Effect of termination of the left anterior descending coronary artery (wrapped or non-wrapped property) on tissue Doppler echocardiography findings in patients with anterior myocardial infarction: an observational study

Anteriyor miyokart enfarktüs hastalarında sol ön inen koroner arterin sonlanım şeklinin (sarılı olan ve olmayan özelliği) doku Doppler ekokardiyografi bulgularına etkisi: Gözlemsel bir çalışma

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Abstract

Objective: We aimed to evaluate effect of termination property of left anterior descending (LAD) on tissue Doppler echocardiography (TDE) parameters in patients experiencing their first anterior myocardial infarction (AMI) who had undergone successful primary percutaneous coronary intervention (PCI)

Methods: A prospective, cross-sectional observational study was performed. Eighty-four patients were enrolled in the study. Echocardiography was performed during the first three days of AMI. Conventional TDE measurements were obtained from right ventricular (RV) and four left ventricular (LV) walls: for the systolic function - mitral annular TDE systolic velocity - Sm, for diastolic function - mitral annular TDE early and late diastolic velocities - Em, Am, transmitral early and late diastolic velocities ratio - E/A, and combined systolic and diastolic function - myocardial performance index (MPI). Coronary arteries were evaluated and patients were divided into two groups (non-wrapped LAD and wrapped LAD) according to the termination properties. Student-t, Mann-Whitney U and Chi-square tests, bivariate Pearson and Spearman correlation analyses were used for statistical analysis.

Results: Baseline characteristics and conventional echocardiographic parameters of the patients were similar. There was a statistically significant difference for the anterior wall Sm parameter, whereas there was no substantial difference for Em, Am and MPI values. The anterior wall Sm was more affected in patients with non wrapped LAD than in patients with wrapped LAD (6.70±1.66 and 7.44±1.66 cm/s; p=0.036,).The anterior Sm parameter was uniquely correlated with LAD termination status when compared with other independent parameters (r=0.236, p=0.036).

Conclusion: We showed that termination of LAD is important for the anterior wall systolic functions in the early stage of AMI treated successfully. *(Anadolu Kardiyol Derg 2012; 12: 465-71)*

Key words: Coronary anatomy, coronary artery, tissue Doppler echocardiography, myocardial infarction, systolic function, diastolic function

Özet

Amaç: Primer perkütan koroner girişim ile başarılı tedavi edilen anteriyor miyokart enfarktüs (AME) hastalarında sol ön inen koroner arter (LAD) sonlanımının doku Doppler ekokardiyografi(DDE) bulgularına etkisinin değerlendirilmesi amaçlandı.

Yöntemler: Çalışma enine kesitli gözlemsel prospektif olarak planlandı. Seksen dört hasta çalışmaya dahil edildi. Hastalara ilk üç gün içinde ekokardiyografik değerlendirme yapıldı. Klasik DDE parametreleri sağ ventrikül (RV) lateral duvar ve sol ventriküle (LV) ait dört duvardan alındı. DDE parametreleri olarak; sistolik fonsiyonların değerlendirilmesinde - DDE mitral annüler sistolik hız değeri - Sm, diyastolik fonksiyonların - DDE mitral annüler erken ve E/A değerleri, kombine sistolik ve diyastolik fonksiyonların değerlendirilmesinde - miyokart performans indeksi (MPI) değeri kullanıldı. LAD sonlanım özelliğine göre iki gruba (sarılı olan ve olmayan LAD) ayrıldı. İstatistiksel analizde Student-t, Mann-Whitney U ve Ki-kare testleri, Pearson ve Spearman bivaryasyon korelasyon analizleri kullanıldı.

