DOI: 10.38103/jcmhch.86.11

Original research

# EVALUATION OF LEFT VENTRICULAR SYSTOLIC FUNCTION BY TISSUE MOTION ANNULAR DISPLACEMENT OF THE MITRAL VALVEDERIVED BY SPECKLE - TRACKING ECHOCARDIOGRAPHY IN PATIENTS WITH CORONARY ARTERY DISEASE

Truong Thi Bich Phuong[1], Nguyen Anh Vu[2], Ho Anh Binh[3], Cao Thi Thuy Phuong[3], Tran Quoc Bao[3]

[1]Family Hospital - Đa Nang

[2]Hue University of Medicine and Pharmacy

[3]Cardiovascular center - Hue Central Hospital

**ABSTRACT**

***Objectives:*** *Evaluation of the left ventricular systolic function using tissue motion annular displacement of mitral valve derived by speckle - tracking echocardiography and the correlation between mitral valve annular displacement and echocardiographic parameters for left ventricular systolic function in patients with coronary artery disease.*

***Methods:*** *Descriptive cross - sectional study on 106 patients with coronary artery disease and 106 controls, at Hue University of Medicine and Pharmacy Hospital, from 3/2019 - 10/2021. The study population meet all inclusion criteria according to research objectives. Mitral valve annular displacement derived by speckle - tracking echocardiography was acquired and analyzed offline with QLAB 13.*

***Results:*** *Median age was 66.09 ± 13.25 years and 66.7% was woman. Mitral valve annular displacement derived by speckle - tracking echocardiography in patients with coronary artery disease decreased statistically significant when comparing to control group ($p < 0.01$). This index which was strongly correlated not only with left ventricular ejection fraction on 2D ($r = 0.706$) but also with peak mitral annular systolic velocity (S' velocity) by tissue Doppler ($r = 0.882$). It was a favorable correlation with maximum mitral annular systolic displacement on M - mode ($r = 0.419$), but was not correlated with the location, degree, and number of coronary stenosis.*

***Conclusions:*** *Tissue motion annular displacement of the mitral valve derived by speckle - tracking echocardiography is a simple, rapid and endothelium - independent parameter that supports the left ventricular ejection fraction parameter in the evaluation of left ventricular systolic function when poor endocardial visualization.*

***Key words:*** *Mitral valve annular, echocardiography, coronary artery disease*

**Received:**
29/4/2022
**Revised:**
28/5/2023
**Accepted:**
03/6/2023

**Corresponding author:**
Ho Anh Binh
Email:
drhoanhbinh@gmail.com
Phone: 0913489896

## I. INTRODUCTION

Coronary artery disease is a very common disease among heart diseases and has also tended to increase very rapidly in developing countries in recent years [1]. Assessment of left ventricular (LV) systolic function is important for guiding patient management and prognosis [2]. Speckle tracking echocardiography (STE) is a newly emerging algorithm for analyzing echocardiographic imaging in 2D, regardless of angle, which provides an objective and reproducible quantification of global and regional myocardial function [3].

Myocardial fibers are susceptible to ischemia, especially longitudinal subendocardial fibers [4]. The global longitudinal strain (GLS) assessed by speckle tracking echocardiography (STE) can detect subclinical cardiac dysfunction even if the LV ejection fraction is normal. As the cardiac apex is relatively fixed and mitral annulus displacement (MAD) towards the apex reflects global longitudinal function of LV, it may be a sign of subclinical LV dysfunction in patients with coronary artery disease [5]. Therefore, the aim of our study is to evaluate LV longitudinal function using tissue motion annular displacement of the mitral valve (TMAD) derived by speckle - tracking echocardiography and detect the correlation between TMAD with parameters for left ventricular systolic function and stenosis degree in patients with coronary artery disease (CAD).

## II. MATERIALS AND METHODS

### 2.1. Study population

We enrolled 106 patients with CAD and 106 controls without cardiovascular diseases, at Hue University of Medicine and Pharmacy Hospital, from 3/2019 - 10/2021.

- Disease group: CAD diagnosed by coronary angiography with ≥ 50% reduction of lumen diameter. Exclusion criteria include: valvular disease, pericardial disease, congenital heart disease, atrial fibrillation, chronic pneumonia, liver failure, kidney failure, organ transplantation, calcification of the valve annulus, poor quality imaging.

- Control group: Patient health checked without arterial hypertension, diabete, no pulmonary hypertension, normal echocardiography.

