





## Assessment of tissue mitral annular displacement in patients with coronary artery stenosis

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### Original Article

#### Abstract

**BACKGROUND:** The high incidence of coronary heart diseases requires early diagnosis to prevent complications. This study aims to assess the mean value of tissue mitral annular displacement (TMAD), using Speckle tracking echocardiography (2D STE) in patients with coronary artery stenosis.

**METHODS:** 149 patients aged 50 to 76 years were included in this cross-sectional study who were admitted with primary diagnosis of acute coronary syndrome (ACS) to the emergency department. In all patients, the TMAD data were measured using 2D speckle tracking technology.

**RESULTS:** 149 patients with a mean age of  $61.83 \pm 7.14$  years old were studied. Regarding the involved coronary artery as left anterior descending (LAD), right coronary artery (RCA), or left circumflex artery (LCX), the TMAD data was reduced significantly ( $P < 0.001$ ) in the relevant walls [base of anterior and anteroseptum ( $4.46 \pm 3.53$  mm), base of inferior and inferoseptum ( $4.91 \pm 3.81$  mm), and base anterolateral and inferolateral walls ( $5.53 \pm 3.827$  mm), respectively.] TMAD in anterior, inferior, and lateral ST-elevation myocardial infarction (STEMI) were  $2.64 \pm 0.870$ ,  $4.78 \pm 3.8$ , and  $2.80 \pm 0.83$  mm, respectively which were significantly reduced compared to the non-ST-elevation myocardial infarction (NSTEMI) and unstable angina ( $P < 0.001$ ). TMAD in different LV function categories was only reduced in those with LAD lesion and with severe LV systolic dysfunction ( $2.47 \pm 0.834$  mm,  $P < 0.001$ ).

**CONCLUSION:** The current study describes a significant relationship between TMAD and left ventricular function, ACS type, and the culprit coronary artery. In different types of ACS, the TMAD value was worse in the subgroups of STEMI and in the walls affected by the stenosed coronary artery. This method might be helpful in defining the culprit coronary artery.

**Keywords:** Acute Coronary Syndrome; Echocardiography; Left Ventricular Function; Coronary Stenosis

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#### Introduction

Presently, coronary heart diseases (CHDs) remain as a major cause of death and disability in developed countries with about one-third or more of all deaths in individuals over the age of 35 years.<sup>1-4</sup> Reasons for this could be the social and economic changes in developing countries leading to increased life expectancy, use of westernized diets, physical inactivity, and increased smoking.<sup>5</sup> Consequently,

international leaders have called for action plans to avert the projected global epidemic of ischemic

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heart diseases in developing countries.<sup>6</sup> Occluded arteries could result in regional wall motion abnormality and left ventricular systolic dysfunction. Electrocardiography (ECG) does not have sufficient sensitivity for detecting acute coronary syndrome. The replacement of rapid and new non-invasive methods is very helpful to achieve the goal of early diagnosis.<sup>7</sup> The measurement of global longitudinal strain (GLS) by two-dimensional (2D) speckle tracking ECG is a reliable method for assessment of myocardial deformation, but the technique needs good visualization of the entire LV endocardium and is time consuming.<sup>8</sup> The recent works have shown that the mitral annulus is an essential, dynamic, and tightly coupled component of the mitral valve/left atrial/left ventricular complex that could aid in effective and efficient valve closure and unimpeded left ventricular filling.<sup>7</sup> Tissue motion annular displacement (TMAD) is a simple method for the evaluation of the left ventricular systolic function. There are limited echocardiographic studies on TMAD and its changes in ventricular dysfunction or its relation to coronary artery stenosis.<sup>8-10</sup> In this study, the aim is to determine whether TMAD has any association with the coronary artery stenosis, detected during the coronary angiography.