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Bulgular: Hastaların demografik verileri ve bazal ekokardiyografik ölçümleri benzerdi. RV ve LV için 4 duvardan alınan anüler DDE parametrelerinden sadece anteriyor Sm değerinde (Ant Sm) istatistikî anlamlılık ortaya çıkarken, Em, Am ve MPI değerlerinde anlamlı değişiklik tespit edilmemiştir. LAD koroner arterin LV apikalde sonlanan, diyafragmatik yüze (sarılı olmayan) geçiş göstermeyen olgularda anteriyor duvarın Sm değeri LAD koroner arterin LV apikalde sonlanmayan, diyafragmatik yüze geçiş gösterdiği (sarılı olan) olgulara göre daha fazla etkilendiği ortaya çıkmıştır (6.70±1.66 and 7.44±1.66 cm/sn; p=0.036). Anteriyor Sm değeri ile LAD uzunluğu arasında korelasyon tespit edildi (r=236, p=0.036).
Sonuç: LAD sonlanımı primer perkütan koroner girişim ile başarılı tedavi edilen AME hastalarında, erken dönemde anteriyor duvarın sistolik fonksiyonları için önemli bir parametredir. *(Anadolu Kardiyol Derg 2012; 12: 465-71)*
Anahtar kelimeler: Koroner anatomi, koroner arter, miyokart enfarktüsü, doku Doppler ekokardiyografi, sistolik fonksiyon, diyastolik fonksiyon

Introduction

Myocardial infarction (MI) eventuates irreversible myocardial damage. Anterior ST segment elevation MI (STEMI) is caused by total occlusion of the left anterior descending (LAD) coronary artery at different levels. In the literature, LAD is classified two groups according to termination (1-5). The normal anatomic pattern in most individuals (6), which is approximately 3/4 of all patients, is for the LAD to course around the apex and terminates along the diaphragmatic area of the left ventricle; some researchers call this a wrapped LAD. In the other 1/4 of patients, the LAD does not reach the diaphragmatic area, terminating at the LV apex or before the apex; this is called a non-wrapped LAD (1-5).

Although myocardial damage in regard to termination of LAD coronary artery can be shown by electrocardiography (ECG) criteria (1-4), the localization and extensity of the myocardial injury was not correlated with ECG, echocardiographic, and angiographic findings (7, 8). Inferior ST elevation during acute anterior myocardial infarction and ECG findings related to the termination and localization of the LAD coronary artery lesion in patients with anterior MI have been defined in the literature (1-5, 9). In addition, the localization, extensity of the myocardial injury, and possible effect on ventricular function have not yet been determined elaborately by imaging modalities.

Therefore, we thought that the termination of the LAD could be an important feature for anterior, inferior wall, and right ventricular (RV) systolic and diastolic function in anterior MI and this hypothesis have not been confirmed before.

In this study, we sought to confirm the above mentioned hypothesis and aimed to evaluate the effect of termination properties of the LAD coronary artery on the left ventricular (LV) and RV systolic and diastolic functions by tissue Doppler echocardiography (TDE) in patients experiencing their first anterior myocardial infarction who had undergone successful primary percutaneous coronary intervention (PCI).

Methods

Study design

A cross-sectional prospective observational trial was performed.

Patient selection

Eighty-four patients with their first attack of STEMI, who were hospitalized to Cardiology Department, Selcuk University Faculty of Medicine Hospital, within 1-12 hours of symptom onset and who had undergone successful primary PCI (balloon angioplasty and bare metal stent implantation was performed if required), were enrolled in the study between June 2007 and June 2009. Patients with bundle branch block, recurrent percutaneous interventions (acute stent thrombosis), prior history of MI and percutaneous transluminal coronary angioplasty to the LAD, critical stenosis (>50%) in the right coronary artery (RCA) and circumflex coronary artery (Cx), moderate-severe valve regurgitation or stenosis were excluded from the study.

The ethical implications regarding the study were approved by the local Ethics Committee and informed consent was obtained from each patient.

Echocardiography

Echocardiography was performed during the first three days of acute MI. Philips Envisor-HD11XE and 2-4 MHz phase transducers (Philips Medical Systems, Andover, MA, USA) were used simultaneously with ECG recording. Conventional TDE measurements were obtained from the parasternal long- and short- axis and apical 2-4 -chamber imaging windows in the left lateral decubitus position. RV measurements were obtained from the parasternal short axis and RV lateral wall, and tricuspid inflow measurements were obtained from the apical four chambers. Records were obtained while the patient was holding his or her breath at expirium. Measurements were obtained from three consecutive beats and mean values were recorded. The left atrial diameter, aortic diameter, systolic and diastolic diameters of the LV, septal and posterior wall thickness's were recorded from the standard parasternal long axis views. LV end-systolic, end-diastolic volumes and ejection fraction (EF) were calculated from apical two- and four- chamber views by using the modified Simpson method. Using the semi-quantitative method, the LV wall motion was given points as follows: 1) normokinetic, 2) hypokinetic, 3) akinetic, 4) dyskinetic, 5) aneurysm. Then the sum of these points is divided by the number of the segments calculated (16 segments), and a wall motion score index (WMSI) is obtained. All values are recorded based upon the recommendations of the American Society of Echocardiography (10).

