KLİNİK ÇALIŞMA / ORIGINAL ARTICLE

Kararlı anjina pektorisi olan hastalarda SYNTAX skoru ile hesaplanan koroner arter hastalığı yaygınlığı ve ciddiyetinin sol atriyum deformasyonu parametreleri üzerine etkileri

The effects of severity, and extent of coronary artery disease estimated using SYNTAX score on the left atrial deformation parameters in patients with stable angina pectoris

Dr. Arzu Kalaycı, Dr. Can Yücel Karabay, Dr. Onur Taşar, Dr. Servet İzci, Dr. Çetin Geçmen, Dr. Vecih Oduncu, Dr. İbrahim Akın İzgi, Dr. Cevat Kırma

Kartal Koşuyolu Yüksek İhtisas Eğitim ve Araştırma Hastanesi, Kardiyoloji Kliniği, İstanbul

ÖZET

Amaç: Bu çalışmada amacımız, kararlı anjina pektoris (KAP) ile başvuran ve koroner arter hastalığı (KAH) saptanan hastalarda, SYNTAX skoru (SXskoru) ile hesaplanan anjiyografk lezyon yaygınlığı ve ciddiyeti ile iki boyutlu (2D) speckle tracking ekokardiograf (STE) yöntemi ile değerlendirilen sol atriyum deformasyonu paremetreleri arasında ilişki olabileceğini göstermektir.

Çalışma planı: Çalışmaya KAP tanısı konmuş 60 hasta (40 erkek 20 kadın) ve bazal özellikleri yönünden benzer 30 sağlıklı bireyden oluşan kontrol grubu alındı. Konvansiyonel ekokardiyografk parametrelerle birlikte ventrikül ve atriyal sistolleri sırasında pik sol atriyal strain (sırasıyla, LA-RES ve LA-PUMP), ventrikül sistolü sırasında pik sol atriyal strain oranı (LA-SRS), erken diyastol sırasında pik sol atriyal strain oranı (LA-SRE) ve atriyal sistolü sırasında pik sol atriyal strain oranı (LA-SRA) ölçümleri elde edildi.

Bulgular: Hastalar SXskoru <20 (grup I) ve yüksek SXskoru ≥20 (grup II) olmak üzere iki gruba ayrıldı. Sol ventrikül (SV) diyastolik fonksiyonlar SXskoru yüksek grupta bozulmuş olup, SV dolum basınçlarında anlamlı artış saptandı. LA-RES (kontrol grubu: 42.3±7.9, grup I: 36.4±8.2 grup II: 27.5±8.1 p<0.001) ve LA-PUMP (kontrol grubu: 17.6±3.4, grup I: 15.7±2.5 grup II: 13.1±3.2 p<0.001) yüksek SXscore grubunda düşük SXscore grubuna göre anlamlı olarak daha düşüktü. Üç grup arasında LA-SRS, LA-SRE, LA-SRA açısından anlamlılık saptanmadı. SXskoru seviyesi ile LA-RES fonksiyonu arasında ise negatif ilişki olduğu saptandı (r:-0.49, p<0.001).

Sonuç: Kararlı koroner arter hastası SXskoru yüksek kişilerde 2D-STE'ye ilişkin sol atriyal deformasyon parametreleri anlamlı derecede bozulmaktadır. KAP'li hastalarda, LA-RES ve LA-PUMP değerleri, KAH'nın yaygınlığı ve ciddiyetini öngörmede kullanılabilir.

ABSTRACT

Objectives: Aim of the present study was to investigate correlation between left atrial (LA) deformation parameters assessed using 2-dimensional (2D) speckle tracking echocardiography (STE) and complexity of coronary artery disease according to SYNTAX score (SXscore) in patients with stable angina pectoris (SCAD).

