Original Article

Right Ventricular Function Assessment according to the Primary Percutaneous Coronary Intervention Methods (primary PCI, rescue PCI or PCI in thrombolysis Responders), Following Acute Anterior ST-Segment Elevation Myocardial Infarction

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Abstract

Introduction: The incidence of acute myocardial infarction (AMI) is high in Iran. AMI treatment is performed by thrombolysis or percutaneous coronary intervention (PCI). In cases of thrombolysis failure, rescue PCI is performed. It is hypothesized that right ventricular function is affected by AMI and might be a predictor of prognosis in AMI. The aim of this study was to compare right ventricular (RV) function in anterior AMI patients undergoing the three different treatment modalities. **Materials and methods:** This prospective cohort study was conducted on AMI patients who were referred to two tertiary hospitals in 2019 Iran. All subjects underwent echocardiography. Demographic characteristics as well as past medical history and echocardiographic findings were collected in a checklist. Data was analyzed by SPSS software version 23 using chi-square, ANOVA and Kruskal-Wallis. **Results:** A total of 70 subjects were recruited in this study (30 in primary PCI, 20 in rescue PCI,20 in thrombolysis responders). The mean age of the subjects was 54.89 ± 12.09 years old. There was no significant difference between treatment modalities in terms of age, sex, past medical history and smoking ($p>0.05$). Only a significant difference was observed in left ventricular end diastolic diameter (LVEDD) ($p=0.035$), RV fractional area change (FAC) ($p=0.031$) and right atrial volume (RAV) index between treatment groups. LVEDD was significantly higher in rescue PCI group compared to primary PCI group and FAC was significantly lower in rescue PCI group compared to thrombolysis responders and primary PCI groups and RAV index was significantly higher in rescue PCI group compared to the primary PCI. **Conclusions:** Right ventricular function is impaired to a greater extent in rescue PCI group. There is a need for further studies to evaluate these findings.

Keywords: Thrombolytic therapy; Percutaneous coronary intervention; Anterior wall myocardial infarction; Right ventricular function

Introduction

The incidence of non-communicable diseases is increasing worldwide [1]. Cardiovascular diseases, which may result in myocardial infarction are among the common non-communicable diseases [2]. Acute myocardial infarction is caused by the reduced coronary blood flow due to vascular occlusion as a result of thrombus formation after the rupture of an atherosclerotic plaque [3]. This procedure may result in reduced or complete breakdown of blood flow to regions in myocardium [3].

In the United states, every 42 seconds an acute myocardial infarction (AMI) occurs [4]. Although the trend of AMI has declined in developed countries like the members of the

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European Union over the past 25 years [5], the incidence of AMI and its resultant morbidity and mortality is either increasing or is reduced to a smaller amount in developing countries [6-8]. The incidence of AMI in Iran was reported to be 73.3 per 100000 based on a systematic review [9]. Based on the systematic review by Mohseni et al. (2017) the highest prevalence of AMI was reported in North Khorasan province (152.5 per 100000) and the lowest prevalence from Qom province (24.5 per 100000) [9]. These figures indicate a high prevalence of AMI among Iranian population.

The first line in the treatment of AMI is to improve or reestablish myocardial blood flow, which is currently undergone using two major methods; thrombolysis and primary percutaneous coronary intervention (PCI) [10]. These methods have resulted in an acceptable success rate [10]. Though, there is a possibility that thrombolytic administration fails to reestablish adequate myocardial blood flow [10]. In this case, patients might undergo rescue PCI [11, 12]. Different methods are being used to assess the prognosis after AMI, including two-dimensional echocardiography [13]. Although previous studies have shown that the right ventricle (RV) function can be a predictor of AMI prognosis after primary treatment [14-17], there is scarcity of data regarding the comparison of RV function in patients with AMI who were treated with primary PCI, rescue PCI and successful thrombolysis. Therefore, the aim of this study was to compare RV function between treatment different methods (primary PCI, rescue PCI and successful thrombolysis) in anterior ST elevated AMI patients.

