Advanced Medical Journal, Vol.11, No.2, P.26-33,2026 https://doi.org/10.56056/amj.2026.454

Correlation of Electrocardiography with Echocardiography in the Assessment of Left Atrial Overload

Chro Saber Muhammad* Amar Talib Al-Hamdi Jaafar Sadeq Ali Aldoori*****

Abstract

Background and objectives: Left atrial overload parameters in the electrocardiogram could suggest rising left atrial pressure that leads to heart disease. An increase in the Left atrial area and pressure are signs of left ventricle diastolic dysfunction. Therefore, we aimed to find the relationship between electrocardiogram and left ventricle diastolic function by echocardiography to assess left atrial overload.

Methods: This observational, cross-sectional study enrolled 200 patients with cardiac symptom(s) from April 2024 to April 2025 at Sulaimani Cardiac Hospital and Faruk Medical City, using a convenient sampling method. The patients underwent electrocardiography and echocardiography. Later, the correlations between both techniques were determined in relation to left atrium overload in diastolic dysfunction.

Results: Among studied patients, 51.5% had hypertension, 32.5% had diabetes, 19% had ischemic heart disease, 57.5% presented with shortness of breath, 38% with chest pain, 25.5%, with palpitation, 1.5% had aortic stenosis, 2.0% had aortic regurgitation, and 41% had diastolic dysfunction. Echocardiography showed that tricuspid regurgitation velocity and heart rate did not differ among the grades of diastolic dysfunction. P-duration exhibited a decent correlation with left atrial volume index ($p<0.001$), while P terminal force in V1 showed rational correlations with left atrial volume index and E/é ($p<0.001$). P-duration and P terminal force in V1 significantly correlated among left ventricle diastolic function grades ($p<0.001$).

Conclusions: P-duration and P terminal force in V1 could indicate left atrial overload if electrocardiography and echocardiography are used to correlate grades of diastolic dysfunction.

Keywords: Diastolic dysfunction, Echocardiography, Electrocardiography, Left Atrial Overload, P-duration

*MBChB, KHCMS, Cardiology, Sulaimani Cardiac Hospital, Sulaimani Directorate of Health, Sulaimaniyah, Iraq. E-mail: chro.sabr@gmail.com (Corresponding author)
**MBChB, MRCP, FRCP, Professor of Medicine and Consultant Cardiologist/Electrophysiologist, Sulaimani Cardiac Hospital, Sulaimani Directorate of Health, Sulaimaniyah, Iraq. E-mail: amaralhamdi@yahoo.com
***MBChB, FICMS, CABM, MSc, Interventional Cardiologist, Sulaimani Cardiac Hospital, Sulaimani Directorate of Health, Sulaimaniyah, Iraq. E-mail: jaafar_aldorii@yahoo.com