### 2.2. Methodology

Comparative cross - sectional study. All patients were physically examined with paraclinical tests. All echocardiographic parameters were recorded. We used SPSS 18.0 software for Data Analysis.

### 2.3. Research ethics

Approved by the Ethics Council in Biomedical Research of Hue University of Medicine and Pharmacy. All medical records were confidential, and didn't affect the health and treatment of the patients.

## III. RESULT

**Table 1:** Characteristics of study population

| Parameters | Control group (n = 106) | Patient group (n = 106) | P |
|---|---|---|---|
| | X ± SD | X ± SD | |
| Age | 64.31 ± 10.67 | 66.09 ± 13.25 | > 0.05 |
| BMI (kg/m$^2$) | 21.9 ± 1.9 | 22.5 ± 2.8 | < 0.05 |
| LA (mm) | 33.03 ± 5.61 | 31.96 ± 4.2 | < 0.05 |
| LVMI (g/m$^2$) | 102.9 ± 10.3 | 109.8 ± 24,8 | < 0.05 |
| LVIDd (mm) | 46.3 ± 5.1 | 48.1 ± 7.1 | > 0.05 |
| IVSd (mm) | 9.8 ± 1.5 | 11.1 ± 2.5 | < 0.05 |
| LWPWd (mm) | 9.6 ± 1.1 | 10.6 ± 1.8 | < 0.05 |
| S' (mm/s) | 7.7 ± 1.5 | 8.7 ± 0.6 | < 0.05 |
| MAPSE (mm) | 18.6 ± 2 | 16.1 ± 3.6 | < 0.05 |
| EF biplane (%) | 66.8 ± 6.8 | 63.2 ± 11.5 | < 0.05 |

There was a difference between 2 groups in BMI, left atrial diameter, left ventricular mass, interventricular septal thickness diastolic, left ventricular posterior wall thickness diastolic, S', MAPSE and EF. This difference was statistically significant ($p < 0.05$)

**Table 2:** Tissue motion annular displacement of the mitral valve derived by speckle - tracking echocardiography

| | **Patient group n = 106** | **Control group n = 106** | **P** |
|---|---|---|---|
| TMAD% (%) | 15.6 ± 2.3 | 17.0 ± 1.1 | < 0.01 |
| TMAD mean (mm) | 13.8 ± 2.5 | 15.2 ± 1.2 | < 0.01 |

There was a difference between the patient group and the control group in the mean of TMAD and the percentage of TMAD derived by STE. This difference was statistically significant ($p < 0.01$)

**Table 3:** Comparison of TMAD by classification of heart failure NYHA

| | **NYHA 1 n = 88** | **NYHA 2 n = 15** | **NYHA 3 n = 2** | **NYHA 4 n = 1** | **P** |
|---|---|---|---|---|---|
| TMAD % (%) | 15.9 ± 2.0 | 15.0 ± 2.7 | 10.3 ± 0.4 | 9.5 | < 0.05 |
| TMAD mean (mm) | 14.1 ± 2.2 | 13.0 ± 2.8 | 7.8 ± 0.2 | 7.2 | < 0.05 |

The TMAD and the percentage of TMAD on STE in heart failure groups decreased according to the NYHA classification. This difference was statistically significant ($p < 0.05$).

**Table 4:** Comparison of TMAD by chest pain classification CCS

| | **CCS 1 n = 25** | **CCS 2 n = 45** | **CCS 3 n = 25** | **CCS 4 n = 11** | **P** |
|---|---|---|---|---|---|
| TMAD % (%) | 17.9 ± 0.8 | 15.7 ± 1.7 | 15.3 ± 1.0 | 10.8 ± 0.7 | < 0.05 |
| TMAD mean (mm) | 16.6 ± 0.8 | 13.9 ± 1.6 | 12.8 ± 0.7 | 8.7 ± 1.0 | < 0.05 |

The TMAD and the percentage of TMAD on STE in patient group decreased according to the degree of chest pain CCS. This difference was statistically significant ($p < 0.05$).

