ORIGINAL ARTICLE

https://doi.org/10.1590/1806-9282.20230607

CHA2DS2-VASc score, P-wave indexes, and echocardiographic parameters in sinus rhythm patients without valvular heart disease

Amanda Vanessa Demarchi[1*], Luciana Vidal Armaganijan[1], Dalmo Antonio Ribeiro Moreira[1], Mariane Higa Shinzato[1], Kelvin Henrique Vilalva[1], Pablo Santos Graffitti[1], Rodrigo Augusto de Miranda Bertin[1], Mathias Antonio Haruno de Vilhena[1], Murilo Amato David[1], Guilherme Dagostin de Carvalho[1]

SUMMARY

OBJECTIVE: The aim of this study was to evaluate the correlation between P-wave indexes, echocardiographic parameters, and CHA2DS2-VASc score in patients without atrial fibrillation and valvular disease.

METHODS: This retrospective cross-sectional study included patients of a tertiary hospital with no history of atrial fibrillation, atrial flutter, or valve disease and collected data from June 2021 to May 2022. The exclusion criteria were as follows: unavailable medical records, pacemaker carriers, absence of echocardiogram report, or uninterpretable ECG. Clinical, electrocardiographic [i.e., P-wave duration, amplitude, dispersion, variability, maximum, minimum, and P-wave voltage in lead I, Morris index, PR interval, P/PR ratio, and P-wave peak time], and echocardiographic data [i.e., left atrium and left ventricle size, left ventricle ejection fraction, left ventricle mass, and left ventricle indexed mass] from 272 patients were analyzed.

RESULTS: PR interval (RHO=0.13, p=0.032), left atrium (RHO=0.301, p<0.001) and left ventricle diameter (RHO=0.197, p=0.001), left ventricle mass (RHO=0.261, p<0.001), and left ventricle indexed mass (RHO=0.340, p<0.001) were positively associated with CHA2DS2-VASc score, whereas P-wave amplitude (RHO=-0.141, p=0.02), P-wave voltage in lead I (RHO=-0.191, p=0.002), and left ventricle ejection fraction (RHO=-0.344, p<0.001) were negatively associated with the same score. The presence of the Morris index was associated with high CHA2DS2-VASc (p=0.022).

CONCLUSION: Prolonged PR interval, Morris index, increased left atrium diameter, left ventricle diameter, left ventricle mass, and left ventricle indexed mass values as well as lower P-wave amplitude, P-wave voltage in lead I, and left ventricle ejection fraction values were correlated with higher CHA_2DS_2-VASc scores.

KEYWORDS: Heart function tests. Electrocardiography. Echocardiography. Risk factors.

INTRODUCTION

The CHA_2DS_2-VASc score is used to assess the risk of stroke in patients with atrial fibrillation (AF)[1,2]. However, recent studies have shown validation of this score as a predictor of cardiovascular outcomes (including the development of AF), thromboembolic events, and death, even in the absence of AF[3-7].

Electrocardiographic parameters such as P-wave duration (PWD), variability and dispersion, interatrial block, maximum P (Pmax), and P-wave voltage in lead I (PVL1) have been studied as risk stratifiers for AF[8-11]. Echocardiographic parameters, including left atrial (LA) and left ventricular (LV) size, LV ejection fraction (LVEF), and LV mass, have also been associated with the risk of developing AF as well as all-cause mortality, myocardial infarction, and stroke or transient ischemic attack (TIA)[12-14].

Despite the data presented, there are no enough data on the correlation between these parameters and the CHA_2DS_2-VASc score in the population without AF.

The aim of this study was to evaluate the correlation between P-wave indexes [i.e., Morris index, mean duration, standard deviation (SD) and variability of P-wave, Pmax, minimum P (Pmin), P-wave dispersion, PVL1, PR interval (PRi), P/PR ratio (PPRi), and P-wave peak time] and echocardiographic findings (i.e., LA and LV size, LVEF, LV mass, and LV indexed mass) and CHA_2DS_2-VASc score in patients without AF and without valvular disease.

METHODS

The research project that resulted in this article was sent to Plataforma Brasil, received the number CAAE

[1]Instituto Dante Pazzanese de Cardiologia – São Paulo (SP), Brazil.
*Corresponding author: amandademarchi@id.uff.br
Conflicts of interest: the authors declare there is no conflicts of interest. Funding: none.
Received on June 24, 2023. Accepted on July 03, 2023.

46451521.2.0000.5462, and was approved on June 01, 2021 by the Research Ethics Committee of Dante Pazzanese Cardiology Institute. All patients included in the study signed an informed consent form.