Materials and Methods

This prospective cohort study was conducted on AMI patients who were referred to two tertiary hospitals in Mashhad, Iran from 2019 to 2020. This study was approved by the Ethical Committee of the Mashhad University of Medical Sciences (Reg. Code: IR.MUMS.MEDICAL.REC.1397.565). All patients signed the informed consent form prior to participation in the study. Since no similar study has yet been published, this pilot study was performed on AMI patients with the minimum number of 20-30 in each treatment group.

Inclusion criteria were being diagnosed with anterior ST elevation AMI (isolated involvement of the proximal and medial sections of the left anterior descending artery), normal sinus rhythm and having favorable echocardiographic image record. Subjects were excluded if they had previous history for cardiac diseases, moderate to high tricuspid insufficiency, tricuspid stenosis or high pulmonary artery pressure (PAP > 50 mmHg).

Patients were divided into three groups based on the treatment they received, including primary PCI, thrombolysis responders and rescue PCI. Rescue PCI patients included patients with AMI who received thrombolytic medications but failed to achieve myocardial blood flow diagnosed by electrocardiography and clinical symptoms. Echocardiographic assessment was performed for all patients 3 to 5 days after treatment. Transthoracic echocardiography was done using Siemens ACUSON SC2000 Ultrasound System with 4V1c Transducer (Frequency Bandwidth: 1.25 – 4.5 MHz). Demographic data, including age, gender, history for diabetes mellitus, hypertension, hyperlipidemia and smoking history, as well as the New York Heart Association (NYHA) Function class and echocardiographic parameters were collected in a researcher made checklist. All echocardiographic measurements were made in accordance with the current American Society of Echocardiography guideline recommendations [18]. The echocardiographic parameters included ejection fraction (EF), left ventricular end diastolic diameter (LVEDD), left ventricular end systolic diameter (LESD), left ventricular end diastolic volume (LVEDV) left ventricular end systolic volume (LVESV), left atrial volume (LAV) index, Right atrial volume (RAV) index, E, A, DT (TV inflow), E/A, Em/Am, E/Em, Em, Sm, Right ventricular fractional atrial change (FAC), Mid right ventricular diameter (RVD), tricuspid annular plane systolic excursion (TAPSE), peak systolic annular velocity (STV), PAP and Tei index.

TAPSE was categorized into normal and abnormal based on the cut-off value of 1.7 cm, while FAC was categorized into normal and abnormal based on the cut-off value of 35%. RV function was assessed based on the TAPSE and FAC criteria. Abnormal RV function was defined as having at least one abnormal criterion (FAC<35% or TAPSE<1.7 cm), while subjects with no abnormal criterion were considered to have normal RV function [19, 20].

Statistical analysis

Data was analyzed using the statistical package for social sciences (SPSS) software (IBM, Inc, Chicago, Il, USA) version 23. Mean and standard deviation (SD) were used for normally distributed data while median and interquartile range (IQR) were used for non-normally distributed data. Frequency and percentage were used for categorical data description. Comparison of the continuous variables between treatment groups was performed using the one-way analysis of variance (ANOVA) for normally distributed variables and the Kruskal-Wallis test for non-normally distributed variables. The Tukey test was used as post hoc test for one-way ANOVA. Comparison of continuous variables was also conducted between primary and rescue PCI groups using the independent t-test or Mann-Whitney test. Comparison of the distribution pattern of categorical variables between treatment groups was performed using the chi-square or Fisher exact test. The level of statistical significance was considered as $p<0.05$.