**Table 5:** Correlation of TMAD with classic echocardiographic parameters

| **TMAD** | | **S'** | **MAPSE** | **EF biplane** |
|---|---|---|---|---|
| TMAD% (%) | r | 0,899 | 0,412 | 0,846 |
| | p | < 0.05 | < 0.05 | < 0.05 |
| TMAD mean (mm) | r | 0,884 | 0,366 | 0,082 |
| | p | < 0.05 | < 0.05 | < 0.05 |

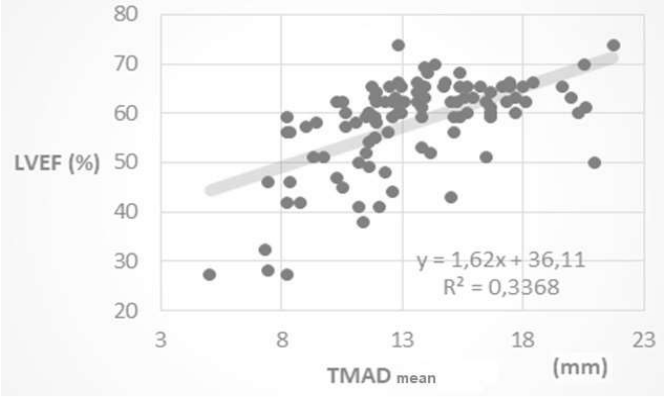


**Figure 1:** Linear regression between EF STE and TMAD mean

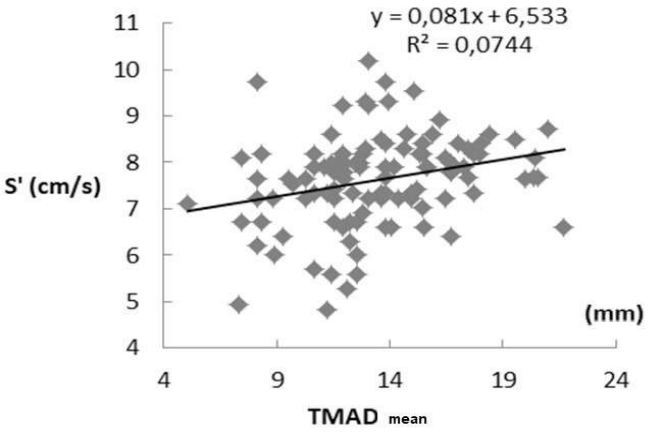


**Figure 2:** Linear regression between S' and TMAD mean

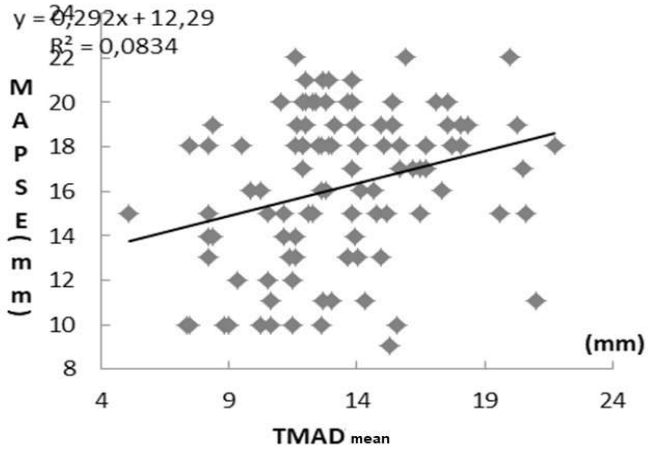


**Figure 3:** Linear regression graph between MAPSE and TMAD mean

**Table 6:** Correlation of TMAD in patient groups according to the degree of coronary stenosis

| TMAD (mm) | | General relatives | Lad | LCx | Rca | Number of vessel disease |
|---|---|---|---|---|---|---|
| TMAD % | r | 0,059 | - 0,053 | - 0,066 | - 0,002 | 0,094 |
| | p | > 0.05 | > 0.05 | > 0.05 | > 0.05 | > 0.05 |
| TMADTB (mm) | r | 0,099 | - 0,019 | - 0,035 | 0,004 | 0,096 |
| | p | > 0.05 | > 0.05 | > 0.05 | > 0.05 | > 0.05 |

Comment: There was no correlation between TMAD and the location, degree, and number of coronary stenosis.

## IV. DISCUSSION

### 4.1. General characteristics of the study population

A total of 106 patient with CAD was analyzed and compared to 106 patients without CAD. The average age in our patient group was 66.09 ± 13.25 years old, which was similar to that of many studies. Iwakura (2018) studied left ventricular systolic function using LVEF, GLS, and TMAD on 247 patients with acute myocardial infarction with an average age of 62.0 ± 12.0 years old [6]. In the study of Pham Quang Tuan (2019), the age of

coronary heart disease group was 65.7 ± 12.3 years old. The youngest was 37 years old and the oldest was 101 years old [7]. In our study, the average BMI of the study group was 22.5 ± 2.8 kg/m$^2$. The largest BMI was 30.1 kg/m$^2$. The lowest BMI was 16.3 kg/m$^2$. Overweight or obesity rate was found in 39.6% of patients. Our results were similar to Do Phuong Anh's study on 190 patients with ischemic heart disease, with an average BMI of 22.7 ± 2.6 kg/m$^2$ [8].