## Materials and Methods

**Study subjects:** This cross-sectional study covered 149 outpatients aged 50 to 76 years, including 74 males and 75 females. All patients were admitted with acute coronary syndrome (ACS) to the heart disease emergency departments of Quaem or Imam Reza hospitals affiliated with Mashhad University of Medical Sciences, Mashhad, Iran, between March 2014 and March 2016. The patients with a history of heart failure, mitral annulus calcification, history of revascularization [coronary artery bypass grafting (CABG) or percutaneous coronary intervention (PCI)] or valve replacement, poor view echowindow, left main coronary artery disease (LMCAD), advanced diastolic dysfunction, moderate or more valve regurgitation, any valve stenosis, multi vessel disease (2vd, 3vd), atrial fibrillation, left bundle branch block, and congenital heart disease were excluded from the study.

**ECG:** Transthoracic ECG was performed using a commercially available ultrasound machine (Samsung Medison EKO 7, Korea) equipped with a broad-band transducer. Conventional two-dimensional ECG measuring left ventricular dimension, volume, and wall thickness was

conducted according to the recommendations by the American Society of Echocardiography.<sup>11</sup> TMAD was measured by 2D STE. Three standard apical views (four and two chambers and long axis) were used. In each view, three points on the left ventricle were identified, the two at the extreme sides of the mitral annulus and the third one located in the apex and tracked using this feature. This measurement was expressed as the percentage of LV length at end-diastole.

Six TMADs were gathered in each patient, regarding to the assessed left ventricular wall (Figure1). We also considered the predominant coronary artery, feeding different LV walls. The average of TMAD in the base of inferoseptum and inferior walls (II) was used for right coronary artery (RCA) lesion, in base of antero-septum and anterior for left anterior descending (LAD), and in the base of anterolateral and inferolateral (AI) for left circumflex artery (LCX).

**Coronary Angiography:** Coronary angiography was performed for all patients. Cases with stenosis of at least 50% were included in this study.<sup>12</sup>

**Statistical Analysis:** Statistical analysis was carried out using SPSS software (version 16.0, SPSS Inc., Chicago, IL, USA). All continuous data were reported as mean  $\pm$  standard deviation (SD) and categorical data as percentages. The comparison between the mean values of TMAD in different territories and different groups of systolic function was performed by the one-way analysis of variance (ANOVA) test. Comparison between the distribution patterns of the involved coronary arteries and different types of ACS was performed using the chi-square test. The level of  $P < 0.050$  was considered statistically significant.

**Ethics:** Approval for accessing the patient health records was obtained from the local research ethics committee (IR.MUMS.fm.REC.1394.335) and an informed consent was obtained from all patients.

## Results

149 patients with ACS with a mean age of  $61.83 \pm 7.14$  in the age range of 50 to 76 years were enrolled in the current study. 74 (49.7%) and 75 (50.3%) of the participants were males and females with a mean age of  $62.24 \pm 7.12$  and  $61.43 \pm 7.02$ , respectively ( $P = 0.480$ ).

In the study population, 47 (31.54%), 7 (4.70%), 63 (42.28%), 27 (18.12%), and 5 (3.36%) patients had anterior ST-elevation myocardial infarction (STEMI), non-ST-elevation myocardial infarction (NSTEMI), unstable angina, inferior STEMI, and lateral STEMI, respectively.

**Table 1.** State of left ventricular (LV) systolic function (number of patients) in different types of acute coronary

| LV systolic function (%) | UA<br>(n = 63) | NSTEMI<br>(n = 7) | Anterior STEMI<br>(n = 47) | Lateral STEMI<br>(n = 5) | Inferior STEMI<br>(n = 27) |
|--------------------------|----------------|-------------------|----------------------------|--------------------------|----------------------------|
| Normal                   | 12             | 2                 | 0                          | 0                        | 0                          |
| Mild dysfunction         | 18             | 1                 | 0                          | 5                        | 19                         |
| Moderate dysfunction     | 33             | 4                 | 32                         | 0                        | 8                          |
| Severe dysfunction       | 0              | 0                 | 15                         | 0                        | 0                          |

LV: left ventricular; UA: Unstable angina; NSTEMI: Non-ST elevation myocardial infarction; STEMI: ST elevation myocardial infarction

Additionally, 14 (9.40%), 43 (28.90%), 77 (51.70%), and 15 (10.10%) patients had respectively normal left ventricular ejection fraction (LVEF) (more than 55%), mild systolic dysfunction (45-55%), moderate systolic dysfunction (30-44%), and severe systolic dysfunction (less than 30%).