Results

A total of 70 subjects were evaluated. The mean age of the subjects was 54.89 ± 12.09 years old. Majority of the subjects (72.9%) were males. The prevalence of hypertension among the study subjects was (38.6%) while diabetes mellitus was reported in 15 (21.4%) of the subjects. Eighteen subjects

(25.7%) were smokers. Primary PCI was performed for 30 (42.9%) of the subjects while thrombolysis responders and rescue PCI each comprised 20 (28.6%) of the subjects. The median and IQR for age were 53.00 (22.00) years old in primary PCI, 59.00 (13.75) years old in thrombolysis and 50.00 (10.75) years old in rescue PCI group. There was no significant difference between treatment groups in terms of age (p=0.109). Among the primary PCI group 23 (76.7%) were male and 7 (23.3%) were female. Among the subjects in thrombolysis and rescue PCI groups 14 (70.0%) were male and 6 (30.0%) were female. There was no significant association between gender and treatment group based on chi-square test (p=0.825). Description and comparison of the distribution patterns of hypertension, diabetes mellitus, hyperlipidemia and smoking as well as NYHA class is presented in Table 1. There was no significant difference between treatment groups in terms of the distribution pattern of hypertension, hyperlipidemia, diabetes mellitus and smoking. There was no association between NYHA class and treatment groups (p=0.571).

Echocardiographic findings of the subjects based on the treatment group are presented in Table 2. There was a significant difference in LVEDD (p=0.035), FAC (p=0.031) and RAV index between treatment groups (Table 2). The Tukey HSD revealed a significant difference in LVEDD (p=0.049) and FAC (p=0.019) between primary PCI and rescue PCI groups and a significant difference in RAV index between rescue PCI and both primary PCI (p=0.044) and successful thrombolysis groups (p=0.028).

The distribution pattern of FAC, TAPSE and RV function categories among treatment groups are presented and compared in Table 4. There was no significant difference between treatment groups in terms of the distribution pattern of TAPSE and RV function (p=0.916 and p=0.207 respectively) but there was a significant difference in the distribution pattern of FAC categories between treatment groups (p=0.007). Among the treatment groups, there was a significant distribution difference in FAC between primary PCI and rescue PCI group (p=0.002).

Discussion

The findings of our study revealed that majority of cases were males 72.9%. This finding was in line with the findings of the previous studies that reported a higher prevalence of AMI among men [4, 7, 9, 21].

The findings of our study revealed that the observed mean FAC was within the normal rage (> 35%) [22]. The mean RAV index was previously reported in patients with normal systolic and diastolic volume index to be 18 ml/m^2 and 15 ml/m^2 respectively [23]. Therefore, in our study groups only the mean RAV index in the rescue PCI group exceeded the reference values. This indicates that in our study right atrial volume was more affected in rescue PCI patients. On the other hand, since none of the subjects in our study had sever tricuspid insufficiency or stenosis, the observed higher RAV index might be reliable predictor for right ventricular function. Therefore, it could be inferred that the right ventricular function was affected in AMI subjects in our study. It was previously shown that right ventricular function is affected by anterior AMI [24, 25].

The findings of our study revealed that among the echocardiographic variables LVEDD, FAC and RAV index were significantly different between treatment groups. These findings indicate that LVEDD was significantly higher in rescue PCI group compared to primary PCI group and FAC was significantly lower in rescue PCI group compared to thrombolysis responders and primary PCI groups and RAV index was significantly higher in rescue PCI group compared to the primary PCI. To the best of our knowledge no study has yet compared right ventricular function between treatment modalities of AMI. Therefore, we here discuss the findings of separate studies on each modality in relation to the findings of our study. In a study on 40 anterior AMI patients who underwent primary PCI in Cairo, Egypt, the mean FAC was reported to be 45% [26]. This finding was in line with the observed findings of our study in the primary PCI group. In another study on 40 ST elevation AMI patients who were treated with thrombolysis, the mean FAC was reported to be 37.5% which was close to the findings of our study in the thrombolysis responder group (42%) [27]. In contrast to the observed value of FAC (36%) in our study, a previous study on 28 patients AMI who underwent rescue PCI had FAC of 29.6% [28]. A possible reason for this difference might be the differences in the sample sizes between the studies. Although the values of FAC in our study is not below the cut of value, but both values including our data and aforementioned study are considered low. These findings indicate that there is a tendency for rescue PCI patients to have lower FAC levels and thus worse right ventricular function in comparison to primary PCI and thrombolysis responders. This finding might be due to the patient condition as they were primarily candidate for thrombolysis, the severity of the condition might be different from the primary PCI group, and as the medication failed to improve blood flow, their benefit from a rescue PCI was also unfavorable.