Study design: **A** total of 60 patients (40 men, 20 women) diagnosed as SAP who underwent coronary angiography and 30 healthy controls with comparable demographic characteristics were included in the study. Measurements of conventional echocardiographic parameters as well as peak LA strain during ventricular systole (LA-RES), peak LA strain during atrial systole (LA-PUMP), peak LA strain rate during ventricular systole (LA-SRS), peak LA strain rate during early diastole (LA-SRE), and peak LA strain rate during atrial systole (LA-SRA) were obtained.

Results: Patients were categorized into 2 groups: low SXscore of <20 (Group I) and high SXscore of ≥20 (Group II). Left ventricular (LV) diastolic functions were signifcantly impaired and LV flling pressure was signifcantly higher in high SXscore group. LA-RES (Control Group: 42.3±7.9, Group I: 36.4±8.2, Group II: 27.5±8.1; p<0.001) and LA-PUMP (Control Group: 17.6±3.4, Group I: 15.7±2.5, Group II: 13.1±3.2; p<0.001) were signifcantly lower in high SXscore group compared with low SXscore group. There was no statistical difference in LA-SRS, LA-SRE, or LA-SRA between the 3 groups. Correlation analysis indicated inverse correlation between SXscore level and LA-RES function (r=-0.49; p<0.001).

Conclusion: 2D-STE-based LA deformation parameters are significantly impaired in patients with SCAD who have high SXscores. In addition, evaluation of LA-RES and LA-PUMP functions might be useful in estimating severity of disease in patients with SCAD.

Submitted on: 07.04.2016 *Accepted for publication on:* 12.22.2016

Address of correspondence: Dr. Arzu Kalaycı. Anafartalar Caddesi, Taç Mahal Sitesi, B Blok, No: 26,
Cevizli, Kartal, İstanbul, Turkey.
Phone: +90 216 - 500 15 00 e-mail: arzukalayci@yahoo.com

Coronary artery disease (CAD) is the most frequently seen cause of mortality, and morbidity in the world, and in our country, and constitutes a high risk for heart failure. It is already known that in patients with stable angina pectoris, and diffuse CAD, mostly left ventricular diastolic dysfunction or even regional or global left ventricular dysfunction are found , and these findings may be used as an early, and sensitive indicator of ischemia.. [1,2] In the presence of left ventricular dysfunction, the contribution of left atrium becomes even more important in the formation of stroke volume.[3] While investigating hemodynamic effects of many diseases, evaluation of left atrial functions conveys importance.. In recent years, "strain", and "strain rate" values which very well reflect global, and region, systolic, and diastolic myocardial deformations have been demonstrated, and confirmed to be strong echocardiographic parametres. These values have been also detected to be sensitive indicators of myocardial ischemia in patients with CAD:[4–8] Measurement of atrial deformation parametres using strain method is a useful, and a promising method. However scarce number of studies in the literature have investigated the relation between atrial myocardial deformation and the presence, and severity of CAD. The extent , and severity of CAD have not been categorized, and evaluated using a classification method .[9–12]

The aim of this study is to investigate the impact of extent, and severity of CAD which are estimated using SYNTAX scores (SXscore) on the left atrial deformation parametres in SAP patients with moderate risk.

PATIENTS AND METHOD

Patient population, and study protocol

The patient group of our case-control study consisted of 60 (40 male: 66.6%) SAP patients with moderate risk (Pretest Risk Probability: 15-85% as assessed according to CAP guideline of European Society of Cardiology) who consulted our hospital [13], and underwent exercise stress test or myocardial perfusion scanning which revealed myocardial ischemia, and subsequently necessitated coronary angiographic (CAG) examination. Thirty healthy volunteers (21 men; 70%) with comparable baseline characteristics constituted the control group. The patients were divided into two subgroups based on SXscores (http://www.syntaxscore.com) which angiographically grades extent and severity of CAD as (<20 , and ≥ 20 pts), and investigations were performed among these 3 subgroups (control, <20, and ≥ 20 pts). All patients underwent conventional, and speckle-tracking echocardiographic examinations

abbreviations:

FCTD: Four chamber tissue Doppler US
CAD: Coronary artery disease
SAP: Stable angina pectoris