The number of patients in each group of the LV systolic function with respect to each category of UA, NSTEMI, and ST elevation MI (anterior, lateral, inferior) is shown in table 1.

**Involved Coronary Artery and ACS:** The results showed that LAD had been culprit lesion in all patients with anterior STEMI (n = 47, 100%). Additionally, in patients with unstable angina, LAD was affected more compared to other territories (n = 33, 52%). The results are shown in table 2.

The culprit coronary artery was LAD, RCA, and LCX in 84 (56.40%), 33 (22.10%), and 32 (21.50%) patients, respectively.

**TMAD and Coronary Artery Involvement:** The mean value of TMAD in patients with LAD lesion was  $4.460 \pm 3.531$  mm, in which the base anterior and anteroseptal walls were more affected (P < 0.001), TMAD in the RCA lesion was  $4.910 \pm 3.811$  mm and the base inferior and inferoseptal walls were the more affected walls, and TMAD in LCX culprit lesion was  $5.530 \pm 3.827$  mm, in which the base anterolateral and inferolateral walls were more affected. TMAD considering different coronary artery territories are shown in table 3.

**TMAD and Genders:** There was not significant differences in TMAD between the male and female groups (P > 0.050) (Table 3).

**TMAD and ACS:** Considering different types of ACS, the TMAD value was worse in the subgroup of STEMI, in the walls affected by the stenosed coronary artery. In 47 participants with anterior STEMI, the mean of TMAD in the base anterior and anteroseptal walls was  $2.640 \pm 0.870$  mm, which was significantly less than that of other variants of ACS (P < 0.001). In 27 patients with inferior STEMI in the base Inferior and inferoseptal walls, TMAD was  $4.780 \pm 3.800$  mm and was significantly less than that in other variants of ACS (P < 0.001) and in 5 patients with lateral STEMI in the base anterolateral and inferolateral walls, TMAD was  $2.800 \pm 0.830$  mm, which was significantly less than TMAD of other variants of ACS (P < 0.001) (Table 4).

**TMAD and LVEF:** The mean TMAD values of the territories were measured and compared to each other in different groups of LV systolic function. The mean TMAD between different groups of LV systolic function and different territories was significantly lower in the base anterior and anteroseptal walls and patients with severe systolic dysfunction (LVEF < 30%) (Table 5).

## Discussion

The left ventricular function is routinely assessed by ejection fraction and is highly dependent on the patient's image quality, in addition to being time consuming and needing tracing of endocardium. TMAD is a technique based on the tissue tracking method and has been established to correlate well with the ejection fraction and has several advantages.

**Table 2.** Frequency distribution of the involved coronary arteries in different types of acute coronary syndrome (ACS)

| ACS types               | Involved coronary artery |         |         |               | P*      |
|-------------------------|--------------------------|---------|---------|---------------|---------|
|                         | LAD                      | RCA     | LCX     | Total [n (%)] |         |
| Anterior STEMI [n (%)]  | 47 (100)                 | 0       | 0       | 47 (100)      | < 0.001 |
| NSTEMI [n (%)]          | 4 (57)                   | 2 (28)  | 1 (15)  | 7 (100)       |         |
| Unstable angina [n (%)] | 33 (52)                  | 11 (18) | 19 (30) | 63 (100)      |         |
| Inferior STEMI [n (%)]  | 0                        | 20 (74) | 7 (26)  | 27 (100)      |         |
| Lateral STEMI [n (%)]   | 0                        | 0       | 5 (100) | 5 (100)       |         |
| Total [n (%)]           | 84 (56)                  | 33 (22) | 32 (22) | 149 (100)     |         |

ACS: Acute coronary syndrome; LAD: Left anterior descending; RCA: Right coronary artery; LCX: Left circumflex artery; STEMI: ST elevation myocardial infarction; NSTEMI: Non-ST elevation myocardial infarction

