Coronary artery ectasia is associated with atrial electrical and mechanical dysfunction: an observational study

Koroner arter ektazisi, atriyal elektriksel ve mekanik fonksiyon bozukluğu ile ilişkilidir: Gözlemsel bir çalışma

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Abstract

Objective: The aim of our study was to investigate total atrial conduction time and left atrial (LA) mechanical function in patients with isolated coronary artery ectasia (ICAE).

Methods: Sixty patients with ICAE without any visible coronary stenosis were enrolled to this cross-sectional observational study. The control group consisted of 40 age- and gender-matched patients. Left atrial mechanical functions were measured by the method of discs in the apical-four chamber echocardiographic view. LA mechanical function parameters were calculated. P wave dispersion was measured on electrocardiography (ECG). The total atrial conduction time (PA-tissue Doppler imaging (TDI) duration) was assessed by measuring the time interval between the beginning of the P wave on the surface ECG and point of the peak A wave on TDI from LA lateral wall just over the mitral annulus. Student t, Mann-Whitney U, Pearson's, and Spearman's correlation analysis and multiple regression analysis were used for statistical analysis.

Results: The clinical and laboratory characteristics were similar in two groups. Both groups were similar in terms of Vmax and LA total emptying volume (29.0±7.3 vs. 31.9±6.5 mL/m^2, p=0.082 and 19.9±5.1 vs. 20.0±5.2 mL/m^2, p=0.821). However, LA passive emptying volume and LA passive emptying fraction were significantly decreased with ICAE patients (11.1±3.2 vs. 13.5±3.8 ml/m^2, p=0.005 and 35.2±7.2 vs. 47.8±9.4 mL/m^2, p<0.001). But LA active emptying volume and LA active emptying fraction were significantly increased in ICAE patients (9.1±2.6 vs. 6.4±3.0 mL/m^2, p<0.001 and 45.3±8.1 vs. 40.7±6.7 mL/m^2, p=0.002). PA-TDI duration was measured significantly higher in patients with ICAE than control group (131.8±5.7 vs. 114.4±9.1 ms, p<0.001). Multiple linear regression analyses showed that ectatic segment number was an independent factor of PA-TDI duration (β=0.581, 95% CI=4.046-6.295, p<0.001).

Conclusion: Our study demonstrated presence of LA electrical and mechanical dysfunction in patients with ICAE. LA dysfunction may be associated with cardiac pathologies as arrhythmias, decrease in cardiac output and congestive failure.

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Key words: Total atrial conduction time, coronary ectasia, atrial functions, tissue Doppler imaging, regression analysis

Özet

Amaç: Bizim çalışmamızın amacı, izole koroner arter ektazisi (İKAE) olan hastalarda total atriyal ileti süresi ve sol atriyal (SA) mekanik fonksiyonların araştırılmasıdır.

Yöntemler: Enine-kesitli gözlemsel bu çalışmaya, herhangi bir darlığı olmayan 60 İKAE'li hasta alındı. Kontrol grubu yaş ve cinsiyet açısından eşleştirilen 40 bireyden oluşturuldu. Sol atriyal mekanik fonksiyonlar disk metoduyla apikal dört boşluktan ölçüldü. Sol atriyal mekanik fonksiyon parametreleri hesaplandı. P dalga dispersiyonu yüzey elektrokardiyografisinden (EKG) ölçüldü. Total atriyal ileti süresi, yüzey EKG'sinde P dalgasının başından, doku Doppler ile mitral lateral duvardan ölçülen A' dalgasının tepesine kadar olan zaman aralığı olarak ölçüldü. İstatistiksel analizde; Student t, Mann-Whitney U, Pearson ve Spearman korelasyonu ve çoklu doğrusal regresyon analizi kullanıldı.

