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Echocardiographic evaluation of post MI patients with consistent ST segment elevation who underwent angiography: a follow up study

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Abstract

Introduction: Percutaneous coronary intervention (PCI) is an accepted method of reperfusion in patients with acute ST-segment elevation myocardial infarction (STEMI). Establishing coronary blood flow during angiography does not always result in the proper coronary circulation. There are many factors related to patient outcomes after PCI. ST-segment resolution (STSR) is one of these factors that can be achieved noninvasively and indicates reperfusion. However, the relationship between STSR and echocardiographic findings has not been widely studied. The present study aims to evaluate electrocardiogram (ECG) and echocardiography findings in post-STEMI patients undergoing PCI.

Materials and Methods: A total of 340 patients who had STEMI and underwent successful PCI were selected by convenience sampling and participated in this follow-up study. After considering the exclusion criteria, 12-lead ECG was performed on each patient within 60 min, 90 min, 120 min, 24 h, and 2 months after PCI. Additionally, a transthoracic echocardiogram (TTE) was performed after PCI, and 2 additional ones were performed at 24 h and 2 months post-PCI. ST-segment resolution was evaluated in every ECG and the results were compared with the TTE findings.

Results: The mean±SD for the time duration between the onset of symptoms and calling EMS, the door-to-balloon time, and the time duration between the first medical staff visit and angioplasty were 114.4±56.63 min, 35.58±4.43 min, and 60.58±4.43 min, respectively. Ejection fraction and end-systolic volume in patients with ST-segment resolution greater than 30% at 60 min, 90 min, 120 min, and 24 h after PCI were significantly higher than those with resolution lower than 30%. This finding was not observed two months after PCI.

Conclusion: While delays in managing patients with STEMI had favorable outcomes in our center despite similar studies, attempts should be made to reduce these delays. STSR greater than 30% at 90 and 120 min after successful PCI is significantly related to higher ejection fractions and lower end-systolic volumes in patients with STEMI. The patients are more likely to have low ejection fractions and high end-systolic volumes if the STSR occurs after 24 hours.

Keywords: Echocardiography, Electrocardiography, Myocardial infarction, Percutaneous coronary intervention

1. Introduction

Cardiovascular disease is the leading cause of mortality worldwide. The mortality rate has increased 40.8% from 1990 to 2013 despite the decrease in deaths attributed to epidemiologic changes (1) Myocardial infarction (MI) is a severe manifestation of some cardiovascular diseases (2). The end feature of MI is myocyte necrosis, which will lead to ventricular function disruption (3). Chronic total occlusion usually occurs in patients with ST-segment elevation MI (STEMI) and reperfusion needs to be established within 60 to 90 min (3). Preliminary results of successful angiography improved left ventricular function and increased patient survival. While there are some non-invasive markers are suggested for assessing reperfusion, these results are more comparable to those of angiography (4, 5). Primary angioplasty mostly leads to early and complete reperfusion; however, reopening of the coronary arteries does not always indicate successful reperfusion (4-6). An angiographic snapshot of blood flow through the infarcted myocardium fails to guarantee coronary microvasculature remains intact later (7). Electrocardiography (ECG) is an inexpensive and widely used technique for determining reperfusion injury that requires more attention from researchers (8). Myocardial perfusion defects, which are predictable using ECG, significantly defer from angiographic findings of thrombolysis in myocardial infarction (TIMI) grade 3 flow in an infarct-related artery. This fact challenges the notion that TIMI grade 3 flow is a sufficient indicator of reperfusion. Approximately one-third of acute MI patients show impaired microvascular reperfusion after successful recanalization (8). Persistent ST-segment elevation is thought to be related to sustained transmural injury shortly after successful recanalization (8). The resolution is correlated with restoring blood flow and myocyte function. ST-segment resolution (STSR) is related to the mortality rate of patients in addition to determining reperfusion (9). STSR is thought to be related to ejection fraction; however, this concept has not been widely studied. Hallen et al. recently reported that left ventricular ejection fraction is only related to the sum of STSR within 90 min after PCI (10). STSR is related to cardiac ejection fraction at different times. The present research attempts to find a relationship between STSR after successful PCI of STEMI patients and their echocardiographic features as an indicator of global myocardial performance index.

2. Materials and methods

This follow-up study was approved by the Research Ethics Committee of Mashhad University of Medical Sciences and conducted on patients referred to the cardiology unit of Ghaem Hospital in Mashhad, Iran. Patients suspected of having STEMI were chosen by convenience sampling. Exclusion criteria for patients were as follows: chest pain more than 12 hours before admission; severe renal insufficiency; angioplasty results other than TIMI 3, cardiopulmonary resuscitation before angioplasty; a history of open-heart surgery or angioplasty; and a previous history of MI, heart failure, or severe concomitant valvular disease.

