echocardiographic assessment should ideally be performed before any reperfusion strategy as there is a possibility of recovery of RV function. But it was considered unethical to delay reperfusion for echocardiographic assessment. In patients with atrial fibrillation and high-grade atrioventricular block it was difficult to assess myocardial infarction using pulsed doppler and tissue doppler imaging; therefore, the recordings in sinus rhythm were assessed in this study. Relatively, a small number of patients is included in this study.

CONCLUSION

Tissue Doppler Imaging (TDI) is a relatively new echocardiographic technique that uses doppler principles to measure the velocity of myocardial motion. This study revealed high diagnostic significance of myocardial performance index MPI and systolic myocardial velocity SmRV in predicting RVMI in inferior MI patients.

SIGNIFICANCE STATEMENTS

- The TDI is a sensitive tool in diagnosing RVI and also proved the return of right ventricular functions rapidly after PTCA
- This study revealed high diagnostic significance of myocardial performance index MPI and systolic myocardial velocity SmRV
- For MPI (Area under the curve was 0.91) with a cut off value >0.51 for a diagnosis of RVMI had a 83.3% sensitivity and a 80% specificity ($p<0.001$) for differentiation between patients with RVI and healthy control group
- For systolic myocardial velocity SmRV, a cut off value of 13.5 cm sec^{-1} yielded an area under the curve of 90% ($p<0.001$) for differentiation between patients with RVI and healthy control group with sensitivity 83.3% and specificity 70%
- Therefore, the MPI and Sm wave velocity of the tricuspid annulus could be used as a sensitive tool to diagnose RVI. Thus it can rely on both MPI and tricuspid annular peak systolic (S wave) to exclude RVI

REFRENCES

1. Gul, E.E., K.C. Nikus, O. Sonmez and M. Kayrak, 2011. Dilemma in predicting the infarct-related artery in acute inferior myocardial infarction: A case report and review of the literature. Cardiol. J., 18: 204-206.
2. Ninkovic, V.M., J.Z. Perunicic, S.M. Ninkovic, V.M. Miloradovic, G. Vojislav and D.G. Jakovljevic, 2013. Predictors of in-hospital mortality in patients with acute inferior infarction of the left ventricle accompanied by right ventricular infarction when treated with percutaneous coronary intervention. J. Clin. Exp. Cardiol., Vol. 4. 10.4172/2155-9880.1000253.
3. Kosuge, M., T. Ishikawa, S. Morita, T. Ebina and K. Hibi *et al*., 2009. Posterior wall involvement attenuates predictive value of ST-segment elevation in lead V4R for right ventricular involvement in inferior acute myocardial infarction. J. Cardiol., 54: 386-393.
4. Bleeker, G.B., P. Steendijk, E.R. Holman, C.M. Yu and O.A. Breithardt *et al*., 2006. Assessing right ventricular function: The role of echocardiography and complementary technologies. Heart, 92: i19-i26.
5. Chetboul, V., 2002. Tissue doppler imaging: A promising technique for quantifying regional myocardial function. J. Vet. Cardiol., 4: 7-12.
6. Ferrario, M., A. Poli, M. Previtali, L. Lanzarini and R. Fetiveau *et al*., 1994. Hemodynamics of volume loading compared with dobutamine in severe right ventricular infarction. Am. J. Cardiol., 74: 329-333.
7. Gulati, V.K., W.E. Katz, W.P. Follansbee and J. Gorcsan III, 1996. Mitral annular descent velocity by tissue Doppler echocardiography as an index of global left ventricular function. Am. J. Cardiol., 77: 979-984.
8. Nunez-Gil, I.J., M.D. Rubio, A.J. Carton, P. Lopez-Romero and L. Deiros *et al*., 2011. Determination of normalized values of the Tricuspid Annular Plane Systolic Excursion (TAPSE) in 405 Spanish children and adolescents. Revista Espanola Cardiologia, 64: 674-680.
9. Rudski, L.G., W.W. Lai, J. Afilalo, L. Hua and M.D. Handschumacher *et al*., 2010. Guidelines for the echocardiographic assessment of the right heart in adults: A report from the American Society of Echocardiography. J. Am. Soc. Echocardiogr., 23: 685-713.