Bulgular: Klinik ve laboratuvar bulgular açısından gruplar benzerdi. Her iki grupta Vmaks ve SA total boşalma oranı benzerdi (31.9±6.5 karşı 29.0±7.3 mL/m^2, p=0.082 ve 20.0±5.2 vs. 19.9±5.1 mL/m^2, p=0.821). Ancak, SA pasif boşalma hacmi ve SA pasif boşalma oranı İKAE hastalarında anlamlı olarak

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azalmıştı (11.1±3.2 karşı 13.5±3.8 mL/m^2, p=0.005 ve 35.2±7.2 karşı 47.8±9.4 mL/m^2, p<0.001). Fakat SA aktif boşalma hacmi ve SA aktif boşalma oranı İKAE hastalarında anlamlı olarak artmıştı (9.1±2.6 karşı 6.4±3.0 mL/m^2, p< 0.001 ve 45.3±8.1 karşı 40.7±6.7mL/m^2, p=0.002). Total atriyal ileti süresi İKAE grubunda normal gruba göre anlamlı olarak daha uzun ölçüldü (131.8±5.7 karşı 114.4±9.1 ms, p<0.001). Çoklu doğrusal regresyon analizinde ektazik segment sayısı total atriyal ileti süresinin bağımsız bir faktörü olarak tespit edildi (β=0.581, %95 GA=4.046-6.295, p<0.001).

Sonuç: Bu çalışma İKAE'li hastalarda SA elektriksel ve mekanik fonksiyonlarının bozulduğunu gösteren ilk çalışmadır. Bozulmuş olan SA fonksiyonları kardiyak aritmiler, azalmış kardiyak atım hacmi ve kalp yetersizliği ile ilişkili olabilir.

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Anahtar kelimeler: Total atriyal ileti süresi, koroner ektazi, atriyal fonksiyonlar, doku Doppler görüntüleme, regresyon analizi

Introduction

Isolated coronary artery ectasia (ICAE) is one of the coronary artery anomalies, defined as the dilatation of the arterial segment to a diameter at least 1.5 times of that of the adjacent normal segment (1, 2). The prevalence of ICAE is approximately 1.5-5% with male predominance (2, 3). The pathogenesis of ICAE is not clear, but in general, it is thought to be a different form of atherosclerotic disease and vascular remodeling (4). In addition, ICAE was shown to be associated with increased sympathetic activity, oxidative stress, myocardial ischemia and high levels of inflammatory markers (5-7). All of these probable factors may also adversely affect atrial electrical and mechanical function.

Currently, the most commonly used method to estimate the extent of atrial remodeling is the measurement of the left atrial (LA) size. Left atrial size and volumes are independent predictors of new-onset atrial fibrillation (AF) in the general population. In addition total atrial conduction time provides more exact evaluation of the atrial remodeling than conventional echocardiography parameters (8). Also total atrial conduction time provides important value for the prediction of new onset AF or paroxysmal AF (8). Previous studies assessed atrial conduction abnormalities with P-wave dispersion and tissue Doppler imaging (TDI) echocardiography (8-11). Recently atrial conduction abnormalities in patients with ICAE was investigated as atrial electromechanical delay by TDI echocardiography (12) but the total atrial conduction time and atrial mechanical function have not been evaluated. We included this important parameter to our assessment in ICAE for the first time in the literature.

Previous studies have shown that oxidative stress, myocardial ischemia, increased sympathetic activity and high plasma levels of inflammatory markers are associated with ICAE (4-7). In addition, these factors may cause atrial arrhythmias such as atrial fibrillation.

Accordingly, our study was designed to investigate the total atrial conduction time and left atrial mechanical functions that they are indicators of atrial fibrillation. Therefore, we aimed to assess the relationship between atrial electrical and mechanical functions in patients with ICAE.

Methods

Study design

This was a cross -sectional observational study that carried out in Cardiology Department of Faculty of Medicine of Abant İzzet Baysal University between June 2010 and February 2012.