LA-PUMP left atrial late diastolic pump phase
LA-RES Left atrial rszervuar phase
LAVI *Left atrial volume index*
LVEDD Left ventricular end-diastolic diameter
LV-EF *Left ventriculaar ejection fraction*
LV-ESD Left ventricular end systolic diameter

Exclusion criteria of the study

i) History of known CAD (history of myocardial infarction, angioplasty, and coronary bypass), *ii)* Patients with ejection fraction of <50%, *iii)* Patients presenting with unstable angina, and acute coronary syndrome , *iv)* History of stroke, and peripheral artery disease , *v)*Concomitant valvular disease of moderate severity, *vi)* History of cardiac surgery or presence of congenital heart disease , *vii)* Nonsinus rhythm and *viii)* Pregnant or nursing women. Study protocol was approved by the local ethics committee .

Echocardiography

All patients, and the control group underwent transthoracic echocardiographic examinations in the left lateral decubitus position. Echocardiographic data of the patients were obtained using Vivid-7 (GE Vingmed Ultrasound AS, Horten, Norway). Three successive cardiac cycles of the patients who held their breath during examination were recorded using 3.5 MHz transducer set at 16 cm penetration depth, and off-line analysis was performed (EchoPAC 6,1; GEVingmed Ultrasound AS). All measurements, and assessments were made based on the guideline of American Society of Echocardiography (ASE)' On apical 4-chamber examination, left ventricular ejection fraction (LVEF) was estimated according to biplane Simpson method Left ventricular end-systolic (LVESD), and end-diastolic diameters (LVEDD) were calculated. Besides transmitral flow velocities were recorded from this window using pulse Doppler US. Early (E), and late diastolic (A) velocities were calculated. From early (E), and late (A)diastolic velocities E/A ratio was estimated. Transmitral flow velocities were recorded from apical four-chamber view, and based on these recordings early diastolic peak velocity (Em) was estimated.E/Em ratio was also calculated to evaluate diastolic functions

Left atrial volume was calculated based on left atrial areas, and lengths measured from apical 4, and 2 chamber views as follows: [(left atrial area measured in 4-chamber view x left atrial area measured in 2-chamber view x 0.85) / left atrial length] and the resultant was divided by body surface to obtain LAVI

Left atrium was evaluated using two dimensional (2D) speckle tracking echocardiography (STE), at 2D gray scale in consideration of echocardiographic apical 4-chamber view and three cardiac cycles were recorded at a frame rate of 60-68 /sec. Off-line analysis was performed. As previously described in the literature during apical 4-chamber examination endocardium of the left atrium was identified manually, and region of interest (ROI) was determined according to the left atrial wall thickness Peak longitudinal strain (LA-RES) values estimated at the end of reservoir phase on a strain curve where QRS complexes of a total of 6 atrial segments were accepted as a reference, and late diastolic contractile pump (LA-PUMP) values were expressed as percentages (%). Strain rate values were recorded as LA-SRS, LA-SRE, and LA-SRA, respectively (Figure 1).

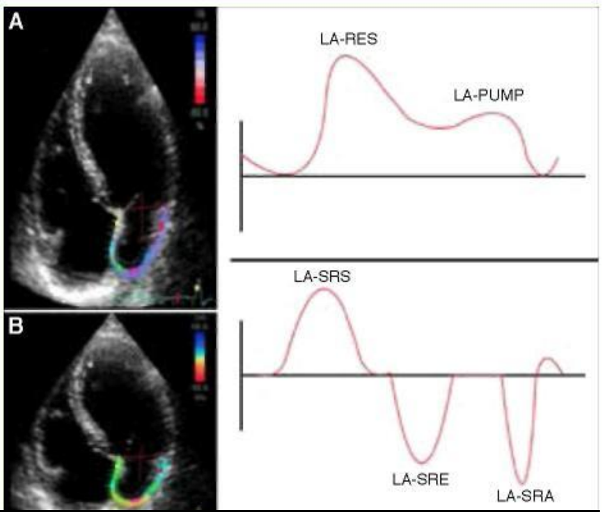


Figure 1.Left atrial deformation parameters **(A)** speckle tracking echocardiography analysis starting from the QRS complex: LA-RES: peak strain value recorded just before opening of the mitral valve; LA-PUMP:left atrial peak strain value **(B)** recorded during late diastole just before left atrial contraction Strain Rate analysis : LA-SRS: LA strain rate during ventricular contraction, LA-SRE: LA strain rate during passive ventricular filling, and LA-SRA: LA strain rate obtained during left atrial contraction