10. Tei, C., K.S. Dujardin, D.O. Hodge, R.A. Kyle, A.J. Tajik and J.B. Seward, 1996. Doppler index combining systolic and diastolic myocardial performance: Clinical value in cardiac amyloidisis. J. Am. Coll. Cardiol., 28: 658-664.
11. Andersen, H.R., E. Falk and D. Nielsen, 1987. Right ventricular infarction: Frequency, size and topography in coronary heart disease: A prospective study comprising 107 consecutive autopsies from a coronary care unit. J. Am. Coll. Cardiol., 10: 1223-1232.
12. Dell'Italia, L.J., M.R. Starling, R.A. Walsh, F.R. Badke, J.C. Lasher and R. Blumhardt, 1985. Validation of attenuation-corrected equilibrium radionuclide angiographic determinations of right ventricular volume: Comparison with cast-validated biplane cineventriculography. Circulation, 72: 317-326.
13. Ghio, S., F. Recusani, C. Klersy, R. Sebastiani and M.L. Laudisa *et al*., 2000. Prognostic usefulness of the tricuspid annular plane systolic excursion in patients with congestive heart failure secondary to idiopathic or ischemic dilated cardiomyopathy. Am. J. Cardiol., 85: 837-842.
14. Karatasakis, G.T., L.A. Karagounis, P.A. Kalyvas, A. Manginas, G.D. Athanassopoulos, S.A. Aggelakas and D.V. Cokkinos, 1998. Prognostic significance of echocardiographically estimated right ventricular shortening in advanced heart failure. Am. J. Cardiol., 82: 329-334.
15. Witt, N., M. Alam, L. Svensson and B.A. Samad, 2010. Tricuspid annular velocity assessed by doppler tissue imaging as a marker of right ventricular involvement in the acute and late phase after a first ST elevation myocardial infarction. Echocardiography, 27: 139-145.
16. Kaul, S., C. Tei, J.M. Hopkins and P.M. Shah, 1984. Assessment of right ventricular function using two-dimensional echocardiography. Am. Heart J., 107: 526-531.
17. Meluzin, J., L. Spinarova, J. Bakala, J. Toman and J. Krejci *et al*., 2001. Pulsed Doppler tissue imaging of the velocity of tricuspid annular systolic motion. A new, rapid and non-invasive method of evaluating right ventricular systolic function. Eur. Heart J., 22: 340-348.
18. Kumar, N.S., M. Anwar, K.B. Mahendran and K.N. Kalaivanam, 2013. Significance of lipid profile estimation in patient with acute myocardial infarction. Int. J. Applied Biol. Pharmaceut. Technol., 4: 248-250.
19. Fan, Y., J.X. Shen, S.S. Yang, C.H. Xiu, L.F. Wang, F.H. Xue and Y.L. Huang, 2005. [Evaluation of right ventricular function by tissue Doppler echocardiography and Tei index in right ventricular myocardial infarction]. Zhonghua Nei Ke Za Zhi, 44: 180-183, (In Chinese).
20. Ondrus, T., J. Kanovsky, T. Novotny, I. Andrsova, J. Spinar and P. Kala, 2013. Right ventricular myocardial infarction: From pathophysiology to prognosis. Exp. Clin. Cardiol., 18: 27-30.
21. Mukhaini, M., P. Prashanth, S. Abdulrehman and M. Zadjali, 2010. Assessment of right ventricular diastolic function by tissue Doppler imaging in patients with acute right ventricular myocardial infarction. Echocardiography, 27: 539-543.
22. Hsiao, S.H., K.R. Chiou, W.C. Huang, C.C. Cheng and F.Y. Kuo *et al*., 2010. Right ventricular infarction and tissue Doppler imaging: Insights from acute inferior myocardial infarction after primary coronary intervention. Circ. J., 74: 2173-2180.
23. Zaborska, B., E. Makowska, E. Pilichowska, P. Maciejewski and B. Bednarz *et al*., 2011. The diagnostic and prognostic value of right ventricular myocardial velocities in inferior myocardial infarction treated with primary percutaneous intervention. Kardiologia Polska, 69: 1054-1061.
24. Lopez-Candales, A., N. Rajagopalan, N. Saxena, B. Gulyasy, K. Edelman and R. Bazaz, 2006. Right ventricular systolic function is not the sole determinant of tricuspid annular motion. Am. J. Cardiol., 98: 973-977.
25. Bowers, T.R., W.W. O'Neill, M. Pica and J.A. Goldstein, 2002. Patterns of coronary compromise resulting in acute right ventricular ischemic dysfunction. Circulation, 106: 1104-1109.
26. Bowers, T.R., W.W. O'Neill, C. Grines, M.C. Pica, R.D. Safian and J.A. Goldstein, 1998. Effect of reperfusion on biventricular function and survival after right ventricular infarction. N. Engl. J. Med., 338: 933-940.