Eachpatientunderwent PCIandacardiologistevaluated infarct-related artery flow after performing transthoracic echocardiography. The PCI response was evaluated by ECG at 60 min, 90 min, 120 min, 24 h, and 2 months after PCI. A decrease in the ST-segment greater than 70% was considered a complete response. ST-segment depression between 30% and 70% was considered a partial response. ST-segment depression less than 30% was considered without response. Partial and complete responses to PCI were considered successful treatment compared with the no response group. Additionally, participants underwent transthoracic echocardiography before hospital discharge and at 2 months post-discharge.

Descriptive statistics, including measures of central tendency, frequency, and distribution in the form of appropriate tables and figures have presented the characteristics of participants in each group. Cardiac function and ejection fraction are presented as continuous variables using the means and standard deviation. The $\chi 2$ test was used for the statistical analysis of categorical variables. The student's t-test was used for continuous variables in the case of normal distribution. The Mann-Whitney test was also used for the comparison of non-normally distributed variables between study groups.

3. Results

A total of 340 patients (mean±SD:49.96±8.62 years of age; range:45-55 years of age) who successfully underwent angiography have participated in the present study. Most of the patients were male (52.4%). The mean±SD of low-density lipoprotein (LDL), cholesterol, total cholesterol, triglyceride, and high-density lipoprotein (HDL) levels were 121.14±18.53 mg/dl, 196.4±20.01 mg/dl, 190.06±18.58 mg/dl, and 37.26±6.99 mg/dl, respectively. Other descriptive statistics of discrete demographic variables are summarized .

The mean±SD for the time duration between the onset of symptoms and calling EMS (OSCE), the door-to-

Table 1. Patient ECG and echocardiographic descriptive features

	Standarddeviation		Mean	
Ejection fraction				
First echocardiography	3.07		31.96	
Echocardiography 24h post-PCI	3.38		35.51	
Echocardiography 2 months post-PCI	4.08		40.45	
End-systolic volume	Standard deviation		Mean	
First echocardiography	3.12		62.88	
Echocardiography 24h post-PCI	3.12		69.88	
Echocardiography 2 months post-PCI	3.9		72.72	
ST-segment	<30%		>30%	
	Prevalence	Percentage	Prevalence	Percentage
60min	184	54.1	156	45.9
90min	178	52.4	162	47.6
120min	174	51.2	166	48.8
24h	170	50	170	50
2 months	83	24.4	257	75.6

balloon time (DTB), and the first visit to medical staff and angioplasty (FMVA) were 114.4±56.63 min, 35.58±4.43 min, and 60.58±4.43 min, respectively. The mean ejection fraction and end-systolic volume showed an increasing pattern during the study (Table 1). Considering the ECG at 60 min, 90 min, 120 min, and 24 h post-PCI, diabetic patients and patients with anteroseptal and anteroseptal/ lateral MI showed less than 30% STSR compared to the control group (P=0.009, P=0.005, P=0.002, and P=0.001, respectively, for diabetic patients; p<0.001 for the ECGs in all courses for patients with anteroseptal and anteroseptal/ lateral MI).

Diabetes was significantly related to a lower ejection fraction 2 months post-PCI (P=0.021). Delayed referral in different stages was significantly associated with ejection fraction and end-systolic volume, which is summarized in table 2. Hypertensive patients had lower end-systolic volume (P<0.001), and patients with hypercholesterolemia had higher end-systolic volume at the time of admission and at the end of 24h (P=0.024). Additionally, patients with inferior and infero-RV posterior MIs had significantly higher ejection fractions at the end of 24 h and 2 months post-PCI (p<0.001 for both periods).

Meaningful relationships between STSR at different stages and echocardiographic findings are summarized in table 3. The ejection fraction and end-systolic volume in

Table 2. Relation between ST-segment resolution and study

ECGvalues		Mean±SD of ST-segment resolution lower than 30%	P-value
OSCE	60min	130.03±3.93	<0.001
	90min	131.63±3.975	<0.001
	120min	132.59±3.98	<0.001
	24h	133.15±4.02	0.01
	2 months	97.95±6.05	0.034
DTB	60min	35.98±0.34	0.098
	90min	36.07±0.344	0.015
	120min	36.1±0.347	0.009
	24h	36.15±0.35	0.01
	2 months	34.28±0.389	0.012
FMVA	60min	60.98±0.34	0.098
	90min	61.07±0.344	0.015
	120min	61.1±0.347	0.009
	24 h	61.15±0.35	0.01
	2 months	59.28±0.389	0.012