Statistical Analysis

Statistical analysis was performed between control SXscore <20, and SX score ≥ 20 groups. Continuous variables were expressed as mean ± standard deviation. Categorical variables were presented as percentages. For the difference between continuous variables one way ANOVA test was used following testing their fitness to normal distribution with Shapiro-Wilk test. For post-hoc analysis Tukey's test was employed. For differences between categorical variables *chi*-square (x^2) test or one of the suitable Fisher's x^2 test were used. For analysis of correlations Pearson's correlation test was used. In all statistical analyses $p<0.05$ was considered as the level of statistical significance. All statistical analyses were performed using SPSS 17.0 (SPSS Inc, Chicago, IL, USA) program.

RESULTS

Baseline characteristics of all three groups are given in Table 1.Any difference was not detected between the patient, and the control group as for age, gender, family history, smoking, diabetes mellitus, dyslipidemia, systolic, and diastolic blood pressures (Age; control: 57.2±5.6, SXscore <20: 54.7±8.0, SXscore≥20: 59.5±10.4; p=0.870, gender; p=0.816; family history ; p=0.927; smoking ; p=0.873; diabetes mellitus; p=0.506; dyslipidemia; p=0.373; systolic blood pressure ; p=0.756; diastolic blood pressure ; p=0.179).

Conventional echocardiographic parametres of all three groups are shown in Table 2. Any difference was not detected among all three groups as for LV-ESD, LV-EDD, and LV-EF, a significant difference was detected as for E/A ratio, E/Em , and LAVI (E/A; control: 1.2±0.2, SXscore 20: 1.1±0.2, SXscore ≥20: 1.0±0.2; p< 0.001; E/ Em; control: 6.4±1.4, SXscore <20: 7.5±1.3, SXscore ≥20: 8.1±1.1; p< 0.001; LAVI; control: 19.1±3.4, SXscore <20: 21.3±3.2, SXscore ≥20: 23.9±2.9; p<0.001).

Left atrial deformation parametres of all three groups are shown in Table 3. LA-RES and LA-PUMP values were significantly lower in the group with higher SX scores. LA-RES: control: 42.3±7.9, SXscore <20: 36.4±8.2, SXscore ≥20: 27.5±8.1; p<0.001 (Figure 2); in post-hoc analysis; control-SXscore <20; p=0.016; control-SXscore ≥20; p<0.001; SXscore <20-SXscore ≥20; p<0.001. LA-PUMP: control: 17.6±3.4, SXscore <20: 15.7±2.5, SXscore ≥20: 13.1±3.2; p<0.001; posthoc

Table 1. Baseline characteristics

	Control (n=30)	SYNTAX <20 (n=30)	SYNTAX ≥20 (n=30)	*p*
Age	57.2±5.6	54.7±8.0	59.5±10.4	0.870
Male gender (%)	21 (70)	19 (63.3)	21 (70)	0.816
Family history (%)	5 (16.7)	5 (16.7)	6 (20)	0.927
Smoking (%)	18 (60)	16 (53.3)	17 (56.7)	0.873
Diabetes mellitus (%)	6 (20)	10 (33.3)	8 (26.7)	0.506
Dyslipidemia (%)	9 (30)	7 (23.3)	12 (40)	0.373
Systolic blood pressure (mmHg), Mean ± SD	121.8±9.7	123.4±11.0	124.0±13.8	0.756
Diastolic blood pressure (mmHg), Mean ± SD	77.9±6.3	82.0±9.1	81.1±10.3	0.179