Study population

The population of this study was selected among 2428 patients who underwent coronary angiography between 2010 and 2012 years in our clinic. The study population included 60 patients (36 men; mean age 51.1±7.1 years) with ICAE. ICAE was defined as luminal dilatation of 1.5-fold to 2.0 fold of the adjacent normal coronary segment without significant obstructive lesions (13). The control group consisted of 40 age- and gender-matched patients (22 men, mean age 48.7±9.7 years) who were selected in a consecutive manner among patients who underwent catheterization during the study period and proved to have normal coronary angiograms. These patients underwent coronary angiography because of typical or atypical angina pectoris. Exclusion criteria were as follows: acute coronary syndrome, prior myocardial infarction and coronary artery stenosis higher than 40% either in ectatic coronary artery or in the nonectatic coronary arteries, congestive heart failure, left ventricular (LV) hypertrophy, chronic obstructive pulmonary disease, valvular heart disease, permanent pacemaker implantation, atrial fibrillation, frequent ventricular preexcitation and atrioventricular conduction abnormalities, medications known to alter cardiac conduction, peripheral vascular diseases, pulmonary or neurological disease, pericarditis, congenital heart disease, alcohol abuse, and renal, hepatic, or thyroid disease. All patients were evaluated clinically with electrocardiography (ECG), echocardiography, and routine biochemical tests.

Written informed consent was obtained from all participants, and the study protocol was approved by the local Ethics committee.

Electrocardiography

At study entry, all subjects underwent standard 12-lead ECG, acquired using the MAC 5500 electrocardiograph (GE Healthcare, Milan, Italy) at a paper speed of 50 mm/s and 20 mm/mV. All recordings were performed in a quiet room, in the supine position. P-wave duration measurements were performed manually by two observers using calipers and magnifying lens for exact definition of the ECG deflection as defined in a previous study (14). The beginning of the P wave was defined as the point where the initial deflection of the P wave crossed the isoelectric line, and the end of the P wave was defined as the point where the final deflection of the P wave crossed the isoelectric line. The ECG recordings with measurable P waves in less than 10 leads were excluded from the analysis. The difference between P wave maximum (Pmax) and P wave minimum (Pmin) durations was defined as P wave dispersion (PWD) (14).

Standard echocardiography

All patients were evaluated by transthoracic M- mode, two-dimensional (2-D), pulsed-wave (PW), continuous wave (CW), color flow and TDI. All examinations were performed with the GE-Vivid-7 system (GE Vingmed, Horten, Norway) with a 2-4 MHz transducer at a depth of 16 cm. During echocardiography, continuous single-lead ECG recording was obtained. All patients were imaged in the left lateral decubitus position. 2-D and conventional Doppler examinations were obtained in the parasternal and apical views according to the guidelines of the American Society of Echocardiography (15). LV diameters and wall thickness were measured by M-mode echocardiography. LV ejection fraction was calculated using the apical two- and four-chamber views by Simpson's method, according to American Society of Echocardiography guidelines (15). The mitral valve inflow pattern [E-wave - early diastolic flow velocity, A-wave - late diastolic flow velocity, E-wave deceleration time (Dt), E/A ratio and isovolumic relaxation time (IVRT)] were measured using pulsed wave Doppler. LV mass index was calculated using the formula with the Devereaux equation (16). LA volumes were obtained apical four-chamber views by a disc's method (15, 17). LA maximum volume (Vmax) at the end-systolic phase, LA minimum volume (Vmin) at the end-diastolic phase and LA volume before atrial systole (Vp) were measured and calculated with adjustment to body surface area. The LA function parameters were calculated as follows;

LA passive emptying volume= Vmax-Vp;

LA passive emptying fraction= [(Vmax-Vp)/Vmax]x100%,

LA active emptying volume= Vp-Vmin;

LA passive emptying fraction= [(Vp-Vmin)/Vp]x100%

LA total emptying volume= Vmax-Vmin (18).

Tissue Doppler echocardiography

TDI was performed by transducer frequencies of 3.5 to 4.0 MHz, adjusting the spectral pulsed Doppler signal filters to acquire the Nyquist limit of 15 to 20 cm/s was reached and using the minimal optimal gain. Myocardial TDI velocities [peak systolic (Sm), early diastolic (Em) and late diastolic velocities (Am)] were measured via spectral pulsed Doppler as of the LV-free wall from the apical four chamber view and Em/Am ratio was calculated (15). The ultrasound beam was positioned as parallel as possible with the myocardial segment to acquire the optimal angle of imaging. A novel echocardiographic consideration based on TDI has been introduced to assess the total atrial conduction time: PA-TDI duration (11). The PA-TDI duration was assessed by measuring the time interval between the beginning of the P wave on the surface ECG and point of the peak A wave on TDI from LA lateral wall just over the mitral annulus (Fig. 1) (9, 11). All measurements were repeated three times, and average values were received for each of parameters. All measurements were performed by two experienced investigators, who were unaware of the subject's clinical status. If a difference of >5% in any of the variables measured by both investigators was found, the patient was not included, whereas if the difference was <5%, the measurements were averaged.