Introduction

The prevalence of heart failure has been increasing worldwide, and about half of patients have preserved left ventricle systolic function. Therefore, assessing left ventricle diastolic function (LVDF) is essential to determine heart failure status using echocardiographic examination.[1] The timely discovery of subclinical left ventricular diastolic dysfunction (LVDDF) is significant for the specific risk of asymptomatic individuals. Thus, the American Society for Echocardiography (ASE) published recommendations to evaluate LVDF using echocardiography, a painless and noninvasive diagnostic tool for various common heart conditions, including left atrial (LA) overload.[2] However, in clinical practice, some cases of LVDDF cannot be determined and can be categorized as cases of indeterminacy.[3] Moreover, an electrocardiogram (ECG) can be used to detect LA overload, which indicates increased LA pressure that results in LA dilatation and, consequently, heart failure.[4] Generally, ECG is none expensive, feasible, easy-to-use formula that can be used as a routine investigation in patients with acute heart failure who are referred to the emergency department and are at more danger of affection and death since it is used to identify potential causes and complications.[5] Inter- and intra-atrial conduction disorders can be recognized on the ECG, displaying as a biphasic P-wave, mostly in lead V1. The terminal negative deflection of a biphasic P-wave in lead V1 is called the P terminal force V1 (PTFV1). PTFV1 is considered as the product of its duration component (PTDV1) and its absolute amplitude component (PTAV1).[6] Abnormal PTF-V1 is an ECG biomarker of more LA volume, high LA filling pressures and LA systolic dysfunction.[7] Magnification of electrocardiographic waves helps determine their duration. Normal P-wave duration (width) is <120 ms and a P-wave duration of ≥ 120 ms is abnormal and indicates a conduction delay between the right atrium and left atrium.[8] Thus, it is essential in the screening of LVDDF. Consequently, echocardiography should be done in patients with a P-duration of ≥ 110 ms to determine LVDDF. However, when echocardiographic suggest LVDDF but do not reach definite criteria, ECG outcome might be helpful. P-duration of ≥ 120 ms and PTFV1 of ≥ 0.04 mm are not effective in screening patients with LVDDF due to their low sensitivity.[9] Consequently, combining ECG with echocardiography allows study of P-wave features in light of concomitant and precise assessment of LA pressure and chamber size. Thus, this study was designed to determine the correlation between LA overload indices by ECG and LVDF indices by echocardiography and to find whether ECG can help in assessing LVDF.

Patients and methods

This observational, cross-sectional, study recruited 200 participants with cardiac symptom(s) from April 2024 to April 2025 at Sulaimani Cardiac Hospital and Faruk Medical City, using a convenient sampling method. Patients aged >18 years old with cardiac symptom(s) were recruited, while patients with atrial fibrillation (AF), atrial flutter (AFL), left bundle branch block (LBBB), right bundle branch block (RBBB), pacemaker, history of ablation, and mitral valve pathology were excluded. The patients' sociodemographic data, including age, gender, height (m^2)/weight (kg) to determine body mass index (BMI; kg/m^2), and smoking status were collected together with their clinical data, including current disease status and presenting symptoms using a standard questionnaire. According to the American Society of Echocardiography (ASE) and the European Association of Cardiovascular Imaging recommendations, transthoracic echocardiography (TTE) was done for all

https://doi.org/10.56056/amj.2026.454

patients to evaluate the LVDF using the same ultrasonic equipment (GE Vivid, E90, USA) as a part of the cardiac examination.[10,11] Then, normal diastolic function was grouped as G0. At the same time, grades I, II, and III of diastolic dysfunctions were grouped as G1 (slightly impaired relaxation), G2 (pseudo normal/raised pressure in the left side of the heart), and G3 (restrictive/significantly raised pressure in the left side of the heart), respectively. When left ventricular diastolic pressure was not determined, it was labelled indeterminate (G_{IND}). Regarding the ECG, a standard electrocardiograph (GE MAC 1600) was used for all patients to determine P-wave utilizing a magnifier. In this regard, 3 heartbeats were counted to calculate P-duration, while the amplitude and width of the P-wave negative phase were used to calculate PTFV1. Finally, the correlations between ECG indices and LVDF indices were determined, and the difference in ECG indices among LVDDF grades was assessed. The same examiner (first author) performed ECG and TTE to obtain reliable reproducibility. Ethical clearance was approved by the Ethical Committee of the Kurdistan Higher Council of Medical Specialties (KHCMS) with No. 1685 on July 21, 2024. Participants' written informed consent was obtained before the study. The data were analyzed using Statistical Package for Social Science (IBM, Chicago, USA). The categorical data was expressed as numbers (n) and percentages (%), while the numerical data was expressed as mean ± standard deviation (SD). The Shapiro–Wilk test was used to test the normality. ANOVA and Kruskal–Wallis tests were used for quantitative variables' normal and abnormal distribution, respectively. The strength and type of correlation were obtained using Pearson correlation and Spearman rank correlation tests. A $p \leq 0.05$ was set as significant, and $p \leq 0.001$ as highly significant.