SS: Standard deviation

Table 2. Conventional echocardiographic parametres

	Control (n=30) Mean ± SD	SYNTAX <20 (n=30) Mean ± SD	SYNTAX ≥20 (n=30) Mean ± SD	*p*
Left ventricular end-diastolic diameter (cm)	4.9±0.3	5.0±0.2	5.0±0.2	0.137
Left ventricular end-systolic diameter (cm)	3.2±0.2	3.3±0.2	3.3±0.2	0.430
Left ventricular ejectiion fraction (%)	59.9±6.4	59.0±6.0	59.6±5.6	0.839
E/A ratio	1.2±0.2	1.1±0.2	1.0±0.2	<0.001
E/Em ratio	6.4±1.4	7.5±1.3	8.1±1.1	<0.001
Left atrial volume index (ml/m^2)	19.1±3.4	21.3±3.2	23.9±2.9	<0.001

E: Early diastolic left ventricular velocity; A:Late systolic ventricular velocity ; Em: Mitral annulus early diastolic velocity . ; SD: Standard deviation

Table 3. Left atrial deformation parametres

	Control (n=30) Mean ± SD	SYNTAX <20 (n=30) Mean ± SD	SYNTAX ≥20 (n=30) Mean ± SD	*p*
Left atrial reservoir phase	42.3±7.9	36.4±8.2	27.5±8.1	<0.001
Left atrial late diastolic pump phase	17.6±3.4	15.7±2.5	13.1±3.2	<0.001
Strain rate during left ventricular systole	1.70±0.28	1.68±0.70	1.58±.48	0.636
Strain rate during early phase of ventricular filling	-1.48±0.22	-1.45±0.32	-1.38±0.26	0.407
Strain rate during early phase of ventricular filling	-1.34±0.18	-1.25±0.23	-1.26±0.35	0.440

SD: Standard deviation

analysis; control- SXscore <20; p=0.048; control-SXscore ≥20; p<0.001; SXscore <20-SXscore ≥20; p=0.004 . Besides an inverse correlation was detected between SXscore and LA-RES (r=-0.49, p<0.001, Figure 3).

DISCUSSION

In our study, in stable angina pectoris patients with moderate risk, in parallel with the extent, and severity of the disease calculated with SXscore following coronary angiography, a decrease in the left ventricular contractile reserve, and pump peak strain values which were measured during left atrial strain analysis was detected. Also a negative correlation between SXscore, and this decrease has been demonstrated.

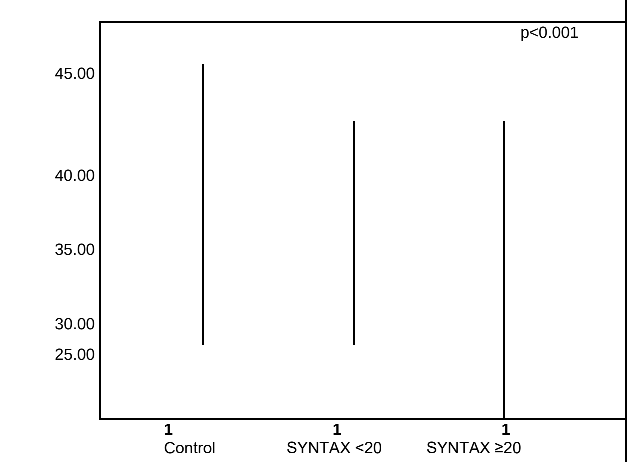
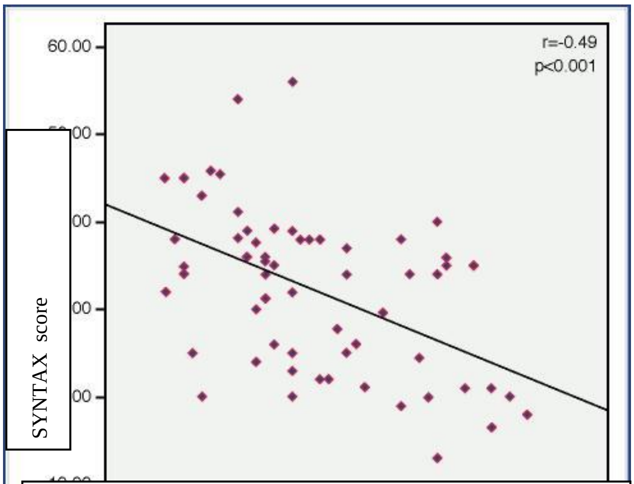