Doppler echocardiography

The sample was placed to the mitral and tricuspid valve tips and transvalvular flow parameters were obtained by means of pulsed wave (PW) Doppler, parallel to the blood flow. Mitral and tricuspid peak early (E) and late (A) diastolic velocities, decelera-

tion time E (dtE), and E/A ratio were calculated. The left ventricular outflow tract and mitral inflow velocities were simultaneously recorded; isovolumic relaxation (IVRT) and contraction (IVCT) times, and ejection time (ET) were calculated. For the RV outflow tract assessment, the sample volume was placed just below the pulmonary valve from the parasternal short axis view, and the RV ejection time was calculated. Total RV systole was calculated from the tricuspid inflow. Conventional LV myocardial performance index (MPI) was calculated by dividing the sum of IVRT and IVCT to ET from LV measurements. RV MPI was derived from RVOT and tricuspid inflow measurements by subtracting RV ET from total RV systolic time and dividing this by RV ET.

LV MPI=(IVRT+IVCT) / ET

RV MPI=(Total RV Systole-RV ET)/RV ET (11, 12)

Tissue Doppler echocardiography

By means of PW TDE from the apical four-chamber view, measurements were obtained for the right ventricle and four LV walls (anterior, septum, inferior, lateral). PW TDE recordings are acquired by placing the sample volume to each wall's mitral annulus for the left ventricle and the tricuspid lateral annulus for RV. Mitral annular velocity values during systole (Sm), early and late diastole (Em and Am) were recorded for each segment. Em/Am and mitral E/Em ratios were calculated. IVRT, ET, and IVRT values were recorded for each wall. TDE derived MPI was calculated for both LV and RV by using the "(IVRT+IVCT)/ET" formula.

LV MPI (TDE)=LV (IVRT+IVCT)/ET

RV MPI (TDE)=RV (IVRT+IVCT)/ET (11, 12)

The imaging angle was adjusted to ensure a parallel alignment of the sampling window with the myocardial segment of interest, and the angle was below 20°. Gain settings, filters, pulse repetitive frequency, sector size, and depth were adjusted to optimize color saturation. The PW TDE spectral signal filters were adjusted to obtain a Nyquist limit of ±30 cm/s. Gain was minimized to obtain a clear signal from the tissue with the lowest possible level of background noise. The Doppler sweep rate was adjusted to 100 mm/s for all measurements. At least 3 consecutive beats were recorded during expirium and analyzed on-line. For the systolic function Sm parameter, for diastolic function Em, Am mitral E/A parameters and combined systolic and diastolic function MPI parameters were used as result of the TDE findings (11, 12). Echocardiographic measurements were made by the same cardiologists who were blinded to the clinical information of the patients.

Coronary angiography

Coronary arteries were evaluated according to the termination properties of the LAD (1-5). The "wrapped LAD" was defined as an LAD artery from an after-reperfusion coronary angiogram that perfused at least one fourth of the inferior wall of the LV in the right anterior oblique and caudal projection (1-5).

A: Non-wrapped LAD: LAD terminates at apex and does not extend to diaphragmatic face (inferior) (Fig. 1).

B: Wrapped LAD: LAD does not terminate at apex and extends through diaphragmatic face (Fig. 2).