\* Chi-square test

**Table 3.** Comparison of mean values of tissue mitral annular displacement (TMAD) in different involved coronary

| Coronary artery | TMAD (mm)                  |                            |                            | ANOVA<br>P | Post-hoc test<br>P  |                     |
|-----------------|----------------------------|----------------------------|----------------------------|------------|---------------------|---------------------|
|                 | AI                         | II                         | AA                         |            |                     |                     |
| LAD (n = 84)    | 10.96 ± 1.023 <sup>a</sup> | 10.58 ± 1.301 <sup>b</sup> | 4.46 ± 3.531 <sup>c</sup>  | < 0.001    | 0.019 <sup>ac</sup> | 0.049 <sup>bc</sup> |
| RCA (n = 33)    | 10.82 ± 1.185 <sup>d</sup> | 4.91 ± 3.811 <sup>e</sup>  | 10.79 ± 1.193 <sup>f</sup> | < 0.001    | 0.023 <sup>de</sup> | 0.036 <sup>ef</sup> |
| LCX (n = 32)    | 5.53 ± 3.827 <sup>g</sup>  | 10.81 ± 1.230 <sup>h</sup> | 10.72 ± 1.198 <sup>i</sup> | < 0.001    | 0.024 <sup>gh</sup> | 0.038 <sup>gi</sup> |
| Gender          |                            |                            |                            |            |                     |                     |
| Male (n = 74)   | 9.72 ± 3.090               | 8.99 ± 3.486               | 7.50 ± 4.089               | 0.085      |                     |                     |
| Female (n = 75) | 9.81 ± 2.893               | 9.76 ± 2.823               | 6.92 ± 4.258               | 0.045      |                     |                     |

TMAD: Tissue mitral annular displacement; ANOVA: Analysis of variance; LAD: Left anterior descending; RCA: Right coronary artery; LCX: Left circumflex artery; AA: Basal inferior and anteroseptal LAD territory; II: Basal inferior and inferoseptal RCA territory; AI: Basal anterolateral and inferolateral LCX territory; The small letters belong to different study groups.

This technique is angle independent and simultaneously could be assessed as contraction in multiple directions.<sup>13</sup> Ito et al. showed association of TMAD with New York Heart Association (NYHA) functional classification and plasma B-type natriuretic peptide (BNP) concentration which might define TMAD as a prognostic contribution factor. Furthermore, TMAD was correlated with left ventricular mass index and Tei index.<sup>14</sup> In a similar study, Luo and Zhou found a powerful statistical relation between TMAD and LVEF and concluded that TMAD can be used in estimating LVEF.<sup>15</sup> In another study, TMAD was suggested not only for the assessment of LV function, but also for the evaluation of the LV functional reserve while using stress ECG.<sup>16</sup>

Two-dimensional ECG study in the field of annular mitral displacement (MAD) has been begun with enthusiasms as rapid and non-invasive methods for early diagnosis of ACS.<sup>10,14,15</sup> The quantitative analysis of the MAD was compared with TMAD measurements and there were no significant differences in the displacement measurements.<sup>10</sup> In a similar study, Zahid et al. used Doppler ECG in 167 patients with NSTEMI and found a correlation between MAD and LVEF.<sup>8</sup>

Additionally, MAD accurately identified patients with NSTEMI with coronary occlusion in this group of patients.

In the current study, we found that TMAD was reduced significantly in the walls of the related stenotic coronary artery.

Coronary angiography was performed in all patients and the significant relation between TMAD and ejection fraction was shown only in the subgroup of patients with LAD lesions and severe LV systolic dysfunction.

It was the first study detecting the decrease in TMAD in the LV walls, compatible with the coronary artery stenosis.

In a previous study by Zahid et al., TMAD was suggested to distinguish between coronary artery lesions, in those with and without infarction and even to define the infarct size and mortality.<sup>8</sup>

We also detected the differences in the TMAD data in different types of ACS (anterior, inferior, and lateral ST elevation myocardial infarction). Therefore, TMAD not only might be used in the diagnosis of coronary stenosis, but also for detecting the involved territory or probably culprit lesions. The latter needs to be aimed in further studies in which cases two or three vessels are included.