Figure 2. Error-plot graph of the left atrial reservoir function of all three groups.



Left atrial reservoir

Figure 3. Graph demonstrating the correlation between SYNTAX score, and left atrial reservoir function values

Besides in paralel with increase in the extent, and severity of CAD, a significant deterioration in diastolic parametres measured during conventional echocardiographic evaluation, and a significant increase in left atrial volume index were detected.

Left ventricular diastolic dysfunction is one of the early findings of ischemic CAD.[2] Deterioration of left ventricular diastolic dysfunction also increases left ventricular filling pressure This increase in pressure reflects on left atrium, and may worsen left atrial deformation parametres. In our study, we detected greater deterioration in diastolic functions with increasing extent of CAD. We also demonstrated decrease in left atrial deformation parametres.

Left atrium with its four fundamental functions has an important role in the regulation of all the functions of the heart. These functions which can be demonstrated reliably, and clearly using 2D-STE method are as follows: ; Phase 1, rezervoir function (accumulation of pulmonary venous flow during left ventricular systole); Phase 2, conduit (blood flow into the left ventricle during early diastole); Phase 3, active contractile pump (it provides 15-30 % of the left ventricular filling during late diastole), and Phase 4, suction power (atrial self-refilling during early systole).[14] By means of these functions left atrium controls left ventricular filling. Various studies performed have demonstrated that with prominency of diastolic dysfunction, left ventricular filling pressure increases, and left atrial deformation parametres start to worsen before any change in atrial volume. This process is followed by left atrial dilation, and increased LV filling pressure .[15,16] In a study cited in the literature, decrease in left atrial reservoir function indicates the presence of atrial myopathy, and also it is closely related to the onset of the symptoms of diastolic dysfunction.17] In another study, strong inverse correlations have been demonstrated between left atrial positive global peak strain value, and invasively measured left ventricular end-diastolic pressure , transmitral flow displayed by Doppler US , pulmonary vein velocity , and left atrial volume .[18] Previous studies similar to ours echocardiographically detected diastolic dysfunction have been demonstrated to be both an early sign, and predictor of CAD[19,20] . In recent years, many studies have found that parametres of strain, and strain rate which reveal myocardial deformation can be used in the evaluation of ischemia as a sensitive marker.[9,10,22,23] Yip et al. have suggested that STE technique can be used in clinical practice, in the determination of ischemia, and myocardial viability, and in the evaluation of LV global, and regional systolic, and diastolic functions.[24]

Urheim et al. performed an experimental study to investigate the correlation between location of CAD, and regional myocardial deformation parametres. They demonstrated decrease in myocardial deformation functions at the area of ischemia developed due to induced-occlusion of left descending artery during acute ischemia using STE analysis.[25] Starting from the outcomes of the studies cited in the literature, we think that left ventricular dysfunction which develops in direct proportion with increased extent, and severity of CAD, worsens left atrial deformation parametres.