In this study there was no significant difference in the distribution pattern of RV dysfunction between study groups, based on the criteria we used for classification of the RV dysfunction. The findings of this study revealed that among the RV function criteria, FAC was the only parameter that was significantly different between groups. In a previous study that compared RV function between primary PCI and rescue PCI patients, also revealed no significant difference in TAPSE between groups [29]. This finding might be due to the effect of anterior MI on interventricular septum and apex, which results in prominent changes in FAC rather than TAPSE, which is evaluated RV function, longitudinally rather than circumferentially.

To the best of our knowledge there isn`t any studies compared three modalities in AMI patients. So, the strength of this study was the inclusion and comparison of the three main types of AMI treatment modalities. One of the limitations of this study was the short follow up period. It is recommended for further researchers to compare the long-term changes in heart function with the emphasis on right ventricular function among different AMI treatment modalities. Another limitation of this study was the small number of subjects in each group. Inclusion of more subjects was not possible due to the time limits and the prospective design of the study. It is recommended for further researchers to perform larger longitudinal or retrospective cohorts to access larger number of subjects.

Conclusion

The findings of this study revealed that the right ventricular function is affected after AMI treatment especially in rescue PCI group. There is a need for larger studies to draw a solid conclusion.

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Conflict of interest

None to be declared.

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Table 1. Comparison of demographic variables and functional class groups between treatment groups

Variable		Total N=70	Primary PCI n=30	Rescue PCI n=20	Thrombolysis responders n=20	p
Hypertension		27 (38.6%)	13 (43.3%)	5 (25.0%)	9 (45.0%)	0.334
Diabetes mellitus		15 (21.4%)	7 (23.3%)	4 (20.0%)	4 (20.0%)	0.945
Hyperlipidemia		21 (30.0%)	11 (36.7%)	4 (20.0%)	6 (30.0%)	0.452
Smoking		18 (25.7%)	8 (26.7%)	4 (20.0%)	6 (30.0%)	0.760
NYHA class	I	52 (74.3%)	22 (73.3%)	13 (65.0%)	17 (85.0%)	0.571
	II	14 (20.0%)	7 (23.3%)	5 (25.0%)	2 (10.0%)	
	III	4 (5.7%)	1 (3.3%)	2 (10.0%)	1 (5.0%)	

NYHA: New York heart association functional class
The chi-square test was used for the comparison except for NYHA class where the Monte Carlo test was used.

Table 2. Comparison of the echocardiographic findings of the study subjects between treatment groups