Coronary angiography

Selective coronary angiography was performed in all subjects by Judkin's technique without nitroglycerin use. All coronary arteries were observed in multiple angulated views. Analyses of angiograms were performed by two experienced cardiologists. ICAE was defined as a dilatation of the arterial segment to a diameter at least 1.5 times or more as that of the adjacent normal artery or normal segments of the same vessel. Mean number of ectatic segments (ESN) was calculated in all patients with ectasia. Diameters of all ectatic segments were collected and the value obtained by dividing the number of ectatic segments and average diameter of ectatic segments (ESN) was determined (12). The total number of ectatic major coronary arteries and ESN also was noted.

Study variables

The presence of coronary ectasia and number of ectatic segments were examined as the predictor variables. Total atrial conduction time, LA size and LA mechanical functional parameters (including LA passive emptying volume and fraction and LA active emptying volume and fraction) were primary outcome variables of this study. Age, IVRT, Em/Am ratio and PWD were confounding variables.

Statistical analysis

All analyses were performed using the SPSS 15.0 (SPSS Inc., Chicago, Illinois, USA) software package. Continuous variables are presented as mean±standard deviation. Categorical variables are presented as the percentage. The normally distributed

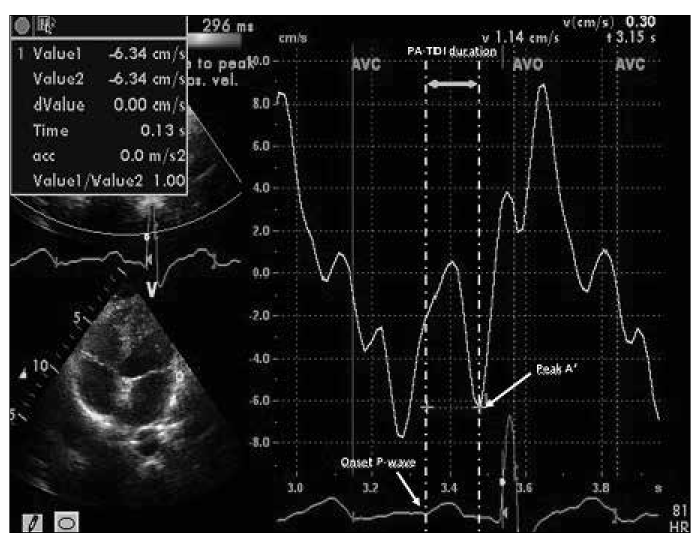

Figure 1. An example of total atrial conduction time (PA-TDI duration) measurement; The PA-TDI duration was assessed by measuring the time interval between the beginning of the P wave on the surface ECG and point of the peak A wave on TDI from LA lateral wall just over the mitral annulus.

ECG - electrocardiogram, LA - left atrium, TDI - tissue Doppler imaging data were compared by Student's t-test, otherwise, Mann-Whitney U test was applied for not normally distributed parameters. Chi-square test was used comparison of categorical variables. Pearson's and Spearman's correlation coefficient were used evaluate relationship between continuous variables. Linear multiple regression analysis was done to identify independent determinants of total atrial conduction time, which incorporated variables that correlated with a P value of less than 0.1 in the correlation analysis. A value of p<0.05 was considered statistically significant.

Results

The clinical, laboratory characteristic and echocardiographic findings of the two groups are shown in Table 1. All parameters except LA diameter, E/A ratio, Em/Am ratio and IVRT were similar between two groups. LA diameter and IVRT were significantly higher in the patients with coronary artery ectasia than the normal group (p=0.004, and p=0.021). Em/Am ratio was significantly lower in patients with ICAE than controls (p=0.001). Both groups were similar in terms of the biochemical analysis and medication.