Results

Among studied patients (n=200), most of them (n=107) had normal diastolic function (G0), and 82 had LVDDF (64 with G1, 16 with G2 and 2 with G3). At the same time, the LVDF could not be determined in 11 patients due to the unavailable optimal measurements of the required indices. The highest mean age was observed in G2 (67.94±13.27 years), and the lowest was in G0 (47.63±11.72 years) ($p<0.001$). The dominant hypertension was noted in G1 (78.1%) and the lowest was in G0 (0.0%) ($p<0.001$). The highest diabetes mellitus prevalence was recorded in G1 (53.1%, n=34), and the lowest was in G3 (0.0%) ($p=0.001$). Moreover, 19% (n=38) of the patients had ischemic heart disease (IHD), and the highest rate was observed in G2 (43.8%, n=7), while the lowest rate was in G3 (0.0%) ($p<0.001$). About 18.2% (n=2) of the G_{IND} had mild aortic regurgitation (AR). Regarding BMI, gender, smoking, shortness of breath (SOB), chest pain, palpitation and mild aortic stenosis (AS), no significant differences between the grades ($p>0.05$) were observed, as found in Table (1). Echocardiographic and electrocardiographic parameters of LVDF in different groups are shown in Table (2). TR velocity and HR did not differ among the grades of LVDF. LAV, LAVi, E/e and P duration were higher and Septal e, Lateral e and Septal+ Lateral e were lower in G2 than G0. In G1, E/A was lower than G0 and E was lower than G Ind. In G2, P amplitude and PTFV1 were higher than G Ind. In respect of ejection fraction, the highest mean was observed in G0 rather than G3. The correlation of P-duration with indices of LVDF by echocardiography is shown in Table (3). A positive correlation between LAV, LAVi, E/e and P-amplitude with P-duration was observed, while a negative correlation was seen between E/A, E, Septal e, Lateral e, Septal+ Lateral e and EF with P-duration. Regarding the PTFV1, a positive correlation was shown between LAV, LAVi, E/e, HR and P-amplitude with PTFV1. On the other hand, a negative correlation was recorded between E/A, E, Septal e and EF with PTFV1. As shown in Figure (1), a positive correlation was documented between PTFV1 and LVDDF grades (r=0.396, p<0.001). Moreover, Figure (2) shows a positive correlation between LAVi and LVDDF grades (r=0.482, p<0.001).

Table (1): Baseline characteristics of the patients according to LVDF grade.

Baseline characteristics	G0 (n=107, 53.5%)	G1 (n=64, 32%)	G2 (n=16, 8.0%)	G3 (n=2, 1.0%)	G_{IND} (n=11, 5.5%)	Total (n=200, 100%)	p-value
Age (Years), mean±SD	47.63±11.72	64.81±10.04	67.94±13.27	58.00±2.83	58.27±10.04	55.44±14.06	<0.001**
BMI (kg/m^2), mean ± SD	27.19±3.96	27.45±5.22	29.69±5.36	28.5±2.12	27.51±5.84	27.51±4.62	0.354
Male gender, n (%)	62 (57.9)	38 (59.4)	11 (68.8)	2.0 (100)	6.0 (54.5)	119 (59.5)	0.708
Smoker, n (%)	27 (25.2)	19 (29.7)	4.0 (25)	2.0 (100)	2.0 (18.2)	54 (27.0)	0.179
HTN, n (%)	35 (32.7)	50 (78.1)	12 (75)	0.0 (0.0)	6.0 (54.5)	103 (51.5)	<0.001**
DM, n (%)	23 (21.5)	34 (53.1)	4.0 (25)	0.0 (0.0)	4.0 (36.4)	65 (32.5)	0.001*
IHD, n (%)	8.0 (7.5)	21 (32.8)	7.0 (43.8)	0.0 (0.0)	2.0 (18.2)	38 (19.0)	<0.001**
SOB, n (%)	54 (50.5)	42 (54.6)	11 (68.8)	1.0 (50)	7.0 (63.6)	115 (57.5)	0.294
Chest pain, n (%)	42 (39.3)	27 (42.2)	4.0 (25)	0.0 (0.0)	3.0 (27.3)	76 (38.0)	0.722
Palpitation, n (%)	34 (31.8)	13 (20.3)	1.0 (6.3)	0.0 (0.0)	3.0 (27.3)	51 (25.5)	0.139
AS, n (%)	1.0 (0.9)	0.0 (0.0)	1.0 (6.3)	0.0 (0.0)	1.0 (9.1)	3.0 (1.5)	0.093
AR, n (%)	1.0 (0.9)	1.0 (1.6)	0.0 (0.0)	0.0 (0.0)	2.0 (18.2)	4.0 (2.0)	0.003*