Variable	Total N=70	Primary PCI n=30	Rescue PCI n=20	Thrombolysis responders n=20	p
LVEDD (mm)	4.90±0.47	4.74±0.39[a]	5.05±0.54[a]	5.00±0.45	0.035*
LVESD (mm)	3.13±0.61	2.95±0.59	3.34±0.58	3.25 (1.25)†	0.074
LVEDV (cm^3)	105.21±29.38	100.20±23.20	110.80±28.80	107.15±37.53	0.437
LVESV (cm^3)	55.66±19.67	52.43±16.33	57.35±18.93	58.80±24.71	0.488
EF (%)	39.16±9.47	40.00 (10.50)†	32.50 (12.25)†	35.50 (17.50)†	0.450
LAV index (ml/m^2)	30.61±10.22	28.12±8.88	31.47±9.91	29.58 (18.28)	0.093
E (LV) (cm/s)	60.36±17.01	60.07±17.30	60.00 (27.5)	60.65±13.97	0.911
A (LV) (cm/s)	68.29±18.91	67.27±17.18	74.75±21.65	63.35±17.56	0.151
E/A (LV)	0.93±0.37	0.85 (0.52)†	0.83±0.27	0.82 (0.38)†	0.515
DT (LV) (ms)	179.59±64.78	175.00 (41.25)†	180 (78.75)†	157.50 (61.00)†	0.214
Em (LV) (cm/s)	6.70±1.93	6.35 (3.00)†	6.04±1.65	7.25 (2.00)†	0.159
Sm (LV) (cm/s)	6.47±1.44	6.00 (1.25)†	6.23±1.52	6.75±1.55	0.516
FAC (%)	0.41±0.12	0.45±0.12[b]	0.36±0.10[b]	0.42±0.12	0.031**
RVD (cm)	2.82±0.34	2.78±0.30	2.90±0.31	2.80±0.43	0.439
TAPSE (cm)	1.85 (0.42)†	1.80 (0.49)†	1.80 (0.40)†	1.97±0.41	0.719
STV (cm/s)	12.22±2.51	12.07±1.82	12.20±3.35	12.00 (2.75)†	0.912
E (RV) (cm/s)	42.76±10.66	40.93±11.41	44.50±10.64	42.50 (11.5)†	0.452
A (RV) (cm/s)	41.26±10.85	40 .00 (12.50)†	40.40±9.83	45.15±14.11	0.154
E/A (RV)	1.09±0.38	1.08±0.36	1.10 (0.43)†	1.00 (0.24)†	0.995
DT (RV) (ms)	260.09±76.99	270.33±75.31	256.05±69.05	220.00 (156.25)†	0.410
e′(RV) (cm/sec)	9.58±2.97	9.47±2.79	9.50±2.76	9.85±4.50	0.897
a′(RV) (cm/sec)	15.04±4.96	14.57±4.59	16.15±6.26	14.65±4.02	0.735
e′/a′(RV)	0.64 (0.30)†	0.64 (0.28)†	0.62 (0.34)†	0.66±0.13	0.704
PAP (mmHg)	24.99±6.57	22.00 (6.25)†	25.00 (6.75)†	22.50 (10.00)†	0.586
Tei index(RV) Or MPI	0.61±0.28	0.57±0.29	0.60±0.18	0.62 (0.40)†	0.846
RAV index (ml/m^2)	17.00±5.80	16.08±5.80[c]	20.01±5.95[cd]	15.39±4.68[d]	0.015*
E/e′(RV)	4.88±2.05	4.14 (2.98)†	4.31 (2.38)†	4.92±1.85	0.810
LVESV (BSA) ml/m2	30.95±10.59	29.26±8.83	32.00±10.00	32.43±13.35	0.517

LVEDV (BSA) ml/m2	58.55±14.87	55.93±11.02	61.94±14.39	59.08±19.68	0.373

LVEDD: left ventricular end diastolic dysfunction, EF: ejection fraction, LVESD: left ventricular end systolic dysfunction, LVEDV: left ventricular end diastolic volume, LVESV: left ventricular end systolic volume, LAV: left atrial volume, RAV: Right atrial volume, FAC: fractional atrial change, RVD: right ventricular diameter, TAPSE: tricuspid annular plane systolic excursion, STV: segmental thickness variability, PAP: pulmonary artery pressure, DT: deceleration time, E: early diastolic mitral flow, A: transmitral flow velocity with atrial contraction, MPI:myocardial performance index

† Median and interquartile range were used due to the non-normal distribution; therefore, the Kruskal-Wallis test was used for the comparison and Mann-Whitney test was used for pairwise comparison. The one-way ANOVA was used for other variables.

