



Right Ventricular Involvement in either Anterior or Inferior Myocardial Infarction

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ABSTRACT

Background: Unlike left ventricular function, less attention has been paid to Right Ventricular (RV) function after Myocardial Infarction (MI).

Objectives: The current study aimed to compare RV function in patients with inferior and anterior MI.

Patients and Methods: During the study period, 60 patients consecutively presented to the Emergency Department with chest pain were divided into two groups based on their electrocardiographic findings. Accordingly, 25 patients had inferior MI (IMI group) and 35 ones had anterior MI (AMI group). Echocardiography was performed 48 hours after starting the standard therapy. Conventional echocardiographic parameters and Tissue Doppler Imaging (TDI) measurements were acquired from the standard views. Student t-test and the chi-square test were respectively used for comparisons of the normally distributed continuous and categorical variables in the two groups. Besides, $P < 0.05$ was considered to be statistically significant.

Results: The ratio of early diastolic velocity of the tricuspid flow to early diastolic velocity of the tricuspid annulus in the lateral side (E/E') was significantly higher in the AMI group compared to the IMI group (6.73 ± 1.64 vs. 5.68 ± 1.32 , $P = 0.01$). In addition, abnormal E/E' ratio of the tricuspid valve was present in 27 (77%) and 14 (56%) patients in the anterior and inferior MI groups, respectively. Besides, the RV Tei index was significantly higher in the AMI group compared to the IMI group (0.65 ± 0.11 vs. 0.58 ± 0.13 , $P = 0.02$). Overall, 28 patients (80%) with anterior infarction and 12 patients (48%) with inferior infarction had abnormal RV Tei index. However, no significant difference was found between the two groups regarding other variables.

Conclusions: RV dysfunction commonly occurs after a first acute ST-elevation MI. However, RV functional changes are more pronounced in patients with anterior MI.

► Implication for health policy/practice/research/medical education:

This study showed that right ventricular dysfunction commonly occurs after a first acute ST-elevation myocardial infarction. However, right ventricular functional changes are more pronounced in patients with anterior MI.

1. Background

Assessment of Left Ventricular (LV) function using 2D echocardiography shortly after acute Myocardial Infarction (MI) is essential and one of the most important prognostic parameters. However, the association between Right Ventricular (RV) function and adverse events after acute

MI is poorly known, especially in patients with mild LV dysfunction (1).

Because of therapeutic implications, there has been growing interest in early recognition of RV infarction with non-invasive techniques. Zornoff et al. demonstrated that in patients with Left Ventricular Ejection Fraction (LVEF) $\leq 40\%$, RV function was a significant independent predictor of death and development of heart failure after an acute MI (2). Thus, quantitative assessment of RV function after MI should be noted.

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Up to now, most studies on RV function after MI have concentrated on patients with inferior infarction. Nearly 50% of patients with inferior infarcts and 10% or fewer patients with anterior infarcts show evidence of RV involvement (3, 4). Yet, inferior and anterior infarctions lead to quite different RV hemodynamic responses. Patients with inferior infarction, despite equivalent infarct size, are associated with a much lower mortality rate compared to those with anterior infarction. Therefore, the site of MI can predict the severity and extension of infarction. Furthermore, some investigators have reported RV dysfunction after inferior infarction, but not after anterior infarction (5), while others have found it in both groups (6).

2. Objectives

Due to these conflicting reports, the current study aims to compare the extent of RV dysfunction in patients admitted during the first acute ST-segment elevation inferior or anterior infarction.

3. Patients and Methods

3.1. Patient Selection

This study was conducted on 60 patients who had referred to the Emergency Department of Shahid Faghihi hospital (in Shiraz) with chest pain and were hospitalized with a diagnosis of acute MI for the first time from February to September 2013.

The subjects were divided into two groups based on Electrocardiographic (ECG) findings. Group I (Inferior Myocardial Infarction, IMI) consisted of 25 patients with ST-elevation in the inferior and posterior leads (II, III, aVF, V7, and V8) and group II (Anterior Myocardial Infarction, AMI) included 35 patients with ST-elevation in the precordial and lateral leads (V1-V6, aVL, and I). An echocardiography was performed 48 hours after the beginning of standard treatment, including Percutaneous Coronary Intervention (PCI) or fibrinolysis. Out of the 60 patients who met the inclusion criteria, 21 were treated by primary PCI (10 and 11 with inferior and anterior MI, respectively) and 39 were treated with streptokinase (15 and 24 with inferior and anterior MI, respectively).