Statistical analyses

The statistical analyses were performed using software (SPSS 15.0, SPSS Inc, Chicago, Ill, USA). The Kolmogorov-Smirnov test was used to evaluate whether the variables were

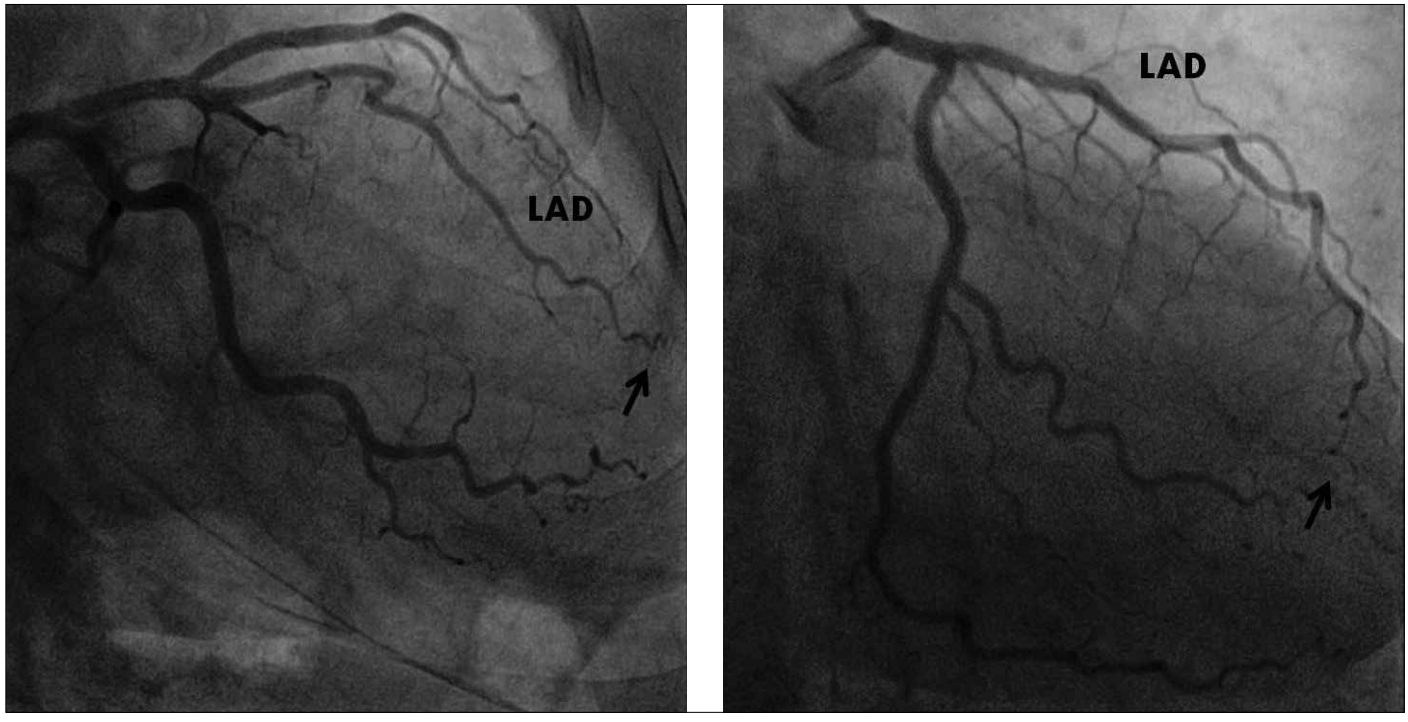

Figure 1. Non-wrapped left anterior descending artery (LAD), black arrow shows termination of LAD