**4.2. Comparison of TMAD in two disease groups and control groups**

With the results obtained, we found TMAD in the disease group was lower than in the control group. In the disease group, the average TMAD was calculated to be 13.8 ± 2.5mm and the percentage of TMAD on STE was calculated to be 15.6 ± 2.3%. This difference was statistically significant ($p < 0.05$). This data was also consistent with previous studies on cut - off of TMAD. In Sharma's study (2020), in the significant stenosis group, the average TMAD and percentage of TMAD derived by STE was measured at 9.7 ± 1.79 mm and 13.09 ± 2.14 mm, respectively. The difference between 2 groups (disease and control) had statistically significant differences ($p < 0.001$) [9].

**4.3. Correlation of TMAD with EF - biplane**

In our study, there was a strong positive correlation between EF and the mean of TMAD (r = 0.706) and percentage of TMAD on STE with (r = 0.713). Our results were comparable to those of Wang (2021), which also showed a strong positive correlation between EF - biplane and the percentage of TMAD (r = 0.72) [10]. This proves that the TMAD is a good indicator to evaluate LV systolic function. Some experts have proposed using this parameter to assess LV longitudinal systolic function when the LVEF is not measured or the echo - image quality is poor. The EF bi - plane represented global LV function, while the TMAD at slice position showed the displacement of the LV wall in the corresponding position. It means a large cavity is a function. When we minimized the error of the mean, this TMAD was closer to the same value of global LV function in severe coronary artery disease group. When taking the mean value, this error has been minimized, bringing the parameters closer to the same value with the same goal of assessing the general function of the ventricular in the severe group of epilepsy. Nishi's (2019) study suggested that simple and rapid estimation of LV longitudinal deformation by tissue-tracking mitral annular displacement in single apical view may be used as a simple index of LV longitudinal deformation [11].

**4.4. Correlation of mean TMAD with S'**

In our study, we found a positive correlation between S' and mean TMAD (r = 0.882), and the percentage (r = 0.862). Suzuki and his colleagues studied TMAD on STE echocardiography in patients with different heart diseases. They showed a strong positive correlation r = 0.611 between the mean TMAD derived by STE and S' [12].

**4.5. Correlation of TMADTB with MAPSE**

Mitral annular plane systolic excursion (MAPSE), reflecting longitudinal myocardial shortening, is a simple and sensitive echocardiographic parameter for assessing global longitudinal LV wall function. Reduced MAPSE is mostly related to subendocardial ischaemia or to fibrosis in some extent. This parameter seems to be much more sensitive, compared with global EF, for detecting early abnormalities, especially useful in patients with poor imaging qualities. Reduced MAPSE is also related to poor outcome in patients with various cardiovascular diseases. Despite the routine use of newer and more refined echocardiographic technologies, MAPSE measurement is still helpful to evaluate LV systolic function during daily routine echocardiography in case of poor sonographic windows as this measurement demands very little of image quality on account of the high echogenicity in the atrioventricular annulus while most advanced echocardiographic techniques (except TDI) require very good image quality [13].

Our study showed a positive correlation between MAPSE and mean TMAD (r = 0.419), and the percentage (r = 0.451). In recent years, STE has established its role in conventional echocardiography. But, not all medical facilities can be equipped and routinely used this imaging technique. In this situation, MAPSE has been suggested as a parameter for left ventricular (LV) function.

**4.6. Correlation of mean TMAD with coronary lesions**

In our study, there was no correlation between TMAD and the location, degree, and number of coronary stenosis. Hoorak et al. (2020) studied 149 patients with cute coronary syndrome (ACS). They described a significant relationship between TMAD and LV 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 [4]. Thapa et al. showed that TMAD improved the assessment of the LV systolic function in cases of regional dyskinesia because displacement is measured in both lateral and septal side of the mitral annulus. TMAD is a reliable indicator to evaluate the global longitudinal systolic (GLS) function of the left ventricle. This evaluation is useful for rapid and early diagnosis in case of coronary artery disease before coronary angiography [14]. Iwakura (2021) found that TMAD could be a simple and reliable alternative to GLS for predicting outcomes in patients with myocardial infarction [15].