Post hoc test results: significant difference between groups are defined using superscript letters. [a] p=0.049, [b] p=0.019, [c] p=0.044, [d] p=0.028

Table 3. Comparison of the echocardiographic findings of the study subjects between primary PCI and rescue PCI groups

Variable	Primary PCI n=30	Rescue PCI n=20	p
LVEDD (mm)	4.74±0.39	5.05±0.54	0.034*
LVESD (mm)	2.95±0.59	3.34±0.58	0.028*
LVEDV (mm)	100.20±23.20	110.80±28.80	0.157
LVESV (mm)	52.43±16.33	57.35±18.93	0.333
EF (%)	40.00 (10.50)†	32.50 (12.25)†	0.072
LAV index (ml/m^2)	28.12±8.88	31.47±9.91	0.219
E (LV) (cm/s)	60.07±17.30	60.00 (27.5)	0.921
A (LV) (cm/s)	67.27±17.18	74.75±21.65	0.181
E/A (LV)	0.85 (0.52)†	0.83±0.27	0.469
DT (LV) (ms)	175.00 (41.25)†	180 (78.75)†	0.350
Em (LV) (cm/s)	6.35 (3.00)†	6.04±1.65	0.233
Sm (LV) (cm/s)	6.00 (1.25)†	6.23±1.52	0.655
FAC (%)	0.45±0.12	0.36±0.10	0.008**
RVD (cm)	2.78±0.30	2.90±0.31	0.165
TAPSE (cm)	1.80 (0.49)†	1.80 (0.40)†	0.603
STV (cm/s)	12.07±1.82	12.20±3.35	0.872
E (RV) (cm/s)	40.93±11.41	44.50±10.64	0.272
A (RV) (cm/s)	40 .00 (12.50)†	40.40±9.83	0.675
E/A (RV)	1.08±0.36	1.10 (0.43)†	0.663
DT (RV) (ms)	270.33±75.31	256.05±69.05	0.501
e′(RV) (cm/sec)	9.47±2.79	9.50±2.76	0.967
a′(RV) (cm/sec)	14.57±4.59	16.15±6.26	0.339
e′/a′(RV)	0.64 (0.28)†	0.62 (0.34)†	0.526
PAP (mmHg)	22.00 (6.25)†	25.00 (6.75)†	0.327
Tei INDEX OR MPI (RV)	0.57±0.29	0.60±0.18	0.589
RAV index (ml/m^2)	16.08±5.80	20.01±5.95	0.024*
E/e′(RV)	4.14 (2.98)†	4.31 (2.38)†	0.494
LVESV (BSA) (mm)	29.26±8.83	32.00±10.00	0.315
LVEDV (BSA) (mm)	55.93±11.02	61.94±14.39	0.101

LVEDD: left ventricular end diastolic dysfunction, EF: ejection fraction, LVESD: left ventricular end systolic dysfunction, LVEDV: left ventricular end diastolic volume, LVESV: left ventricular end systolic volume, LAV: left atrial volume, RAV: Right atrial volume, FAC: fractional atrial change, RVD: right ventricular diameter, TAPSE: tricuspid annular plane systolic excursion, STV: segmental thickness variability, PAP: pulmonary artery pressure

† Median and interquartile range were used due to the non-normal distribution and the Mann-Whitney test was used for the comparison; therefore, the Mann-Whitney test was used for the comparison. Other variables were compared using independent t-test.

Table 4. Comparison of the distribution pattern of TAPSE, FAC and RV function among treatment groups

Variable		Primary PCI n=30	Rescue PCI n=20	Thrombolysis responders n=20	p
TAPSE	Normal	21 (70.0%)	14 (70.0%)	15 (75.0%)	0.916
	Abnormal	9 (30.0%)	6 (30.0%)	5 (25.0%)	
FAC	Normal	25 (83.3%)	8 (40.0%)	12 (60.0%)	0.007**
	Abnormal	5 (16.7%)	12 (60.0%)	8 (40.0%)	
RV function	Normal	18 (60.0%)	7 (35.0%)	9 (45.0%)	0.207
	Abnormal	12 (40.0%)	13 (65.0%)	11 (55.0%)	

TAPSE: tricuspid annular plane systolic excursion, FAC: fractional atrial change, RV: right ventricle
The chi-square test was used for the comparison.
** Significant at α=0.01