This was a retrospective cross-sectional study that included patients with no history of AF, atrial flutter, or valve disease, who were followed up at Dante Pazzanese Cardiology Institute and underwent electrocardiogram (ECG) and echocardiogram at the same institution. Patients with unavailable medical records, pacemaker carriers, absence of echocardiogram report, or with uninterpretable ECG were excluded from the study. Overall, 321 patients were included in the study period and data collection was performed in the same period (06/01/2021 to 05/01/2022).

The insufficient data on the correlation of ECG parameters and CHA_2DS_2-VASc score made it impossible to calculate the sample size before carrying out this study, which, in turn, may serve as a basis for sample calculations for other future studies with similar objectives. Therefore, the sample size of this study was defined by convenience.

Calculation of the CHA_2DS_2-VASc score

The CHA_2DS_2-VASc score was calculated based on the data available on medical records. Information about heart failure (HF), hypertension (HTN), diabetes mellitus (DM), vascular disease, history of stroke or TIA, gender, and age at the time of ECG were obtained. A high CHA_2DS_2-VASc score was considered if ≥2 for males and ≥3 for females.

ECG analysis

All ECGs were analyzed by an investigator to determine the P-wave indexes using the CardioCalipers® program. A second investigator performed the same measurements on 20% of the sample in order to assess the interobserver agreement. Both investigators were unaware of the patients' clinical data.

PWD was measured in all 12 leads. The highest value was chosen to determine Pmax and the lowest for Pmin. P-wave dispersion was calculated by the difference between Pmax and Pmin. The mean PWD and SD were also calculated. P-wave variability was obtained by dividing the SD by the mean PWD.

The PRi was measured in lead II. The PPRi ratio was calculated by dividing the PWD by the PRi.

P-wave peak time was measured from the beginning to the peak of the P-wave in lead II. P-wave voltage (PVL1) was measured in lead I, while P-wave amplitude was measured in lead II.

The presence of the Morris index was considered when the product of the amplitude (mm) and time (ms) of a terminal negative P-wave in V1 was>40.

Echocardiographic analysis

The following echocardiographic variables were collected: LA dimension, LV diastolic diameter, LVEF, LV mass, and LV indexed mass.

Statistical analysis

Continuous variables were presented by measures of central tendency (mean and median) and dispersion (variation and SD), and categorical variables were presented by frequency distribution (number of cases and relative percentage).

Categorical variables (high or low CHA_2DS_2-VASc score) were compared in relation to numerical variables (P-wave and echocardiographic measurements) with Student's t-test. Shapiro-Wilk's tests were used to test the normality of the data. If data normality was not verified, the Mann-Whitney U-test was adopted.

The chi-square test was used to verify the association between the categories. To verify the correlation between numerical variables, Spearman's rank correlation coefficient (RHO) was used. The kappa coefficient was applied to measure inter-rater reliability.

RESULTS

A total of 49 patients were excluded due to unavailable medical records (n=40) or the absence of available echocardiogram reports (n=9).

The mean age of the 272 individuals included in the final analysis was 62.4 (12.6) years, 56.6% (n=154) were females, 82% (n=223) of patients had HTN, 72.4% (n=197) had dyslipidemia, 35.3% (n=96) had atherosclerotic disease, 34.2% (n=93) had DM, and 21% (n=57) had HF. The mean CHA_2DS_2-VASc score was 3. The majority of patients [68% (n=185)] were on beta-blockers, and 18% (n=49) were on antiarrhythmics. Beta-blockers were indicated due to coronary disease, HF, and refractory HTN. Antiarrhythmics were indicated for the treatment of ventricular and supraventricular arrhythmias, excluding AF and atrial flutter (Table 1).

The mean LA and LV diameters were 40.1 (5.1) and 51.6 (6.9) mm, respectively. The mean LVEF was 57.9 (11)%. The mean LV mass and LV indexed mass were 209.5 (63.3) g and 117.2 (31.6) g/m^2, respectively. For P-wave indexes, the mean PWD was 110.3 (14.2) ms, PVL1 was 0.79 (0.27) mm, P amplitude was 1.1 (0.39) mm, and the PRi was 174.4 (39.9)

Table 1. Demographic characteristics, echocardiographic parameters, P-wave indexes, and CHA2DS2-VASc score.