Ischemic heart disease is the most frequent cause of regional wall - motion abnormalities which can reduce annulus mitral displacement and the correlation between TMAD parameters and LVEF could be affected. However, when Wang et al. (2020) evaluated the TMAD derived by STE, on 456 patients, including 46 patients with regional dyskinesia, they showed no significant differences between the observed and the estimated LVEF in the regional wall motion abnormalities set [10].

**V. CONCLUSION**

Tissue motion annular displacement of the mitral valve derived by speckle - tracking echocardiography is a simple and rapid parameter, endothelium - independent that supports the left ventricular ejection fraction parameter in the evaluation of left ventricular systolic function when poor endocardial visualization.

**REFERENCES**


1. Nguyen VA. Study of disease patterns in inpatient treatment at the Vietnam Heart Institute during 2003-2007. Vietnam Journal of Cardiology. 2010;52:1-18.
2. Knuuti J, Wijns W, Saraste A, Capodanno D, Barbato E, Funck - Brentano C, et al. 2019 ESC Guidelines for the diagnosis and management of chronic coronary syndromes. Eur Heart J. 2020;41(3):407-477.
3. Vu NA. Echocardiography - diagnostic update. Hue University Press. 2019;8:192- 215.
4. Poorzand H, Alborz H, Alimi H, Emadzadeh M. Assessment of tissue mitral annular displacement in patients with coronary artery stenosis. ARYA Atheroscler. 2021;17(3):1-6.
5. Kaushik A, Sharma JB, Choudhary R, Deora S. Sharma, J.B., Deora, S., Choudhary, R. Kaushik, A.Comparison of mitral annular displacement and global longitudinal strain imaging for predicting significant coronary atherosclerotic disease in patients of chronic stable angina pectoris. Int J Cardiovasc Imaging. 2020;37:1-8.
6. Iwakura K, Okamura A, Koyama Y, Inoue K, Iwamoto M, Nagai H, et al. auTomated assessment of left ventricular systolic function predicts functional and clinical outcomes after acute myocardial infarction. Journal of the American College of Cardiology. 2018;71(11_ Supplement):A1711-A1711.
7. Tuan PQ, Study on the diagnostic role of serum IMA (Ischemia Modified Albumin) in collaboration with hs-Troponin T in patients with acute coronary syndrome. Hue University of Medicine and Pharmacy Journal. 2019;3(1)23-28.
8. Anh DP, Research on left ventricular function by myocardial tissue Doppler ultrasound in patients with chronic ischemic heart disease before and after reperfusion treatment. Hanoi Medical University Journal. 2014;4(1):43-37.
9. Sharma JB, Deora S, Choudhary R, Kaushik AJE. Diagnostic utility of mitral annular displacement by speckle tracking echocardiography in predicting significant coronary artery disease in suspected chronic stable angina pectoris. 2020;37(12):2010-2017.
10. Wang Y, Liu S, Li J, Zhang Y, Li G, Kong F, et al., Validation of Estimating Left Ventricular Ejection Fraction by Mitral Annular Displacement Derived From Speckle-Tracking Echocardiography: A Neglected Method for Evaluating Left Ventricular Systolic Function. J Clin Ultrasound. 2021;49(6):563-5722020.
11. Nishi T, Hozumi T, Takemoto K, Wada T, Maniwa N, Kashiwagi M, et al. P4349Simple and rapid estimation of

left ventricular longitudinal deformation by tissue-tracking mitral annular displacement in single apical view. European Heart Journal. 2019;40(Supplement_1):ehz745.0757.

12. Suzuki K, Akashi YJ, Mizukoshi K, Kou S, Takai M, Izumo M, et al. Relationship between left ventricular ejection fraction and mitral annular displacement derived by speckle tracking echocardiography in patients with different heart diseases. J Cardiol. 2012;60(1):55-60.
13. Bergenzaun L, Öhlin H, Gudmundsson P, Willenheimer R, Chew M. Mitral annular plane systolic excursion (MAPSE) in shock: A valuable echocardiographic parameter in intensive care patients. Cardiovascular ultrasound. 2013;1116.
14. Thapa P, Xing YY, Li YH. Mitral annulus displacement measured by two-dimensional speckle tracking imaging to assess the left ventricular longitudinal systolic function in coronary heart disease. J Clin Ultrasound. 2014;42(9):544-9.
15. Iwakura K, Onishi T, Okamura A, Koyama Y, Inoue K, Nagai H, et al. Tissue Mitral Annular Displacement in Patients With Myocardial Infarction - Comparison With Global Longitudinal Strain. 2021;3(9):530-539.