Mirror changes in inferior wall myocardial infarction and its relationship with coronary lesions in non-infarcted areas using angiographic and electrocardiographic findings

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Research Article

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Abstract

Background and Objectives

The study examined mirror changes in inferior wall myocardial infarction and its relationship with coronary lesions in non-infarcted areas using angiographic and electrocardiographic findings.

Methods

This retrospective study analyses 270 patients with inferior wall myocardial infarction, 135 of whom had mirror changes, and 135 had no. The patients' electrocardiograms, echocardiography results, and angiography results were examined. Ejection fraction, thrombolytic response, coronary artery occlusion, occlusion rate, and the number of occluded vessels were evaluated in two patients with and without mirror changes.

Results

We found no significant relationship between mirror changes and lateral arteries (P = 0.091). The findings indicated a connection between ST-segment depression and the existence of stenosis in the irresponsible vessel (P = 0.026). Also, in those patients exhibiting ST-segment depression, the degree of stenosis was more pronounced in the responsible vessel (P = 0.003). Additionally, no relationship was reported between multi-vessel involvement and ST-segment depression (P = 0.462). There was a noteworthy relationship between ST-segment depression and thrombolytic response (P = 0.002). Moreover, the results indicated that there was no substantial correlation between the EF level and the occurrence of ST-segment depression (P = 0.209).

Conclusion

It seems that mirror change in the ST segment plays a role in the severity of responsible vessel occlusion and the significance of irresponsible vessel occlusion. Mirror change did not affect EF level, though it influenced thrombolytic responses.

Key Summary Points

- Cardiovascular diseases are responsible for a high percentage of worldwide fatalities, being the top contributor to mortality globally with a staggering 40% of all deaths.
- The study was conducted to examine mirror changes in inferior wall myocardial infarction and analyze its relationship with coronary lesions in non-infarcted areas using angiographic and electrocardiographic findings.
Our findings suggest that alterations in the ST-segment can affect the magnitude of the blockage in both the responsible vessel and other vessels not responsible, with no impact on EF levels. However, it does play a role in thrombolytic response.

The findings show the importance of monitoring ST-segment changes in the future patients with suspected or confirmed coronary artery disease.

Introduction

At present, cardiovascular diseases are the leading contributor to mortality globally, including in Iran, accounting for 40% of all fatalities worldwide [1]. A study on disease burden in Iran (2007) found that cardiovascular diseases accounted for 17.9% of the disease burden [2]. In the process of transmural myocardial infarction, the ischemic region undergoes incomplete depolarization. Electrocardiographic findings also indicate ascending changes in the ST segment [3]. These changes are frequently linked to ST-segment depression on the wall that is opposite to the area affected by infarction. Over the years, studies have addressed the cause and importance of ST depression in the non-infarcted zone. Studies have shown that ST-segment depression in the wall opposite the main infarcted territory is due to ischemia that may occur due to the direct expansion of the ischemic zone or its expansion through the collateral vessels feeding the zone.

Many studies have focused on identifying the importance of changes in the zone opposite the main infarct area (mirror changes in electrocardiography). According to the findings, mirror changes in patients with ST-segment elevation are more of a benign electrical phenomenon than a sign of ischemia farther away from the main infarct area [4]. However, as some prospective studies report, mirror changes indicate the severity of the disease, and patients with mirror changes experience wider infarction, weaker ventricular systole, and more likeliness of an ulcer event in the left anterior descending artery (LAD), and poor prognosis [5, 6].

El Atroush et al. (2012) found that patients in Group I experience significant ST-segment elevations (in lower leads) and higher total CPK and CKMB levels than patients in Group II. In addition, patients in Group I had more complications [7]. Using echocardiographic evidence, angiographic findings, complications, and in-hospital mortality, Abbasi et al. (2010) compared the difference in patients without ST-segment depression, with maximum mirror changes declining in leads V1 to V3, and patients with maximum mirror changes decline in leads V4 to V6. ST-segment depression in the pericardial leads, especially V4 to V5, indicates more significant infarction or multi-vessel involvement, which reflects a worse prognosis with lower ejection fraction, more wall movement abnormalities, and higher complications and mortality [8].

Parale et al. (2004) examined the relationship between ECG changes in the mirror leads among patients with acute infarction of the anterior and inferior wall, according to the involved artery location and function of the left ventricle (LV). It was found that patients with ST depression in I, aVL, V4-V6 (lateral apex leads) ≥ ST elevation in lower leads had more multi-vessel involvement with LVEF < 40% (12.78%, P < 0.001). 12% of patients with anterior mirror changes, i.e., VI-V3 leads, and 15% of patients with no
considerable mirror changes in lateral and anterior leads had LVEF < 40% [9]. Nematipour et al. (2002) showed that the prevalence of multi-vessel disease was about 66.6%. After coronary angiography, 33.3% of patients were referred for coronary artery bypass graft surgery (CABGS) and 27.3% for percutaneous transluminal coronary angioplasty (PTCA). In other words, about 60.6% of patients were referred for vascularization (CABG or PTCA) [10].