ICAEs were usually observed more than in one coronary artery and coronary artery segments [one coronary artery in 18 (30%), two coronary arteries in 24 (40%) and three coronary arteries in 18 (30%) patients]. Eight patients (13.3%) had only one segment ectasia. The remaining 52 (86.7%) patients had more than one segment ectasia (Table 2).

LA mechanical function

LA volume measurements and mechanical function are presented in Table 3. Both groups were similar in terms of Vmax and LA total emptying volume (p=0.082 and p=0.821). However, LA passive emptying volume and LA passive emptying fraction were significantly decreased with ICAE patients (p=0.005 and p<0.001). However, LA active emptying volume and LA active emptying fraction were significantly increased with ICAE patients (p<0.001 and p=0.002). There was a positive correlation between LA active emptying volume and LA active emptying fraction with ESN (r=0.41 p<0.001 and r=0.33 p=0.001). There was a negative correlation between the LA passive emptying fraction and ESN (r=-0.187, p<0.001).

LA electrical function

Total atrial conduction time (PA-TDI duration) and P wave analysis results are presented in Table 4. PA-TDI duration was measured significantly higher in patients with ICAE than control group (p<0.001). Maximum P wave duration and P wave dispersion (PWD) were significantly higher in patients with ICAE than the control group (p=0.003 and p=0.001). There was a significant correlation between PWD and ESN (r=0.214, p=0.043). PA-TDI duration was positively correlated with ESN (r=0.787, p=0.001). There was a positive correlation between PA-TDI duration with LA active emptying fraction (r=0.292, p=0.003, Fig. 2) and there was a negative correlation between PA-TDI duration with LA passive emptying fraction (r=-0.569, p<0.001, Fig. 2).

Using multivariate linear regression analyses (including; Age, LA size, LA active emptying volume/fraction, LA passive emptying volume/fraction, PWD, Em/Am ratio, IVRT and ESN); we demonstrated that, ESN was an independent factor for PA-TDI duration (β=0.581, 95% CI=4.046-6.295, p<0.001, Table 5).

Table 1. Patients' demographics, laboratory characteristics, echocardiographic findings and medications

Variables	Coronary ectasia (n=60)	Control group (n=40)	*p
Age, years	51.1±7.1	48.9±9.6	0.210
Male gender, n (%)	36 (60)	22 (55)	0.778
Hypertension, n (%)	12 (24)	8 (20)	0.552
Diabetes mellitus, n (%)	4 (8)	3 (7.5)	0.774
Smoking, n (%)	8 (16)	5 (12.5)	0.875
BMI, kg/m^2	27.2±4.2	30±5	0.252
BSA, m^2	1.97±0.2	1.89±0.2	0.069
Heart rate, beats/min	71.8±8.7	73.8±6.8	0.215
Systolic blood pressure, mmHg	122.8±10	121.3±9.5	0.496
Diastolic blood pressure, mmHg	77.5±7.0	79±8.0	0.304
LDL, mg/dL	119±26	114±28	0.181
HDL, mg/dL	42±8	43±9	0.333
Total cholesterol, mg/dL	192±22	187±24	0.170
Triglyceride, mg/dL	160±28	154±29	0.364
Beta-blocker, n	5	3	0.365
ACEI/ARB, n	7	5	0.568
Calcium canal blocker, n	4	3	0.452
Hemoglobin, g/dL	13.8±1.2	13.7±1.2	0.853
Creatinine, mg/dL	0.83±0.18	0.82±0.15	0.728
LVEDD, mm	48.9±3.4	48.4±3.3	0.535
LVESD, mm	30.9±3.6	30.2±2.8	0.293
Ejection fraction, %	63.9±7.9	64.1±2.3	0.879
LVMI, g/m^2	102.5±22.5	99.9±18.8	0.255
Septum thickness, mm	10.4±1.2	10.2±0.7	0.207
Posterior wall thickness, mm	9.8±0.9	9.5±1.7	0.189
LA diameter, mm	37.2±3.3	35.9±1.6	0.004
IVRT, msec	96.8±9.5 98.1 (70.0-120.0)	92.2±9.2 92.1 (67.0-110.0)	0.021
Em/Am ratio	0.9±0.2	1.2±0.4	0.025
Deceleration time, msec	233.7±39.4	219.6±29.3	0.069