**Table 4.** Comparison of mean values of tissue mitral annular displacement (TMAD) in different types of acute coronary syndrome

| ACS type                 | TMAD (mm)                   |                             |                             | ANOVA<br>P | Post-hoc test<br>P  |                     |
|--------------------------|-----------------------------|-----------------------------|-----------------------------|------------|---------------------|---------------------|
|                          | AI                          | II                          | AA                          |            |                     |                     |
| Anterior STEMI (n = 47)  | 2.640 ± 0.870 <sup>a</sup>  | 10.620 ± 1.261 <sup>b</sup> | 11.060 ± 0.942 <sup>c</sup> | < 0.001    | 0.012 <sup>ab</sup> | 0.009 <sup>ac</sup> |
| NSTEMI (n = 7)           | 7.430 ± 5.159               | 10.290 ± 1.604              | 10.000 ± 0.942              | 0.684      |                     |                     |
| Unstable Angina (n = 63) | 8.810 ± 3.596               | 10.270 ± 2.238              | 9.790 ± 2.766               | 0.841      |                     |                     |
| Inferior STEMI (n = 27)  | 10.780 ± 1.086 <sup>d</sup> | 4.780 ± 3.866 <sup>e</sup>  | 8.670 ± 4.067 <sup>f</sup>  | < 0.001    | 0.014 <sup>de</sup> | 0.044 <sup>ef</sup> |
| Lateral STEMI (n = 5)    | 10.400 ± 1.517 <sup>g</sup> | 10.000 ± 1.581 <sup>h</sup> | 2.800 ± 0.837 <sup>i</sup>  | < 0.001    | 0.024 <sup>gi</sup> | 0.038 <sup>hi</sup> |
| Total (n = 149)          | 7.210 ± 7.210               | 9.380 ± 3.182               | 9.770 ± 2.983               |            |                     |                     |

TMAD: Tissue mitral annular displacement; ACS: Acute coronary syndrome; ANOVA: Analysis of variance; STEMI: ST elevation myocardial infarction; NSTEMI: Non-ST elevation myocardial infarction; AI: Basal anterolateral and inferolateral left circumflex artery (LCX); II: Basal inferior and inferoseptal right coronary artery (RCA); AA: Basal anterior and anteroseptal left anterior descending (LAD)

The small letters belong to different study groups.

**Table 5.** Comparison of mean values of tissue mitral annular displacement (TMAD) in different territories with the subgroups of systolic function

| LV systolic function | TMAD (mm)                   |                |                |
|----------------------|-----------------------------|----------------|----------------|
|                      | AI                          | II             | AA             |
| Normal (n = 14)      | 10.640 ± 1.336 <sup>a</sup> | 11.070 ± 1.141 | 9.930 ± 1.592  |
| Mild (n = 43)        | 10.790 ± 1.103              | 7.720 ± 4.055  | 7.210 ± 4.313  |
| Moderate (n = 77)    | 5.510 ± 3.995               | 9.750 ± 2.754  | 10.910 ± 1.041 |
| Severe (n = 15)      | 2.470 ± 0.834 <sup>a</sup>  | 10.600 ± 1.298 | 11.070 ± 0.961 |
| Total (n = 149)      | 7.210 ± 4.171               | 9.380 ± 3.182  | 9.770 ± 2.983  |
| P*                   | < 0.001                     | 0.563          | 0.645          |

TMAD: Tissue mitral annular displacement; LV: Left ventricle; AI: Anterolateral and inferolateral left circumflex artery (LCX) territory; II: Inferior and inferoseptal right coronary artery (RCA) territory; AA: Anterior and anteroseptal left anterior descending (LAD) territory

Normal LV systolic function (more than 55%); Mild LV systolic dysfunction (45-54%); 3: Moderate LV systolic dysfunction (30-44%); Severe LV systolic dysfunction (less than 30%)

\* Analysis of variance (ANOVA) test

Post hoc test showed significant difference between the normal group and those with severe systolic (defined with superscript letter (a)); P = 0.009.

### Conclusion

The parameters of TMAD accurately identified the culprit lesion. The parameters of TMAD might be used as a criterion for diagnosis of ACS. The parameters of TMAD may indicate poor LVEF. There are no significant differences in TMAD by gender of patients. Prospectively, the TMAD measurement by the ECG method could help us in early diagnosis of patients with ACS.

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### Conflict of Interests

Authors have no conflict of interests.

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