Numerous studies have been done on MI, mainly on diagnostic and therapeutic cases and less on patient prognosis. In addition to examining the collateral arteries, the present study compares significant irresponsible vessel stenosis, thrombolytic response, and ejection fraction in two groups of patients with and without mirror changes. According to angiographic and electrocardiographic findings, this study is to scrutinize the mirror changes in patients admitted with acute infarction of the inferior myocardial wall and its relationship with coronary lesions in non-infarcted areas.

Materials And Methods

In terms of methodology, this is a retrospective study and descriptive-analytical research, approved by The Ethics Committee of Urmia University of Medical Sciences (Approval Number IR.UMSU.REC.1398.105). The population includes patients with acute myocardial infarction referred to Taleghani and Seyyed Al-Shohada hospitals in Urmia. We considered the presence of acute inferior wall MI as the inclusion criterion. Posterior MI and LCX involvement (as the responsible vessel) were considered the exclusion criteria. Then we evaluated the results of angiography, electrocardiography, and echocardiography. A specialist and echocardiography reviewed angiography reports were performed by a specialist using the Ball's eye method. One hundred thirty-five patients with mirror changes and 135 without were selected. Chi-square, correlation, and independent t-tests were used to analyze the data via SPSS 22.

Results

A total of 270 patients (135 cases with mirror changes and 135 without mirror changes) participated in the study. Both groups' demographic characteristics and risk factors were the same (Table 1).

Table 1. Comparison of demographic characteristics and risk factors
The Chi-square test result showed no significant relationship (P = 0.462) between multi-vessel involvement and mirror changes. The Independent test (P = 0.209) did not reflect any significant difference in multi-vessel involvement in-between the two groups. Table 2 compares the frequency percentage of vessel involvement in both groups.

### Table 2. Percentage frequency and comparison of the number of vessels involved

<table>
<thead>
<tr>
<th>Variable</th>
<th>Patients with mirror change</th>
<th>Patients without mirror change</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>65 ± 13</td>
<td>66 ± 11</td>
<td>0.854</td>
</tr>
<tr>
<td>Male gender</td>
<td>77%</td>
<td>80%</td>
<td>0.601</td>
</tr>
<tr>
<td>Positive history of cardiovascular diseases</td>
<td>43%</td>
<td>30%</td>
<td>0.872</td>
</tr>
<tr>
<td>Diabetes</td>
<td>19%</td>
<td>22%</td>
<td>0.714</td>
</tr>
<tr>
<td>Hypertension</td>
<td>51%</td>
<td>52%</td>
<td>0.843</td>
</tr>
<tr>
<td>Smoking</td>
<td>55%</td>
<td>65%</td>
<td>0.165</td>
</tr>
</tbody>
</table>

The Mann-Whitney test (P = 0.002) revealed a considerable difference between the groups' thrombolytic and PCI responses. Table 3 presents the frequency of thrombolytic response in both groups.

### Table 3. Percentage frequency and comparison of response to thrombolytics

<table>
<thead>
<tr>
<th>Response to thrombolytics</th>
<th>No response to thrombolytics</th>
<th>PCI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients with mirror change</td>
<td>44.9%</td>
<td>4.1%</td>
<td>51%</td>
</tr>
<tr>
<td>Patients without mirror change</td>
<td>65.5%</td>
<td>4.5%</td>
<td>30%</td>
</tr>
</tbody>
</table>

6.4% of patients without mirror changes had lateral vessels to the infarct area, and 93.6% did not have lateral vessels to the infarcted zone. However, 13% of patients with mirror changes had lateral vessels to
the infarct area, and 87% did not have lateral vessels to the infarct area. Regarding the relationship between mirror changes of ST-segment and lateral vessels to infarct areas, the presence of lateral vessels was investigated in two groups. According to the Chi-square test result, there was no significant relationship between mirror changes and lateral vessels to infarcted areas (P = 0.091).

The mean EF in patients without mirror changes was 40.45%, with a standard deviation of 6.67%, and 41.64% in patients experiencing mirror changes with a standard deviation of 7.20%. The EF level was compared between the groups to evaluate the relationship of EF level with ST-segment depression; we marked no noteworthy contrast between the two groups (P = 0.209). Extracted data in Table 4 presents the mean percentage of EF in patients with and without mirror changes.