Data are expressed as mean±SD, median (minimum-maximum) values and number (percentage)
*Chi-square test, unpaired Student`s t-test and Mann-Whitney U test
ACEI - angiotensin converting enzyme inhibitor, Am - mitral annular late diastolic velocity, ARB - angiotensin receptor blocker, BMI - body mass index, BSA - body surface area, Em - mitral annular early diastolic velocity, HDL - high density lipoprotein, IVRT - isovolumic relaxation time, LA - left atrium, LDL - low density lipoprotein, LVEDD - left ventricular end - diastolic diameter, LVMI - left ventricular mass index, LVSDD - left ventricular end -systolic diameter

Table 2. The angiografic features of patients with coronary artery ectasia

Diameter of ectatic segments, mm		5.2±1.5
Mean ESN, n		3.1±1.6
Mean ECAN, n		2.3±0.8
ESN		
	1 segment, n (%)	8 (13.3)
	2 segment, n (%)	12 (20.0
	3 segment, n (%)	15 (25.0)
	4 segment, n (%)	15 (25.0)
	5 segment, n (%)	6 (10.0)
	6 segment, n (%)	4 (6.6)
ECAN		
	1 vessel, n (%)	18 (30.0)
	2 vessel, n (%)	24 (40.0)
	3 vessel, n (%)	18 (30.0)

Data are expressed as mean±SD and number (percentage)
ECAN - ectatic coronary artery number, ESN - ectatic segment number,
mm - millimeter, SD - standard deviation

Table 3. Assessment of left atrial mechanical functions

Variables	Coronary ectasia (n=60)	Control group (n=40)	*p
Vmax, mL/m^2	31.9±6.5	29.0±7.3	0.082
Vmin, mL/m^2	12.3±4.3	9.0±2.9	0.001
Vp, mL/m^2	20.2±5.5	15.2±5.5	<0.001
LA passive emptying volume, mL/m^2	11.1±3.2 11.3 (5.0-21.0)	13.5±3.8 13.5 (7.0-19.9)	0.005
LA passive emptying fraction, %	35.2±7.2 35.7 (24.0-52.0)	47.8±9.4 47.8 (25.0-63.0)	<0.001
LA active emptying volume, mL/m^2	9.1±2.6 9.0 (4.8-16.0)	6.4±3.0 6.4 (2.5-17.5)	<0.001
LA active emptying fraction, %	45.3±8.1 45.2 (26.0-65.0)	40.7±6.7 40.7 (31.0-60.0)	0.002
LA total emptying volume, mL/m^2	20.0±5.2	19.9±5.1	0.821

Data are expressed as mean±SD and median (minimum-maximum) values
*Student`s t- test and Mann-Whitney U test
LA - left atrium, Vmax - left atrial maximum volume, Vmin - left atrial minimum volume, Vp - left atrial volume onset of P wave on electrocardiography

Table 4. P wave analyses and total atrial conduction time and they are relationship with ICAE

Variables	Coronary ectasia (n=60)	Control group (n=40)	*p
PA-TDI duration, msec**	131.8±5.7	114.4±9.1	<0.001
Maximum P-wave duration, msec	104.3±7.8 108.7 (80.0-130.0)	97.2±7.1 102.2 (80-120)	0.003
Minimum P-wave duration, msec	57.8±5.6	56.7±6.7	0.898
P-wave dispersion, msec	44.8±9.2	40.5±7.2	0.001

Data are expressed as mean±SD and median (minimum-maximum) values
*Student`s t -test and Mann-Whitney U test
PA - The interval with tissue Doppler imaging from the onset of p wave on the surface electrocardiogram to point of the peak late diastolic wave (Am wave), PA-TDI - total atrial conduction time