AR: Aortic regurgitation, AS: Aortic stenosis, BMI: Body mass index, DM: Diabetes mellitus, G: Grade, HTN: Hypertension, IHD: Ischemic heart disease, IND: Indeterminate, SOB: Shortness of breath, SD: Standard deviation. The data was analyzed using Analysis of Variance (age), Kruskal–Walli's test (BMI) and Chi-square test (categorical variables).

Table (2): Comparison of echocardiographic and electrocardiographic data according to LVDF grade

Variable	G0 (n=107, 53.5%)	G1 (n=64, 32.0%)	G2 (n=16, 8.0%)	G3 (n=2, 1.0%)	G_{IND} (n=11, 5.5%)	Total (n=200, 100%)	p-value
LAV, ml/m^2	38.15 (20.08)	56.91 (20.08)	91.69 (24.26)	36.50 (3.54)	40.00 (19.31)	48.52 (25.32)	<0.001**
LAVi, ml/m^2	27.95 (8.40)	35.18 (11.79)	55.93 (11.20)	36.97 (19.84)	33.14 (6.69)	32.88 (12.37)	<0.001**
E/A	1.10 (0.30)	0.74 (0.31)	0.97 (0.36)	0.75 (0.07)	0.88 (0.24)	0.96 (0.34)	<0.001**
E, cm/sec	75.93 (15.41)	41.31 (12.00)	46.31 (12.03)	60.50 (27.58)	83.82 (25.02)	62.77 (22.49)	<0.001**
E/é	8.95 (2.01)	14.26 (5.04)	18.28 (6.20)	10.03 (0.90)	12.68 (5.25)	11.61 (4.92)	<0.001**
Septal e, cm/sec	8.36 (1.76)	4.75 (1.15)	4.70 (1.0)	6.50 (0.71)	6.18 (0.87	6.76 (2.29)	<0.001**
Lateral e, cm/sec	12.15 (2.33)	8.00 (2.45)	6.00 (0.14)	8.00 (0.28)	7.88 (1.25)	11.04 (2.88)	<0.001**
Septal + Lateral e	10.73 (1.92)	6.38 (1.70)	5.50 (0.14)	7.50 (0.28)	7.58 (0.38)	9.82 (2.39)	<0.001**
TR velocity, m/sec	2.43 (0.29)	2.67 (0.85)	2.67 (0.49)	2.80 (0.14)	3.00 (0.14)	2.60 (0.56)	0.853
HR (beat per minute)	76.01 (11.46)	75.98 (13.35)	72.25 (10.95)	82.50 (6.36)	72.73 (11.34)	75.59 (12.00)	0.608

https://doi.org/10.56056/amj.2026.454 https://amj.khcms.edu.krd

P-duration, m/sec	45.42 (18.07)	66.81 (23.02)	85.88 (25.77)	80.00 (0.00)	51.09 (32.29)	56.16 (24.91)	<0.001**
P-amplitude, mm	0.83 (40)	0.88 (0.42)	1.33 (0.64)	0.65 (0.49)	0.65 (0.22)	0.87 (0.44)	0.001 *
PTFV1, mm/sec	0.04 (0.03)	0.06 (0.04)	0.12 (0.07)	0.05 (0.04)	0.03 (0.02)	0.05 (0.04)	<0.001**
Ejection Fraction	61.04 (3.02)	55.80 (9.41)	52.19 (10.77)	51.00 (19.80)	58.64 (8.69)	58.42 (7.55)	<0.001**