This study was approved by the Review Board and Ethics Committee of Shiraz University of Medical Sciences. Written informed consents were also obtained from all the patients. The patients who had bundle branch block or any other intraventricular conduction delay and previous history of MI, valvular disease, heart failure, and pulmonary hypertension were excluded from the study.

3.2. Echocardiographic Evaluations

Standard 2-D transthoracic echocardiography and Tissue

Doppler Imaging (TDI) were performed for the patients in the left lateral decubitus position by Vivid 9 GE ultrasound system (Horten, Norway) according to the recommendation of the American Society of Echocardiography. Besides, LVEF was calculated using the biplane Simpson method (7). We sought to investigate the association between LVEF and other measured parameters.

Apical four-chamber view was used to obtain the conventional echocardiographic parameters and TDI measurements. RV minor dimension at the mid-ventricular level was measured in end-diastole. Care had to be taken to obtain a true non-foreshortened apical four-chamber view to achieve the maximum RV dimension. Right Atrial (RA) minor dimension was also measured in end-systole.

Tricuspid Annular Plane Systolic Excursion (TAPSE) was measured as an index of the global systolic function by placing M-mode cursor along the tricuspid valve annulus in apical four-chamber view. Moreover, pulsed Doppler RV diastolic indexes were measured in apical four-chamber view, placing the sample volume at the tip of the tricuspid valve. E and A velocities (m/s) and their ratio were determined, as well.

The myocardial performance index (Tei index), as a simple and reproducible index of combined evaluation of systolic and diastolic function that was first measured by Tei et al. in 1995, was calculated as: $(IVRT + IVCT)/ET$ (8) (Figure 1).

3.3. Statistical Analysis

The statistical analyses were performed using the SPSS statistical software (version 16.0, SPSS Inc., Chicago, IL, USA). First, the data were assessed for normality using Kolmogorov-Smirnov test. Then, continuous data were presented as mean \pm Standard Deviation (SD) and categorical data were presented as frequencies and percentages. Student t-test and chi-square test were respectively used for comparison of the normally distributed continuous and categorical variables in the two groups. Pearson's correlation coefficient was also employed to determine the strength of linear relationships between the study variables and LVEF. P value < 0.05 was considered to be statistically significant.

4. Results

This study was conducted on 60 patients, 25 in group 1 (IMI) and 35 in group 2 (AMI). The baseline characteristics of the patients have been listed in Table 1.

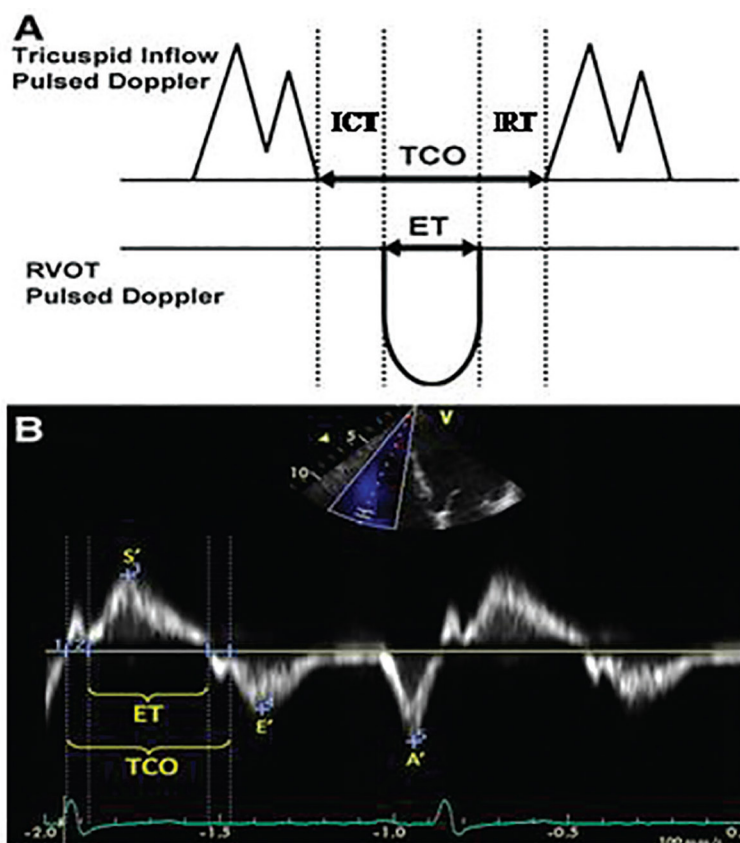
The indices measured by echocardiography have been presented in Table 2. Accordingly, LVEF was lower in the patients with anterior infarction, but the difference was not statistically significant. Also, no significant difference was observed between the patients with AMI and IMI regarding