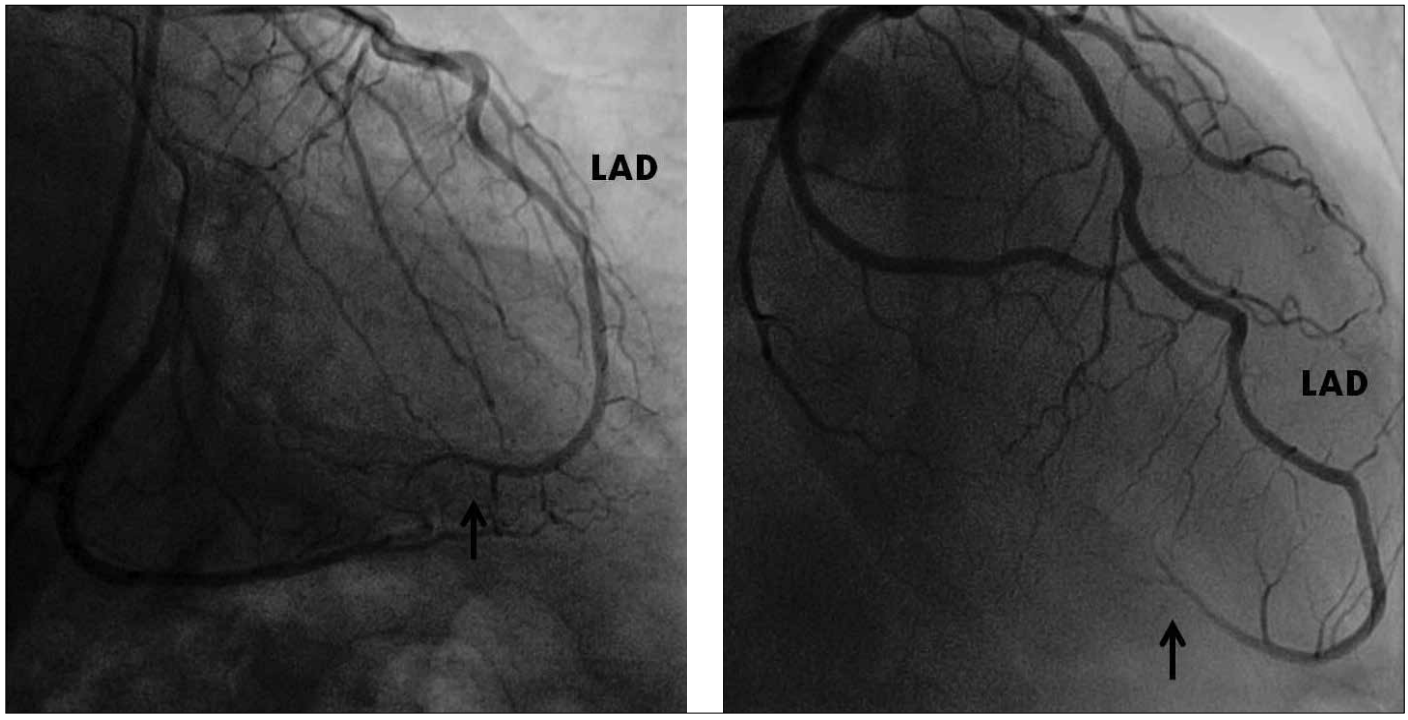

Figure 2. Wrapped left anterior descending artery (LAD), black arrow shows termination of left anterior descending (LAD)

normally distributed. The Continuous variables are presented as mean±SD or as median (interquartile range). The unpaired Student-t test and Chi-square tests were used for comparisons of normally distributed continuous variables and categorical variables in two groups. The Mann-Whitney U test was used for non-normally distributed variables. Bivariate correlation analyses were made using Pearson and Spearman correlation tests. A p value <0.05 was considered statistically significant.

Results

Baseline characteristics

The baseline characteristics of the patients are presented in Table 1. There were no significant differences between the two groups in terms of gender, age, or risk factors, such as hypertension, diabetes mellitus, hyperlipidemia, and smoking. The mean age of the study population was 56.3±13.2 years. In addition, time from onset of the symptoms to PCI and time from admission to echo examination were similar in both groups.

Echocardiography findings

Baseline values of echocardiographic measurements and heart rate did not differ between two groups (Table 1). There was a statistically significant difference for the anterior wall Sm parameter, whereas there was no substantial difference for LV and RV Em, Am, and MPI values. The anterior wall Sm was more affected in patients with non-wrapped LAD than in patients with wrapped LAD (6.70±1.66 and 7.44±1.66 cm/s; p=.036, Fig. 3). The anterior Sm parameter was uniquely correlated with LAD termination status when compared with other independent parameters including age, gender, time from symptom onset to PCI, time from symptom onset to first echocardiographic examination (r=0.236, p=0.036).