E/é: Early diastolic/annular velocity ratio, G: Grade, HR: Heart rate, IND: Indeterminate, LAV: Left atrial volume; LAVi: Left atrial volume index; PTFV1: P-wave terminal force in lead V1; TR: Tricuspid regurgitation. *: Significant difference; **: Highly significant difference using Analysis of Variance (TR and HR) and Kruskal–Walli's test (others).

Table (3): Correlation of echocardiographic parameters with P-duration and PTFV1

Electrocardiographic parameter	P-duration		PTFV1	
	r	p-value	r	p-value
LAV, ml/m^2	0.310	<0.001**	0.223	<0.001**
LAVi, ml/m^2	0.365	<0.001**	0.281	<0.001**
E/A	-0.253	0.011*	-0.178	0.012*
E, cm/sec	-0.419	<0.001**	-0.273	<0.001**
E/e	0.279	<0.001**	0.206	0.003*
Septal e, cm/sec	-0.420	<0.001**	-0.311	<0.001**
Lateral e, cm/sec	-0.384	<0.001**	-0.162	0.229
Septal+ Lateral e, cm/sec	-0.493	<0.001**	-0.194	0.173
TR velocity, m/sec	0.366	0.094*	0.035	0.876
Heart rate (beat per minute)	0.056	0.433*	0.143	0.043*
P-amplitude, mm	0.401	<0.001**	0.870	<0.001**
Ejection fraction	-0.167	<0.001**	-0.176	<0.001**

LAV: Left atrial volume, LAVi: Left atrial volume index, PTFV1: P-wave terminal force in lead V1, TR: Tricuspid regurgitation. *: Significant difference at 0.05; **: Significant difference at 0.01 using the Person correlation test (TR and HR) and Spearman correlation test (others)

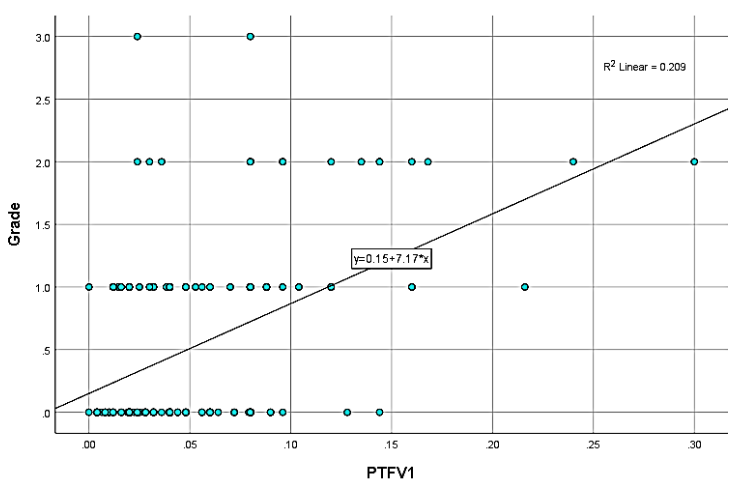

Figure (1): Using the Spearman correlation test, the correlation between PTFV1 and diastolic dysfunction grades. PTFV1: P-wave terminal force in lead V1.