Table 1. The Patients' Baseline Characteristics and Hemodynamic Values

	Inferior (n = 25)	Anterior (n = 35)	P value
Age (years)	60 \pm 10.2	59 \pm 12.9	0.55
Female/male	12/13	12/23	0.3
Blood pressure (mmHg)			
Systolic	118 \pm 7	117 \pm 9	0.75
Diastolic	74 \pm 6	73 \pm 6	0.59
Heart rate (beats/min)	80 \pm 7	78 \pm 7	0.39

The results have been expressed as mean \pm SD.

Figure 1. Calculation of Right Ventricular Myocardial Performance Index (Tei Index). Time Intervals Measured from Pulsed Tissue Doppler Were Obtained from the Lateral Tricuspid Annulus



Abbreviations: TCO = from the onset of isovolumic contraction to the onset of diastolic filling and ET = right ventricular ejection time. The sum of Isovolumic Contraction Time (ICT) and Isovolumic Relaxation Time (IRT) can be obtained by subtracting ET from TCO; MPI = (TCO - ET)/ET.

Table 2. Comparison of the Patients with Anterior and Inferior Infarction Regarding Right Ventricular Functions

	Inferior (n = 25)	Anterior (n = 35)	P value
RV end-diastolic diameter (mm)	29 ± 4	30.3 ± 4	0.30
RA size of minor axis (cm)	3.3 ± 0.5	3.3 ± 0.3	0.8
IVC size (cm)	1.5 ± 0.3	1.5 ± 0.3	0.7
E/A ratio of tricuspid	1.24 ± 0.44	1.23 ± 0.55	0.88
E/E' ratio of tricuspid	5.68 ± 1.32	6.73 ± 1.64	0.01
E' of annulus of tricuspid (cm/s)	7.76 ± 1.78	7.54 ± 2.22	0.68
Tricuspid annular systolic excursion, TAPSE (mm)	17.4 ± 2	17.3 ± 1.7	0.90
Lateral tricuspid annular systolic velocity, S' (cm/s)	9.48 ± 1.66	9.54 ± 2.74	0.91
RV Tei index	0.58 ± 0.13	0.65 ± 0.11	0.02
VTI S' lateral tricuspid annular systolic wave	1.78 ± 0.39	1.65 ± 0.44	0.24
LVEF (%)	41 ± 8	37 ± 6	0.10

Abbreviations: LVEF, left ventricular ejection fraction; RV, right ventricle; RA, right atrium; IVC, inferior vena cava
The data have been presented as mean ± SD.

RV and RA diameters. RV involvement occurred in up to 50% of the patients with acute MI.

Considering the parameters of RV function, no significant differences were found between the anterior and inferior infarction groups regarding the measurements of E/A ratio of the tricuspid valve, TAPSE, and S' velocity. However, TDI showed that the patients with anterior infarction had a significantly higher mean E/E' ratio in comparison to those with inferior infarction (6.73 ± 1.64 vs. 5.68 ± 1.32, p = 0.01). E/E' > 6 was found in 27 out of the 35 patients with anterior

infarction (77%). The RV Tei index was also significantly higher in the anterior infarction group compared to the inferior infarction group (P = 0.02).

The results showed a significant positive correlation between LVEF and E/E' of tricuspid inflow (r = 0.2, P = 0.04), lateral tricuspid annular systolic velocity or S' (r = 0.30, P = 0.01), VTI S' of the lateral tricuspid annular systolic wave (r = 0.28, P = 0.02), and TAPSE (r = 0.39, P = 0.002). Also, a significant negative correlation was found between EF and Inferior Vena Cava (IVC) size (r = -0.27,

P = 0.03).