Comprehensive LV and RV TDI findings are shown in Table 2. LV score index in the non-wrapped group was higher than the wrapped group but it did not reach statistical significance (1.85±.27 and 1.73±.32; p=0.09). In addition, LV EF in the non-wrapped group was lower than the wrapped group but it did not reach statistical significance (42.50%±8.61 and 45.27%±9.08; p=0.07, Fig. 4). There were no differences in TDE parameters showing RV and inferior systolic and diastolic function including MPI between the groups.

Discussion

The main finding of present study is that termination of the LAD is important for anterior wall systolic function in the early stage of AMI. We discussed our results under four titles: systolic functions, diastolic functions and MPI, RV, and inferior wall function.

Systolic function

The anterior wall had only reached statistical significance among the other walls of the LV (lateral, septal, inferior) and RV systolic Sm, reflecting systolic functions (13-16). Although LV mean Sm values were not different in either group, anterior wall Sm values in patients with non-wrapped LAD were significantly lower than patients with wrapped LAD. LV mean EF in the Non-Wrapped group was lower than the Wrapped group with values close to significance (Fig. 4); this can support our findings. Alam et al. (16)

Table 1. Baseline characteristics of the patients

Variables	Non-wrapped LAD (n=44)	Wrapped LAD (n=40)	*p
Patient characteristics			
Age, years	57±12	56±15	0.277
Female / male, n	14/30	10/30	0.165
Body mass index, kg/m^2	28±4	28±6	0.908
Medical history			
Current smoker, n (%)	25 (56)	18 (45)	0.336
Hypertension, n (%)	14 (31)	11 (27)	0.915
Diabetes mellitus, n (%)	11(25)	9 (21)	0.124
Hyperlipidemia, n (%)	4 (9)	4 (10)	0.147
Time intervals relevant to admission			
Time from symptom onset to PCI, hours	6.3±5.2	6.7±6.2	0.380
Time from symptom onset to first echocardiographic examination, hours	35.3±22.7	39.7±29.3	0.808
Hemodynamics			
Blood pressure, mmHg			
Systolic	106±10	105±9	0.908
Diastolic	69±6	68±5	0.568
Heart rate on admission, beat/min	77±11	75±10	0.376
Conventional echocardiography			
LVEF, %	42.5±8.6	45.2±9.0	0.077
LVEDD, cm	4.7±0.4	4.8±0.5	0.361
LVESD, cm	3.2±0.5	3.1±0.6	0.884
LADia, cm	3.6±0.4	3.5±0.4	0.359
IVS, mm	9.8±0.6	9.7±0.5	0.334
PW, mm	9.3±0.3	9.3±0.6	0.289
LV mass, gr	128.6±49.7	127.3±36.0	0.929
Mitral E/A	1.0±0.4	0.9±0.2	0.436
Tricuspid E/A	1.0±0.3	0.9±0.3	0.402
MPI LV conventional	53.7±12	49.5±15.4	0.073
MPI RV conventional	31.3±13.3	35.5±8.8	0.267
LV score index, score/16	1.8±0.2	1.7±0.3	0.094
Anterior wall score index, score/3	5.5±1.5	4.9±1.7	0.098
Medications			
Aspirin, (%)	100	100	>0.05
Clopidogrel, (%)	100	100	
Beta-blockers, (%)	100	100	
ACEI or ARB, (%)	88	90	
Statins, (%)	92	88	
Localization of LAD lesion			
Proximal, n (%)	17 (38)	23 (57)	0.137
Mid, n (%)	25 (57)	15 (38)	0.196
Distal, n (%)	2 (5)	2 (5)	0.928

Data are presented as number (percentage) and mean±SD values
*Chi-square test and unpaired Student-t test
ACEI - angiotensin converting enzyme inhibitors, ARB - angiotensin receptor blockers, IVS - interventricular septum, LAD - left anterior descending, LVEF - left ventricular ejection fraction, LVEDD - left ventricular end diastolic diameter, LVESD - Left ventricular end systolic diameter, LADia - left atrial diameter, LV - left ventricle, MPI - myocardial performance index, PCI - percutaneous coronary intervention, PW - posterior wall, RV - right ventricle