SYNTAX scoring system evaluates number of lesions, their functional significance, location, and complexity which are the criteria determining extent, and severity of CAD. Higher SX score is potentially an indicator of poor prognosis. SXscore focuses on coronary artery anatomy, and its main objective is to classify the severity of CAD.[26]

Many studies cited in the literature, have focused on the evaluation of left ventricular functions in stable CAD. In a study Tsai et al. performed left ventricular strain analysis, and demonstrated a significant decrease in peak systolic global longitudinal strain values in CAD patients without acute coronary syndrome but with normal LVEF. Besides, difference between peak segmental longitudinal strain values, and the ratio between this difference, and peak systolic global longitudinal strain value were found to be significantly higher in patients with CAD.[10]

In a study performed by Yan et al. concerning the relationship between CAD, and left atrial deformation parametres, the authors detected a significant decrease in atrial deformation parametres measured with the aid of velocity vector imaging in patients with stable angina pectoris .[5] In our study, in patients with SAP, extent, and severity of the lesion on coronary angiography were determined by calculating SXscore, and the patients were classified accordingly. Besides the association SXscores and decrease in left atrial deformation functions as determined with STE has been demonstrated.

These findings demonstrate that in the evaluation of left atrial functions in patients with SAP, SXscore may be a potentially useful method, and in the future it will probably considered as one of the parametres predicting extent, and severity of CAD.

Limitations of the study

Since our trial was a single-centered study it contained relatively small number of patients. In addition, in the STE method, dependency on spatial resolution, and frame rate value used while recording, lack of special computer software, and difficulty of making atrial evaluation with available programs are other limitations of our study. We couldn't perform power analysis owing to the lack of studies which may allow us to perform such an analysis. Still our study may be evaluated as a pilot study.

Conclusion

In our study we have demonstrated that left atrial deformation parametres significantly improved in SAP patients with moderate risk in parallel with decreased extent, and severity of CAD. Besides, in line with an increase in the severity of CAD, diastolic parametres measured during conventional echocardiographic evaluation significantly deteriorated, and left atrial volume index also increased significantly.

Conflict of Interest: None declared.

REFERENCES

1. Bonow RO, Bacharach SL, Green MV, Kent KM, Rosing DR, Lipson LC, et al. Impaired left ventricular diastolic flling in patients with coronary artery disease: assessment with radio-nuclide angiography. Circulation 1981;64:315–23.
2. Lee KW, Blann AD, Lip GY. Impaired tissue Doppler diastolic function in patients with coronary artery disease: relationship to endothelial damage/ dysfunction and platelet activation. Am Heart J 2005;150:756–66.
3. Leung DY, Boyd A, Ng AA, Chi C, Thomas L. Echocardiographic evaluation of left atrial size and function: current understanding, pathophysiologic correlates, and prognostic implications. Am Heart J 2008;156:1056–64.
4. Tanaka H, Kawai H, Tatsumi K, Kataoka T, Onishi T, Nose T, et al. Relationship between regional and global left ventricular systolic and diastolic function in patients with coronary artery disease assessed by strain rate imaging. Circ J 2007;71:517–23.
5. Yan P, Li H, Hao C, Shi H, Gu Y, Huang G, et al. 2D-speckle tracking echocardiography contributes to early identifca-tion of impaired left ventricular myocardial function in patients with chronic kidney disease. Nephron Clin Pract 2011;118:232–40.