TTE values			correlationcoefficient	P-value
OSCE	EF	First TTE	-0.040	0.463
		First day TTE	-0.126	0.020
		Second month TTE	-0.228	<0.001
	ESV	First TTE	-0.075	0.165
		First day TTE	-0.075	0.165
		Second month TTE	-0.155	0.004
DTB	EF	First TTE	-0.007	0.900
		First day TTE	0.010	0.857
		Second month TTE	-0.043	0.428
	ESV	First TTE	-0.075	0.165
		First day TTE	-0.033	0.542
		Second month TTE	-0.069	0.201
FMVA	EF	First TTE	-0.007	0.900
		First day TTE	0.010	0.857
		Second month TTE	-0.043	0.428
	ESV	First TTE	-0.033	0.542
		First day TTE	-0.033	0.542
		Second month TTE	-0.069	0.201

The duration between onset of symptoms and calling EMS(OSCE), door-to-balloon time(DTB), first medical staff visit and angioplasty(FMVA), ejection fraction(EF), end-systolic volume (ESV), transthoracic echocardiography(TTE)

Table 3. Meaningful relationships between ST-segment resolution at different stages and echocardiographic variables

TTE variables	ST resolution	mean±SD	P-value
First day EF	<30% resolution in 60min	37.95±3.12	0.002
	>30% resolution in 60min	39.16±3.57	
Second month EF	<30% resolution in 60min	38.68±3.42	<0.001
	>30% resolution in 60min	42.53±3.82	
Second month ESV	<30% resolution in 60min	71.73±3.51	<0.001
	>30% resolution in 60min	73.88±4.02	
First day EF	<30% resolution in 90min	37.98±3.1	0.002
	>30% resolution in 90min	39.09±3.59	
Second month ESV	<30% resolution in 90min	71.64±3.45	<0.001
	>30% resolution in 90min	73.9±4.03	
First day EF	<30% resolution in 120min	37.88±3.04	0.001
	>30% resolution in 120min	39.16±3.61	
Second month EF	<30% resolution in 120min	38.4±3.16	<0.001
	>30% resolution in 120min	42.59±3.84	
Second month ESV	<30% resolution in 120min	71.62±3.47	<0.001
	>30% resolution in 120min	73.87±4	
First day EF	<30% resolution on the first day	37.84±3	<0.001
	>30% resolution on the first day	39.17±3.62	
Second month EF	<30% resolution on the first day	38.29±3.05	<0.001
	>30% resolution on the first day	42.6±3.85	
Second month ESV	<30% resolution on the first day	71.56±3.41	<0.001
	>30% resolution on the first day	73.88±4.01	
Second month EF	<30% resolution in the second month	42±3.72	<0.001
	>30% resolution in the second month	39.95±4.08	
Second month ESV	<30% resolution in the second month	75.67±4.24	<0.001
	>30% resolution in the second month	71.74±3.22	

ejection fraction(EF), end systolic volume(ESV), transthoracic echocardiography(TTE).

patients with STSR greater than 30% at 60 min, 90 min, 120 min, and 24 h after PCI were significantly higher than those with resolution lower than 30%. This relationship was not observed 2 months post-PCI.

4. Discussion

In most cases, successful PCI is not the endpoint of complete reperfusion. Some helpful noninvasive monitoring techniques such as 12-lead ECG are widely available in addition to imaging techniques for assessing reperfusion. STSR after successful PCI is an indicator of cardiac function in the future which depends on other factors, such as possible delays in establishing reperfusion and previous medical conditions.

Currently, there is approximately a 2-hour interval between the onset of STEMI symptoms and seeking medical care. This duration is shorter for patients who are directly transported to the hospital by emergency medical services (EMS) (4). This delayed referral is mostly due to the patient's bias related to the symptoms of a heart attack. Most patients think that a heart attack is dramatically characterized by severe left-sided chest pain

(4). Patients may consider the pain to be self-limited or not serious. Additionally, lack of attention to the importance of immediate action and calling EMS are other possible reasons for a late referral (4). The latest American Heart Association guidelines recommended door-to-balloon time less than 90 min and door-to-needle time less than 30 min for centers with the capability of performing PCI (4). Additionally, the optimal time for the first medical contact-to-balloon is reported to be less than 90 min (11). Kassaian et al. performed a multicenter research trial that was the first study to investigate the management of patients with acute coronary syndrome (ACS) in our country. Patients were followed up for one year during which the above intervals were evaluated (12). The composition of Iranian patients with ACS according to their ACS type is most likely similar to those in developed European countries and different from that of developing countries in Africa and the Middle East (12). According to their study, Iranian physicians were treating ACS patients following guideline recommendations for in-hospital management; however, the prescription of dual antiplatelet therapy was underutilized at discharge (12).