Table 2. Comparison of terminations of LAD properties on TDE parameters

Variables	Non-wrapped LAD (n=44)	Wrapped LAD (n=40)	*p
Lateral SM	7.85±1.88	8.22±2.14	0.308
Lateral EM	8.18±2.95	8.06±2.63	0.811
Lateral AM	10.30±2.98	11.43±3.12	0.051
Lateral MPI	71.54±18.72	71.57±24.23	0.993
Anterior SM	6.6 (5.7-7.3)	7.5 (6.1-8.3)	0.036
Anterior EM	7.43±2.64	7.19±2.85	0.686
Anterior AM	9.57±2.87	11.42±3.36	0.089
Anterior MPI	73.98±18.80	81.05±35.78	0.255
Inferior SM	8.24±1.79	8.32±1.76	0.845
Inferior EM	7.07±2.40	6.93±2.55	0.782
Inferior AM	12.05±2.56	11.65±1.99	0.435
Inferior MPI	72.81±27.11	70.02±25.91	0.634
Septal SM	7.43±1.60	7.67±1.42	0.477
Septal EM	6.50±1.78	6.63±2.27	0.765
Septal AM	10.28±1.86	10.42±1.76	0.720
Septal MPI	74.31±18.50	72.98±22.61	0.768
LV mean SM	7.67±1.46	8.08±1.42	0.208
LV mean EM	7.22±2.26	7.26±2.41	0.937
LV mean AM	10.78±2.03	11.45±1.78	0.120
LV mean MPI	73.60±18.26	71.86±21.77	0.697
RV SM	13.75±2.76	14.03±2.65	0.588
RV EM	18.08±3.46	17.57±3.28	0.330
RV AM	17.24±5.24	15.78±3.97	0.099
RV MPI	48.03±17.33	54.44±27.84	0.131

Data are presented as mean±SD values and median interquartile range (IQR)
*unpaired Student-t test and Mann-Whitney U test
AM - atrial motion (cm/s), EM - early motion (cm/s), LAD - left anterior descending, LV - left ventricle, MPI - myocardial performance index, RV - right ventricle, Sm- systolic motion (cm/s)

showed that Sm value has a good correlation with LV EF. However, the LV mean Sm did not differ significantly according to termination of the LAD. Despite the Ant Sm being affected significantly and the LV mean EF being closer to a significant value, the LV mean Sm was not affected by the wrapped status. This can be explained by compensatory hyperkinesis during the early phase of myocardial infarction (17-19). Kato et al. (19) speculated possibility of left ventricular functions overcompensation by non-infracted myocardium during the early period after successful PCI. Additionally to these findings, Gurudevan et al. (18) revealed up to the 40% compensatory hyperkinesis in the non-infracted left ventricular wall in single coronary artery disease in patients with initial ST-elevation acute myocardial infarction. LV score Index was lower in the wrapped group with a value close to significance. Contrary to prior studies (1-2), the LV score index was lower and the LV EF was higher in patients

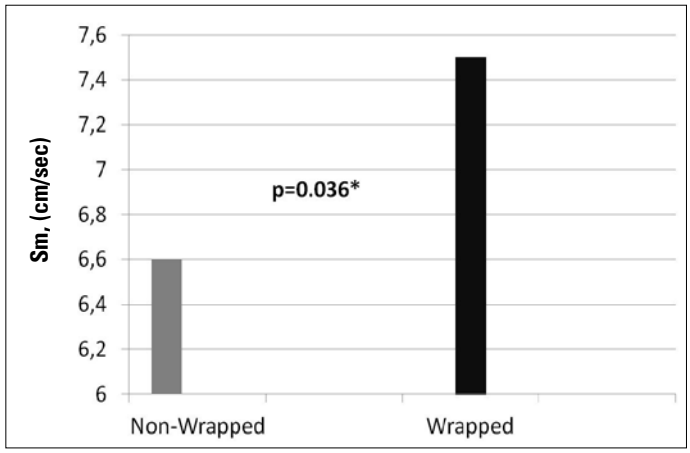

Figure 3. Mean anterior Sm values of non-wrapped and wrapped LAD groups

*Mann-Whitney U test

LAD - left anterior descending artery, Sm - mitral annular systolic flow velocity