https://doi.org/10.56056/amj.2026.454 https://amj.khcms.edu.krd

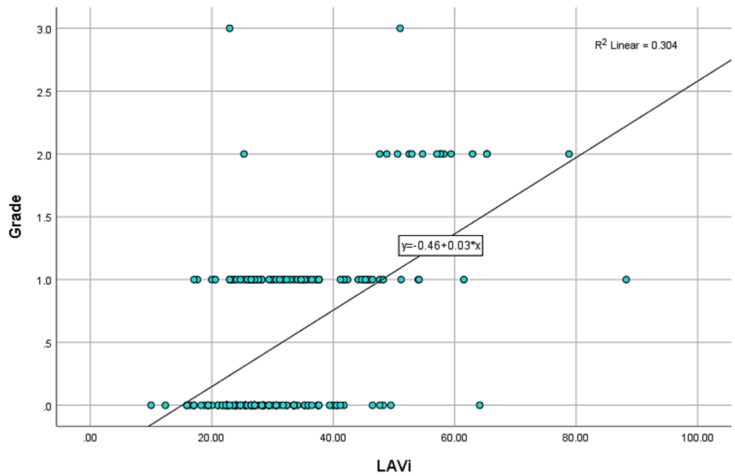

Figure (2): The correlation between Left atrial volume index (LAVi) and diastolic dysfunction grades using Spearman correlation test.

Discussion

In the current study, the correlation between ECG indices of LA overload and LVDF estimation by echocardiography was assessed by finding the duration of the P-wave in lead VI, the amplitude and duration of the P-wave negative phase in lead VI and calculating PTFV1. The results revealed that P-duration is a potential item for screening patients with LVDDF. In this regard, multiple research studies have been conducted on the correlation between P-wave indices and LA size and pressure; however, limited studies have been performed to determine the correlation between LVDF by echocardiography and ECG indices of LA overload.[7] Consequently, in this study, 82 patients (41%) had LVDDF (64 with G1, 16 with G2 and 2 with G3), while another study found 62 cases (53%) with LVDDF (30 with G1, 25 with G2, 7 with G1/2, and 0.0 with G3).[1] In our study, only 2 cases with G3 were found, indicating a significant elevation of pressure in the left side of the heart, which might progress into advanced heart failure if not managed or treated. On the other hand, large numbers of LVDDF with G1 and G2 among patients might be related to the fact that most patients had other comorbidities that affected diastolic function, such as DM, HTN, and IHD, as found in another study.[12,13] Moreover, the results showed that all patients were overweight with a BMI of >27.0 kg/m^2, which might be a leading cause of LVDDF as determined by Rozenbaum et al. who reported that increased BMI is related to high risk of diastolic dysfunction even in healthy individuals.[14] Also, Ng et al. confirmed that obesity was associated with greater LVDDF than diabetes.[15] Additionally, the present study revealed that P-duration has a decent positive correlation with LAVi, with a significant difference between normal LVDF and LVDDF groups. Thus, P-duration is reflected an index that indicates LA size and could be used to find the LVDDF. These results are parallel to that of Sumita et al. in Japan.[1] Accurately determining LVDDF among patients with cardiac problems is potentially essential clinically, and P-duration measurements could aid in this process. In this study, G_{IND} was found in 11 patients (5.5%) who might have diastolic dysfunction with preserved LVDF. Among them, one patient had AS (9.1%) and 2 cases had AR (18.2%). These patients might develop left ventricle enlargement and heart failure. These outcomes are much lesser than

https://doi.org/10.56056/amj.2026.454

those found by Sumita et al. who reported 27 cases (23%) of G_{IND} among patients with cardiac issues.[1] However, they found 2 cases of AS and 2 cases of AR (1.7% each). The limitations of this study are small sample size due to the short duration of the study, the inability to use conventional diagnostic criteria for assessing LA overload, and the inability to follow up the studied patients.

Conclusions

The P-duration is a helpful index in detecting LVDDF. Thus, positive P-duration and PTFV1 indicate the presence of LVDDF with increasing LA pressure. However, in cases of indeterminate LVDF, both ECG and echocardiography should be used together.

Conflict of interest

Not declared.

Acknowledgements

The authors appreciate the staff from the Sulaimani Cardiac Hospital and Faruk Medical City, Sulaimaniyah, Iraq. They also profoundly thank KHCMS for this study opportunity.