6. Leung DY, Ng AC. Emerging clinical role of strain imaging in echocardiography. Heart Lung Circ 2010;19:161–74.
7. Kim DG, Lee KJ, Lee S, Jeong SY, Lee YS, Choi YJ, et al. Feasibility of two dimensional global longitudinal strain and strain rate imaging for the assessment of left atrial function: a study in subjects with a low probability of cardiovascu-lar disease and normal exercise capacity. Echocardiography 2009;26:1179–87.
8. Vianna-Pinton R, Moreno CA, Baxter CM, Lee KS, Tsang TS, Appleton CP, et al. Two-dimensional speckle-tracking echocardiography of the left atrium: feasibility and regional contraction and relaxation differences in normal subjects. J Am Soc Echocardiogr 2009;22:299–305.
9. Perk G, Kronzon I. Non-Doppler two dimensional strain imaging for evaluation of coronary artery disease. Echocardiography 2009;26:299–306.
10. Tsai WC, Liu YW, Huang YY, Lin CC, Lee CH, Tsai LM, et al. Diagnostic value of segmental longitudinal strain by automated function imaging in coronary artery disease without left ventricular dysfunction. J Am Soc Echocardiogr 2010;23:1183–9.
11. Hoit BD. Strain and strain rate echocardiography and coronary artery disease. Circ Cardiovasc Imaging 2011;4:179–90.
12. Dattilo G, Lamari A, Zito C, Carerj S, Marte F, Patane S, et al. 2-Dimensional Strain echocardiography and early detection of myocardial ischemia. Int J Cardiol 2010;145:6–8.
13. Montalescot G, Sechtem U, Achenbach S, Andreotti F, Arden C, Budaj A, et al. 2013 ESC guidelines on the management of stable coronary artery disease: the Task Force on the management of stable coronary artery disease of the European Society of Cardiology. Eur Heart J 2013;34:2949–3003.
14. Mitchell JH, Gilmore JP, Sarnoff SJ. The transport function of the atrium. Factors infuencing the relation between mean left atrial pressure and left ventricular end diastolic pressure. Am J Cardiol 1962;9:237–47.
15. O'Connor K, Magne J, Rosca M, Piérard LA, Lancellotti P. Impact of aortic valve stenosis on left atrial phasic function. Am J Cardiol 2010;106:1157–62.
16. O'Connor K, Magne J, Rosca M, Piérard LA, Lancellotti P. Left atrial function and remodelling in aortic stenosis. Eur J Echocardiogr 2011;12:299–305.
17. Liu YY, Xie MX, Xu JF, Wang XF, Lv Q, Lu XF, et al. Evaluation of left atrial function in patients with coronary artery disease by two-dimensional strain and strain rate imaging. Echocardiography 2011;28:1095-103.
18. Wakami K, Ohte N, Asada K, Fukuta H, Goto T, Mukai S, et al. Correlation between left ventricular end-diastolic pressure and peak left atrial wall strain during left ventricular systole. J Am Soc Echocardiogr 2009;22:847-51.
19. Harizi RC, Bianco JA, Alpert JS. Diastolic function of the heart in clinical cardiology Arch Intern Med 1988;148:99-109.
20. Schofeld, PM, Brooks NH, Bennett DH. Left ventricular dysfunction in patients with angina pectoris and normal coronary angiograms. Br Heart J 1986;56:327-33.
21. Garcia MM, Rodrigues MG, Reis Neto JA, Correia LC. Infuence of subclinical atherosclerosis on diastolic function in individuals free of cardiovascular disease. Arq Bras Cardiol 2010;95:473-8.
22. Kalay N, Celik A, Inanc T, Dogan A, Ozdogru I, Kaya MG, et al. Left Ventricular Strain and Strain Rate Echocardiography Analysis in Patients with Total and Subtotal Occlusion in the Infarct-Related Left Anterior Descending Artery. Echocardiography 2011;28:203-9.
23. Kimura K, Takenaka K, Pan X, Ebihara A, Uno K, Fukuda N, et al. Prediction of coronary artery stenosis using strain imaging diastolic index at rest in patients with preserved ejection fraction. J Cardiol 2011;57:311-5.
24. Yip GW, Zhang Q, Xie JM, Liang YJ, Liu YM, Yan B, et al. Resting global and regional left ventricular contractility in patients with heart failure and normal ejection fraction: insights from speckle-tracking echocardiography. Heart 2011;97:287-94.
25. Urheim S, Edvardsen T, Torp H, Angelsen B, Smiseth OA. Myocardial strain by Doppler echocardiography. Validation of a new method to quantify regional myocardial function. Circulation 2000;102:1158-64.
26. Sianos G, Morel MA, Kappetein AP, Morice MC, Colombo A, Dawkins K, et al. The SYNTAX Score: an angiographic tool grading the complexity of coronary artery disease. Eurointervention 2005;1:219-27.

Anahtar sözcükler: Diyastolic disfonksiyon; sol atriyal strain; SYNTAX skoru.

Keywords: Diastolic dysfunction; left atrial strain; SYNTAX score.