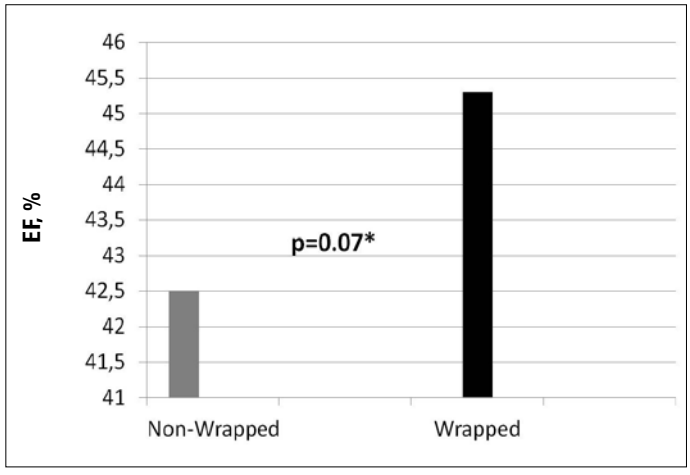

Figure 4. Mean EF values of non-wrapped and wrapped LAD

*unpaired Student-t test

EF - ejection fraction, LAD - left anterior descending artery

with a wrapped LAD. Some differences between our study and other studies are as follows: inclusion of not just LAD lesions, but also right coronary artery and circumflex artery lesions; low rates of TIMI 3 flow and inclusion of TIMI 1 and 2 flows; relatively late application of PCI processes and inclusion of patients with prior history of coronary artery disease and MI; no standardization of reperfusion process (not for only PCI but inclusion of PCI, fibrinolysis, and medical management groups); evaluation of MI size with peak creatine-kinase MB fraction, EF (determination with ventriculography), and LV score index rather than with elaborate echocardiographic imaging.

These factors may all account for the differences between the results. When taking into account inclusion of patients with only LAD lesions, TIMI 3 flow for the entire study population, echocardiographic examination soon after acute MI, and detailed assessment of LV and RV regional systolic and diastolic functions together with respect to termination of LAD increase the significance of our study.

Diastolic function and MPI

We did not find any significance in TDE parameters reflecting diastolic function and MPI in both group. The reason for obtaining non-significant results may be explained by noting that the left ventricular functions were overcompensated by non-infarcted and salvaged myocardium or that measurement parameters were not consistent during the early hours after a successful PCI (19).

RV and inferior wall function

Current research shows that RV involvement in acute left ventricular myocardial infarction (20-21) and substantial ST elevation can be seen in inferior derivations in patients with anterior MI due to the mid portion of wrapped LAD lesions (1-5, 9). Some investigators think this occurs because of transmural ischemia of the LV inferior wall supplied by the wrapped LAD (1-5, 9). Contrary to this suggestion, termination of the LAD did not affect the inferior and RV systolic and diastolic function according to the TDE findings (Table 2).

Study limitations

Current imaging tools as strain/strain rate, speckle tracking echocardiography, MRI, and nuclear molecular imaging may represent the more reproducible, sensitive, methods for assessing ventricular function. Data derived from this study, which associated termination of LAD and TDE findings were not significant. Because of the small study sample, subgroup analyses were not strong either. The main reason for the small study sample size can be explained due to the strict exclusion criteria and single center study. Other limitations of the study were missing data from the collateral index and myocardial blush grading on the termination of LAD assessing myocardial function using TDE and lack of intraobserver variability. In addition, short-term or long-term follow up could be performed to obtain clinical, prognostic data and mortality rate.

Conclusion

The termination property of the LAD is not only considered anatomical information but also a robust clinical entity and may play a pivotal role in some clinical conditions. We revealed that termination of the LAD is important for anterior wall systolic function in the early stage of AMI, which is treated successfully with PCI. Additionally, our results demonstrated that termination of the LAD does not affect RV and inferior wall function. Finally, echocardiography using TDI is easily applicable and gives us important information from the injured myocardium. We need large study populations, further and more comprehensive studies and screening modalities to expose the impact of the termination of the LAD on myocardial injury in the early stage of AMI.

Conflict of interest: None declared.

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