Iranian STEMI patients are more likely to be referred lately to the hospital. However, in-hospital reperfusion therapy is appropriate for these patients (12). The mean time between the initiation of symptoms and calling EMS in our study was less than that reported in the Kassaian et al.'s. Additionally, Kassaian et al. reported that the mean door-to-needle and door-to-balloon time was 45.6 and 82.9 min, respectively which was longer than the corresponding times observed in our study (12). Uncertainty about the diagnosis, presence of other life-threatening medical conditions or delays in filling out and understanding the informed consent forms are possible factors that may increase in-hospital delays (4). Educating the patients and their families will be the first and most important step in reducing the pre-hospital delay which encourage family members to seek immediate medical attention if patients do not take their symptoms seriously.

The evaluation of reperfusion is an important issue after performing PCI. There are various techniques reported for the evaluation of cardiac reperfusion and remodeling. Farag et al. evaluated cardiac remodeling after PCI using echocardiography in 232 patients with STEMI. They defined cardiac remodeling as a 20% increase in left ventricular end-diastolic volume after six months. Symptoms-to-balloon time and symptoms-to-door time were both significant predictors of left ventricular remodeling. These findings highlight the lack of awareness about symptoms of myocardial infarction and the necessity of in-time referral (13). Lenz et al. introduced real-time myocardial perfusion echocardiography as a non-invasive bedside technique for evaluating major adverse cardiovascular events in patients with STEMI (14). They compared CMR infarct mass and real-time myocardial perfusion echocardiography in 27 patients after early reperfusion. Myocardial blood flow and infarct mass were independent predictors of major cardiac events after adjusting risk factors (14).

Twelve-lead ECG is still an inexpensive and easily applicable tool for assessing cardiac conditions after PCI despite CMR and real-time myocardial perfusion echocardiography. ST-segment changes are also used for evaluating myocardial reperfusion. These changes can be considered a reliable non-invasive marker for cardiac reperfusion (5, 6). In one study, STSR fails to occur in approximately 1 in 5 patients with STEMI. STSR is considered an independent predictor of major adverse cardiovascular events (15). Sanati et al. reported that the time from the onset of symptoms to the initiation of catheterization is significantly related to the magnitude of STSR (16). Delays in performing PCI lead to increased reperfusion failure which results in adverse clinical outcomes.

The mean presentation time for patients with complete, partial, and no resolution was 3, 5, and 5.5 hours, respectively. They also concluded that the left anterior descending artery (LAD) involvement is associated with poorer myocardial reperfusion after successful PCI. In our study, anteroseptal and anteroseptal/lateral MI showed poorer STSR. A higher degree of ST resolution is achieved when the right coronary artery is treated as the culprit artery (16). They explained this finding by considering the ability of the right ventricle to handle ischemia (16). Nijveldt et al. study reported that the number of Q waves is as important as STSR (17). They stated that these two electrocardiographic variables are important in evaluating left ventricle function. Somitsu et al. also found that STSR is related to better ejection fraction and regional wall motion after a successful PCI (18). Jung sun et al. investigated that STSR was significantly correlated with left ventricular ejection fraction and transmural infarct size. They divided their patients into 2 groups based on STSR; however, unlike our study, they used STSR less than and greater than 70% for grouping. They found that left ventricular ejection fraction was significantly lower in patients with STSR lower than 70% (19). Farkouh et al. reported that patients with STSR less than 30% were more likely to have an ejection fraction less than 40%. Hallen et al. also suggested that STSR and ventricular ejection fraction were weakly correlated in STEMI patients. Their study demonstrated that the only significant association between STSR and ejection fraction could be observed with the occurrence of resolution before 90 min (10). According to our study results, ejection fraction and end-systolic volume were greater in patients who had STSR greater than 30% at 60min and 90min after PCI. However, these measures were significantly lower in patients who showed STSR greater than 30% at 24 h post-PCI.

5. Conclusion

In-hospital and pre-hospital delays are two prominent findings in our study that related to inappropriate STSR after successful PCI in STEMI patients. Additionally, patients with anteroseptal and anteroseptal/lateral MI showed less STSR. According to our results, STSR greater than 30% at 90 min and 120 min after successful PCI in patients with STEMI was significantly related to a higher ejection fraction and a lower end-systolic volume. However, patients in whom STSR occurred after 24h were more likely to have a lower ejection fraction and a higher end-systolic volume.

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