Table 4. Mean percentage of EF in patients with and without mirror changes

<table>
<thead>
<tr>
<th>Mean EF</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients with mirror change</td>
<td>41.64%</td>
</tr>
<tr>
<td>Patients without mirror change</td>
<td>40.45%</td>
</tr>
</tbody>
</table>

The RCA vessel was considered the responsible vessel for inferior wall infarction. The Independent t-test (P = 0.003) reflected a notable difference between the two groups regarding the severity of RCA stenosis.

The degree of stenosis in LAD and LCX vessels was checked in the two groups to evaluate the relationship between the presence of ST-segment mirror changes with significant stenosis (≥70%) in irresponsible vessels.

The Independent t-test indicated a significant difference (P = 0.026) in LAD stenosis between the two groups. Spearman test was also used to examine the correlation between significant LAD stenosis and ST-segment mirror changes (P = 0.009); a correlation of 0.300 was obtained.

Significant LCX stenosis in the two groups was compared using an independent t-test, and no important difference was noticed in-between the two groups (P = 0.282). Spearman test was used to check the correlation between significant LCX stenosis and ST-segment mirror changes; no significant correlation was observed (P = 0.376).

**Discussion**

The study examined mirror changes in inferior infarction with/without collateral arteries, significant stenosis in responsible and irresponsible vessels, thrombolytic response, and left ventricular ejection fraction.
A retrospective study carried out by Vaidya et al. (2017) aimed to investigate the role of ECG mirror changes in predicting lateral blood flow to the infarct area [11]. Similarly, Radwan et al. (2020) studied the relationship between lateral circulation and ST-segment changes [12], but neither study found a significant correlation between ST-segment depression and the presence of lateral vessels. Vaidya et al. (2017) showed that mirror changes were not associated with lateral vessels nor did they predict their occurrence [11]. Chan et al. (2001) examined patients with venous involvement who underwent percutaneous coronary angioplasty. In the group with ST-segment elevation, none of the patients had a lateral branch to the involved artery, while 16% of patients without ST-segment elevation had a lateral branch to the involved artery. The presence of ST-segment depression in the 12-lead ECG was specific to the absence of lateral branches in cases of acute coronary occlusion. These results suggest a link between ST-segment depression and the absence of lateral vessels [13]. The present analysis compared the presence of lateral vessels in two groups, with and without mirror changes, and found no significant relationship between ST-segment depression and the presence of lateral vessels.

Chan (2001) examined patients with venous involvement who underwent percutaneous coronary angioplasty [13]. In line with our findings, he reported severe artery stenosis of the responsible vessel in patients with ST-segment depression. Chan also reported an association between ST-segment depression during RCA vessel occlusion and extensive RCA stenosis, indicating lateral posterior wall ischemia [13]. In the current investigation, the severity of responsible vessel stenosis was higher in the patients with the ST-segment depression group.

The present study examined ST-segment elevation and its association with significant LAD and LCX stenosis and revealed a relationship between ST-segment depression and the presence of stenosis in the irresponsible vessel (P = 0.026). Liga et al. (2017) evaluated the relationship between mirror changes, Cardiac CT perfusion, and its functional parameters. They reported higher cTFT and more prevalence of no-reflow in irresponsible vessels among patients with mirror changes compared to those without mirror changes (P = 0.004 and P = 0.013, respectively) [14]. El Atroush et al. (2012) performed a prospective study on 40 patients with acute inferior infarction. According to angiographic findings, patients with mirror changes experienced significantly higher LAD artery lesions than patients without mirror changes (P < 0.01) [7]. However, Çelik and colleagues (2003) stated that the absence of a significant association between ST-segment depression and mirror changes in the ST-segment was due to the electrical reflection of ST-segment elevation in the area of the infarction. They used pulsed wave tissue Doppler (PWTD) to study the diastolic movement of the left ventricular myocardium, which may make it possible to diagnose ischemic sections [15].

The current study found no connection between ST-segment depression and involvement of two or three vessels (2VD and 3VD), as indicated by a P-value of 0.462. Nour and colleagues (2017) performed a prospective study to explore the relationship between ST-segment depression in myocardial infarction and the severity of coronary artery disease and the function of the left ventricle. They analyzed electrocardiographic evidence and the extent of ST-segment changes in leads related to the infarction. The results indicated that individuals with ST-segment depression had a higher likelihood of having
involvement in multiple vessels [16]. Radwan and colleagues (2020) studied the relationship between lateral circulation and ST-segment depression in STEMI patients treated with primary percutaneous intervention (PPCI). Their study team reported a significantly higher prevalence of proximal LAD, distal RCA, and distal LCX obstruction in patients with mirror changes than those without mirror changes. As a result, there was a relationship between ST-segment depression and multi-vessel involvement [12]. El Atroush et al. (2012) also reported significantly higher multi-vessel involvement in the group with ST-segment depression [7].