Table 5. Regression analyses of variables associated with prolonged PA-TDI duration

Variables	Beta	t	*p	95 %CI
Age, years	0.148	2.851	0.005	0.060 - 0.338
LA size, mm	0.105	1.834	0.070	-0.145 - 0.756
Em/Am ratio	-0.51	-0.994	0.323	-5.854 - 1.757
IVRT, msec	0.101	1.512	0.102	0.002 - 0.217
P-wave dispersion, msec	0.066	0.769	0.444	0.135 - 0.429
LA passive emptying volume, mL	-0.071	-0.642	0.522	-1.176 - 0.170
LA passive emptying fraction, %	-0.190	-1.235	0.220	-0.382 - 0.301
LA active emptying volume, mL	0.049	0.353	0.725	-0.789 - 1.278
LA active emptying fraction, %	0.130	1.341	0.183	-0.197 - 0.365
Ectatic segment number	0.532	8.297	<0.001	4.046 - 6.295

*Linear regression analysis
Am - mitral annular late diastolic velocity, Em - mitral annular early diastolic velocity, IVRT - isovolumic relaxation time, LA - left atrium, PA-TDI duration - total atrial conduction time

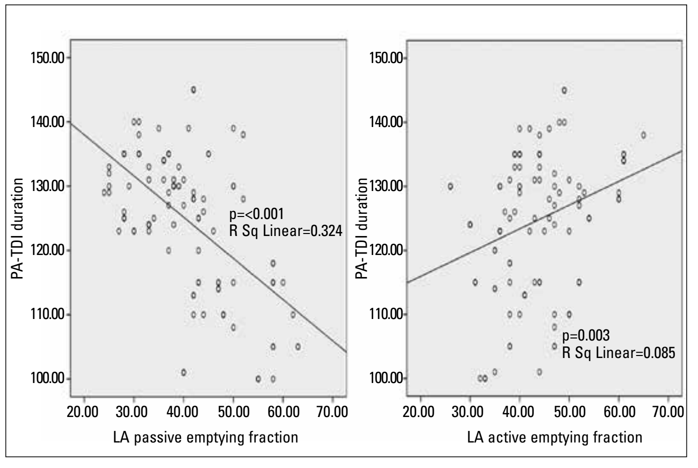

Figure 2. The correlation between left atrial mechanical functions and total atrial conduction time
LA - left atrium and PA - TDI duration-total atrial conduction time

Discussion

In the present study, we investigated that atrial electrical and mechanical function in patients with ICAE. We have demonstrated that Pmax and PWD and the PA-TDI duration were significantly related with ICAE. Furthermore, LA mechanical functions were found to be impaired in patients with ICAE. Lastly, ESN was demonstrated to be an independent factor of PA-TDI duration. To our knowledge, this is the first study that showed impaired left atrial electrical and mechanical functions in patients with ICAE.

Despite the documented etiological role of atherosclerosis, the histopathological alterations of ICAE have not clearly known. Additionally, presence of ectatic segments produces a slow-moving or chaotic blood flow which causes exercise induced angina and myocardial infarction (19). Disturbances in blood flow and washout are common in ICAE, and clearly associated with the severity of ectasia. In this way myocardial ischemia may affect atrial and ventricular functions in patients with ICAE. Recently, Şengül et al. (12) demonstrated that interatrial electromechanical delay and PWD were related ESN in patients with ICAE. Similarly, our study showed the correlation of PWD between ESN. However, this study included only 30 patients with ectasia and atrial mechanical functions and PA-TDI duration had not been studied. Furthermore, atrial mechanical function may be the important factor for atrial remodeling, deformation and autonomic dysfunction. Differently, the present study established that atrial mechanical functions and PA-TDI duration were related with ESN in patients with ICAE. Especially increased ESN may cause more myocardial ischemia and increased ESN may lead to impaired atrial function and conduction time in patients with ICAE.