5. Discussion

The results of the current study demonstrated that both anterior and inferior infarction had marked effects on RV function. RV systolic and diastolic function indices were clearly impaired in such large number of subjects with MI. Although no significant differences were observed between the two groups regarding the measurements of most RV function indices, E/E' ratio of the tricuspid inflow, as an index of RV diastolic function, and RV Tei index by TDI, as a measure of global RV performance, were significantly higher in the patients with anterior infarction compared to those with inferior infarction. The study also revealed that LVEF decline, irrespective of the site of MI, was strongly associated with RV involvement. In agreement with this result, Hsu et al. showed that RV function might be affected discrepantly by the infarction site in patients with a first acute ST-elevation MI without concomitant RV infarction. Additionally, only regional RV diastolic dysfunction was observed in patients with inferior infarction, whereas depressed global RV function was present in those with anterior infarction (9). Jensen et al. also revealed RV involvement in 47% of patients with inferior infarction and 65% of those with anterior infarction via cardiac Magnetic Resonance Imaging (MRI) (10).

Considering RV involvement in MI and its high mortality, more attention should be paid to detection of RV function in acute MI (4). The results of a study suggested that RV function provided important information for prognosis after MI in patients treated with primary PCI and relatively preserved LV function (1). Besides, another study on 423 patients with normal LV function revealed that reduced RVEF had a mild relationship with one-year mortality (11). In contrast, in a study on 416 patients with LV dysfunction, RV function independently predicted cardiovascular mortality (2). These results show that changes in RV function subsequent to MI are closely related to LV alterations. However, in a meta-analysis conducted by Mehta et al., RV dysfunction in inferior infarction was not correlated to the extent of LV myocardial damage (11).

In addition to RVEF, RV Tei index and systolic and diastolic tricuspid annular velocities are other indices used in assessment of RV function. RV Tei index is important in assessment of global RV performance and estimates RVEF with good accuracy (11). It usually increases in the presence of RV systolic or diastolic dysfunction (12). A higher value of this index in patients with ST-elevation MI is associated with more adverse outcomes (13). The results given in the present paper correspond to the clinical study by Moller et al., which demonstrated that an abnormal RV Tei index was present in 80% of patients with MI (13). Ozturk et al. also found a significant increase in this index after anterior ST-elevation MI (14). In that study, the alteration of RV Tei index was more pronounced in patients with anterior MI. Similar to our study, the findings of the study by Hsu et al. revealed that RV Tei index was significantly higher in anterior MI than in inferior MI (9). In the research by Sonmez et al., both systolic and diastolic functions were affected after anterior ST-elevation MI. They also found a

significant increase in RV Tei index, as an important factor affecting prognosis, after anterior MI (15).

In the recent studies, the tricuspid E/E' ratio and diastolic strain rate have been commonly used to evaluate RV diastolic function. These studies indicated a strong relationship between the tricuspid E/E' ratio and RA volume, and hemodynamic parameters (16). The value of the tricuspid E/E' ratio, as a reliable estimate of RV filling pressure, predicts cardiac events and elevated mean arterial pressure (17). An E/E' ratio greater than 6 had a high sensitivity and specificity in detecting the mean RA pressure ≥ 10 mm Hg (18). The results of the current study showed E/E' > 6 in 77% and 56% of the patients with anterior and inferior MI, respectively. Additionally, the E/E' ratio was significantly higher in anterior infarction. In the research by Hsu et al., E/E' ratio was comparable between anterior and inferior infarction, whereas it was higher in anterior infarction compared to the controls (9). Akdemir et al. also demonstrated that TAPSE, as an indicator of RV function, was lower in patients with acute anterior MI than in the control group in the absence of apparent systolic dysfunction. This was attributed to RV diastolic dysfunction (17).

In conclusion, the present study suggested that RV function was extremely affected in the patients with a first acute ST-elevation MI. Besides, RV involvement was more pronounced in anterior MI than in inferior MI. Moreover, LVEF decline, irrespective of the site of infarction, affected RV function.

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Authors' Contribution

Study concept and design: Firoozeh Abtahi, Acquisition of data: Mahkameh Farmanesh, Analysis and interpretation of data: Alireza Moaref and Shahnaz Shekarforoush, Drafting of the manuscript: Firoozeh Abtahi and Shahnaz Shekarforoush, Critical revision of the manuscript for important intellectual content: Firoozeh Abtahi and Shahnaz Shekarforoush, Statistical analysis: Shahnaz Shekarforoush, Administrative, technical, and material support: Alireza Moaref, Study supervision: Firoozeh Abtahi

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