Zoghi and colleagues (2003) carried out a prospective study to investigate the connection between ST-segment elevation and the incidence of coronary artery disease. They found a relationship between ST-segment depression and multi-vessel involvement in acute inferior infarction, which they believed was more than just an electrical phenomenon [17]. Abbase and colleagues (2010) conducted a study on 72 individuals who had experienced an acute myocardial infarction and divided them into three categories: those without ST-segment elevation (Group I), those with the highest ST-segment elevation ranging from 1V to 3V (Group II), and those with the highest ST-segment elevation ranging from 4V to 6V (Group III). The cases underwent echocardiography and angiography. According to angiographic findings, multiple vessel involvement was 70% in group III, 50% in group II, and 33% in group I. Hence, ST-segment depression in the pericardial leads, particularly in the 4V to 6V range, indicates a more severe infarction or involvement of multiple vessels [7]. Parale and colleagues (2004) studied the changes in the mirror leads on the electrocardiogram of patients who had suffered an acute myocardial infarction of either the anterior or inferior wall. They analyzed the effect of the location of the involved artery and the function of the left ventricle on these changes. Their findings showed that in patients with ST-segment depression and an acute inferior wall infarction, multi-vessel involvement was commonly seen in the lateral vertebral leads [9].

Nematipour et al. (2002) reported a considerable relationship between ST-segment depression and multi-vessel involvement [10]. Numerous studies have confirmed the linkage between multi-vessel involvement and ST-segment depression. However, the present study did not reveal any significant association between multi-vessel involvement and ST-segment depression in patients who had suffered acute inferior wall myocardial infarction.

The present study revealed that 61 patients (44.9%) had mirror changes, and 89 patients (65.5%) did not have mirror changes, indicating a significant relationship between ST-segment depression and thrombolytic response (P = 0.002). This finding has not been reported in the literature. Since the severity of involvement and blockage in the responsible vessel is higher in patients with mirror changes, they experienced a less thrombolytic response.

Additionally, the results of the current study showed no significant correlation between the EF and the presence of ST-segment depression, as indicated by a P-value of 0.209. Regarding ET level, Kidambi et al. (2013) did not observe a significant relationship between patients with and without mirror changes [18]. El Atroush et al. (2012) completed a prospective study on 40 patients with acute inferior wall MI. they
reported no important difference between patients with and without mirror changes in EF level [7]. However, Nour et al. (2017) examined 200 patients with acute MI and reported poor left ventricular function (lower EF) for patients with ST mirror changes [16]. Radwan et al. (2020) examined 112 patients with STEMI and reported less prevalence of EF in patients with ST mirror changes (P = 0.007) [12]. In their study, Abbase and colleagues (2010) observed 72 individuals who had experienced an acute myocardial infarction. They found that the average ejection fraction (EF) was the lowest in patients who showed mirror changes on their electrocardiogram [9]. Parale et al. (2004) examined 300 patients and reported EF < 40% in patients with mirror changes (P < 0.001) [8].

Conclusion

It appears that changes in the ST-segment can impact the severity of blockage in the responsible vessel, as well as significant blockage in vessels that are not responsible. It does not affect EF levels but is an influencing factor in thrombolytic response.

Declarations

Ethics approval and consent to participate

The Ethics Committee of Urmia University of Medical Sciences approved the study (Ethics Committee Approval Number IR.UMSU.REC.1398.105), which was performed under the principles outlined in the Declaration of Helsinki. Informed consent was obtained from all the patients and/or their legal guardian(s).

Consent for Publish

The authors declare that they consent to the publication of this paper.

Availability of data and materials

The data that support the findings of this study are available from Urmia University of Medical Sciences, Taleghani Hospital of Urmia, and Seyyed Al-Shohada Hospital of Urmia but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of Urmia University of Medical Sciences, Taleghani Hospital of Urmia, and Seyyed Al-Shohada Hospital of Urmia.

Competing interests

Reza Faramarzzadeh, Mahdieh Nobakht, Mahsa Behnemoon, and Arian Haghtalab state that they do not have any competing interests.
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Authors' contributions

The study's conception and design were a collaboration between Reza Faramarzzadeh, Mahdieh Nobakht, and Mahsa Behnemoon. Reza Faramarzzadeh and Mahdieh Nobakht were responsible for the preparation of materials and data analysis. The initial draft of the manuscript was written by Mahdieh Nobakht and Arian Haghtalab, and all authors reviewed and approved the final version.

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