Total atrial conduction time (PA-TDI duration) is a novel marker of atrial remodeling and in contrast to LA size, it reflects the extent of both electrical and structural remodeling of the atria (8, 11). In addition, this new parameter provides a more accurate evaluation of the presence and degree of atrial remodeling than conventional echocardiographic parameters (11). In our study, prolonged PA-TDI duration was found in ICAE patients. This may be result of LV diastolic dysfunction or myocardial ischemia in ICAE patients. Additionally, sympathetic activity, oxidative stress and serum levels of inflammatory markers were found to be associated with ICAE (5-7) and all of these factors may solely or jointly, affect PA-TDI duration and atrial mechanical functions. In the present study demonstrated the correlation of LA passive emptying fraction, LA active emptying fraction and PA-TDI duration. Therefore, LA mechanical function parameters and PA-TDI duration can be used together to assess atrial remodeling. In addition, the rhythm disturbances as atrial premature complex and atrial fibrillation may be developed secondary to atrial mechanic, autonomic dysfunction and deformation.

In some studies, a relationship between LA diameter and interatrial electromechanical delay has been found (20-25). Such a relation was observed in our study. In addition, our study showed that LA diameter was correlated with PA-TDI duration, in patients with ICAE. LA size, volume and LA mechanical function have recently been identified as a potential indicator of atrial arrhythmias (21, 22). So assessment of atrial functions may be performed by means of atrial volume measurement. Left atrial mechanical functions contain reservoir, passive emptying and active emptying functions at different stages of cardiac cycle. The reservoir function takes effect during ventricular systole, passive emptying function in early diastole and active emptying function during ventricular diastole in the presence of sinus rhythm. LA mechanical functions are important determinant of left ventricular (LV) filling, especially in patients with heart failure (22). In a previous study, Sağlam et al. (23) has demonstrated left ventricular diastolic dysfunction in patients with ICAE. When develops left ventricular dysfunction, the left atrium may possibly preserve adequate cardiac output by regulation of reservoir and booster pump functions. On the other hand, atrial functions intensely have an effect on heart function (20, 21). In our study showed that impaired atrial passive and active function in ICAE patients. Therefore, impaired LA function may results development of heart failure in patients with ICAE. So far, LA mechanical functions have not been investigated in patients with ICAE in the literature. We have shown that LA mechanical functions were impaired in patients with ICAE. This may be the result of the increased end-diastolic LV pressure and/or associated strain on LA. Therefore, it can be speculated that atrial arrhythmias may result from impaired LA functions in these patients.

Atrial activation time measured by transthoracic Doppler tissue imaging can be used as an estimate of the total duration of atrial electrical activation. The PA-TDI duration is a speedy, simple, and reliable method to approximate the total atrial conduction time (8, 11). This novel echocardiographic parameter has been approved against P-wave duration on signal-averaged electrocardiography (11). In a study, Uijl et al. (8) have reported that assessment of PA-TDI duration by using TDI can be used to predict AF recurrence after radiofrequency catheter ablation in patients with paroxysmal AF. Also Antoni et al. (9) showed that PA-TDI duration is a simple measurement that provides important value for the prediction of new onset AF in patients with acute myocardial infarction. Additionally, these studies have been reported that PA TDI duration was a stronger predictor of AF recurrence (8, 9). In our study, we have shown that PA-TDI duration was increased in subjects with ICAE, and ESN was an independent determinant of PA-TDI duration. Consequently, increased PA-TDI duration may be related with an increased risk for AF in patients with ICAE.

Study limitations

The major limitation of our study is its cross-sectional design and relatively small sample size. Patients could not be followed-up prospectively for arrhythmic episodes. Therefore, we do not know whether prolongation of PA-TDI duration and impaired LA mechanical functions for prediction AF in ICAE patients. For these reasons, long-term follow-up and large-scale prospective studies are needed to determine the predictive value of PA-TDI duration and LA mechanical function in this population.

Conclusion

The present study demonstrated prolonged PA-TDI duration and impaired LA mechanical function in patients with ICAE. Therefore, the atrial electrical and mechanical dysfunction in patients with ICAE may be associated with cardiac pathologies as arrhythmias, decrease in cardiac output and congestive failure.

Conflict of interest: None declared.

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