References

1. Sumita Y, Nakatani S, Murakami I, Taniguchi M. Significance of left atrial overload by electrocardiogram in the assessment of left ventricular diastolic dysfunction. J Echocardiogr. 2020, 18(2):105-112.
2. Kuznetsova T, Cauwenberghs N, Sabovčik F, Kobayashi Y, Haddad F. Evaluation of diastole by echocardiography for detecting early cardiac dysfunction: an outcome study. ESC Heart Fail. 2022, 9(3):1775-1783.
3. Kosmala W, Marwick TH. Asymptomatic left ventricular diastolic dysfunction: predicting progression to symptomatic heart failure. Cardiovasc Imaging. 2020, 13(1 Part 2):215-227.
4. Kwon JM, Kim KH, Jeon KH, Kim HM, Kim MJ, Lim SM et al. Development and validation of deep-learning algorithm for electrocardiography-based heart failure identification. Korean Circ J. 2019, 49(7):629-639.
5. Gouda P, Brown P, Rowe BH, McAlister FA, Ezekowitz JA. Insights into the importance of the electrocardiogram in patients with acute heart failure. Eur J Heart Fail. 2016, 18(8):1032-1040.
6. Wolder LD, Graff C, Baadsgaard KH, Langgaard ML, Polcwiartek C, Lee CJ-Y et al. Electrocardiographic P terminal force in lead V1, its components, and the association with stroke and atrial fibrillation or flutter. Heart Rhythm 2023, 20(3):354-362.
7. Tanoue MT, Kjeldsen SE, Devereux RB, Okin PM. Relationship between abnormal P-wave terminal force in lead V1 and left ventricular diastolic dysfunction in hypertensive patients: the LIFE study. Blood Pressure. 2017, 26(2):94-101.
8. Chen LY, Ribeiro AL, Platonov PG, Cygankiewicz I, Soliman EZ, Gorenek B. et al. P wave parameters and indices: a critical appraisal of clinical utility, challenges, and future research—a consensus document endorsed by the International Society of Electrocardiology and the International Society for Holter and Noninvasive Electrocardiology. Circ: Arrhythmia Electrophysiol. 2022, 15(4):e010435.
9. Chen Q, Mohanty S, Trivedi C, Gianni C, Della Rocca DG, Canpolat U et al. Association between prolonged P wave duration and left atrial scarring in patients with paroxysmal atrial fibrillation. J Cardiovas Electrophysiol. 2019, 30(10):1811-1818.
10. Lang RM, Badano LP, Mor-Avi V, Afilalo J, Armstrong A, Ernande L et al. Recommendations for cardiac chamber quantification by echocardiography in adults: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. Eur

Heart J Cardiovasc Imaging 2015, 16(3):233-271.

11. Nagueh SF, Smiseth OA, Appleton CP, Byrd BF, Dokainish H, Edvardsen T et al. Recommendations for the evaluation of left ventricular diastolic function by echocardiography: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. Eur J Echocardiogr. 2016, 17(12):1321-1360.

12. Otsuka T, Suzuki M, Yoshikawa H, Sugi K. Left ventricular diastolic dysfunction in the early stage of chronic kidney disease. J Cardiol. 2009, 54(2):199-204.

13. Hayıroğlu Mİ, Çınar T, Çiçek V, Asal S, Kılıç Ş, Keser N et a. A simple formula to predict echocardiographic diastolic dysfunction-electrocardiographic diastolic index. Herz 2021, 46(Suppl 2):159-165.

14. Rozenbaum Z, Topilsky Y, Khoury S, Pereg D, Laufer-Perl M. Association of body mass index and diastolic function in metabolically healthy obese with preserved ejection fraction. Int J Cardiol. 2019, 277:147-152.

15. Ng AC, Prevedello F, Dolci G, Roos CJ, Djaberi R, Bertini M et al. Impact of diabetes and increasing body mass index category on left ventricular systolic and diastolic function. J Am Society Echocardiogr. 2018, 31(8):916-925.

https://doi.org/10.56056/amj.2026.454