Variable	Category/ Measurements	Frequency (%)/ Measurements
Age	Mean (SD)	62.4 (12.6)
Age range	18–64	140 (51.5)
	65–74	89 (32.7)
	≥75	43 (15.8)
Gender	Male	118 (43.4)
	Female	154 (56.6)
BMI (kg/m^2)	Mean (SD)	28.4 (5.5)
HF		57 (21.0)
HTN		223 (82.0)
DM		93 (34.2)
Stroke/TIA		16 (5.9)
Atherosclerotic disease		96 (35.3)
Dyslipidemia		197 (72.4)
Hypothyroidism		43 (15.8)
Smoking	Smoker	15 (5.5)
	Former smoker	69 (25.4)
	Never smoker	188 (69.1)
Beta-blocker		185 (68.0)
Antiarrhythmic		49 (18.0)
LA (mm)	Mean (SD)	40.1 (5.1)
LVEF (%)	Median (variation)	62.0 (22–79)
LV (mm)	Median (variation)	50 (36–88)
LV mass (g)	Median (variation)	198 (36–464)
LV indexed mass (g/m^2)	Median (variation)	113.1 (34–243)
Average PWD (ms)	Mean (SD)	110.3 (14.2)
P SD (ms)	Mean (SD)	14.4 (4.1)
P variability	Median (variation)	0.13 (0.03–0.24)
Maximum P (ms)	Mean (SD)	131.9 (15.2)
Minimum P (ms)	Mean (SD)	85.5 (16.1)
P dispersion (ms)	Median (variation)	44.0 (16–108)
PVL1 (mm)	Median (variation)	0.8 (0.3–2.2)
P amplitude (mm)	Median (variation)	1.1 (0.2–2.6)
PPRi	Median (variation)	0.69 (0.34–1.24)
P-wave peak time (ms)	Median (variation)	60 (28–100)
PRi (ms)	Median (variation)	172 (88–276)
Morris index		42 (15.4)
CHA_2DS_2-VASc	Median (variation)	3.0 (0–7)
CHA_2DS_2-VASc	0	5 (1.8)
	1	31 (11.4)
	2	67 (24.6)
	3	68 (25.0)
	4	59 (21.7)
	5	31 (11.4)
	6	10 (3.7)
	7	1 (0.4)
High CHA_2DS_2–VASc		193 (71.0)

BMI: body mass index; DM: diabetes mellitus; HF: heart failure; LA: left atrium; LV: left ventricle; LVEF: left ventricular ejection fraction; PPRi: P/PR ratio; PRi: PR interval; PVL1: P-wave voltage in lead I; PWD: P-wave duration; HTN: hypertension; SD: standard deviation; TIA: transient ischemic attack.

ms. The presence of the Morris index was observed in 15.4% of patients (Table 1).

The ECG analysis showed a slight correlation between the CHA_2DS_2-VASc score and PRi (RHO=0.13, p=0.032), P-wave amplitude (RHO=-0.141, p=0.02), and PVL1 (RHO=-0.191, p=0.002), when analyzed as continuous variables. The correlation was positive for PRi and negative for P-wave amplitude and PVL1. The other variables showed no correlation with the CHA_2DS_2-VASc score (Table 2).

All echocardiographic parameters analyzed were significantly correlated with the CHA_2DS_2-VASc score. The LA diameter (RHO=0.301, p<0.001), LV diameter (RHO=0.197, p=0.001), LV mass (RHO=0.261, p<0.001), and LV indexed mass (RHO=0.340, p<0.001) were positively correlated with the CHA_2DS_2-VASc score, whereas LVEF (RHO=-0.344, p<0.001) had a negative correlation (Table 2).

The CHA_2DS_2-VASc score was categorized into high (≥2 for males and ≥3 for females) and low (<2 for males and<3 for females). There was a statistically significant comparison between high CHA_2DS_2-VASc score and PRi (median of 176 ms in high CHA_2DS_2-VASc versus 164 ms in low CHA_2DS_2-VASc). A similar finding was observed with a high CHA_2DS_2-VASc score and all studied echocardiographic variables. The presence of the Morris index was also associated with high CHA_2DS_2-VASc. Morris index was observed in 18.6% of the individuals with high CHA_2DS_2-VASc (Table 3).

Interobserver variation analysis revealed CCC of 0.915 for PVL1 and 0.937 for P-wave amplitude and kappa coefficient of 1.0 for the presence of Morris index, 0.7047 for P-wave peak time, 0.9483 for PRi, and 0.9196 for PWD, indicating substantial to almost perfect agreement for all the examined variables.

DISCUSSION

In this study, we found a correlation between P-wave indexes, echocardiographic parameters, and the CHA_2DS_2-VASc score.

P-wave indexes and CHA_2DS_2-VASc score

The analysis of P-wave indexes should be stimulated by the wide availability and reproducibility of ECG in clinical practice, as it is a low-cost test.

The positive and significant correlation between PRi and the CHA_2DS_2-VASc score reflects that patients with cardiovascular comorbidities tend to have a higher occurrence of first-degree atrioventricular block. PRi prolongation alone is associated with an increased risk of AF, pacemaker implantation, and all-cause mortality[15].

Table 2. Correlation between P-wave indexes, echocardiographic parameters, and CHA2DS2-VASc score.

Variable	Variation	Median	Mean (SD)	RHO	p-Value
Mean PWD (ms)	63–153.1	110.3	110.3 (14.2)	0.084	0.167
P dispersion (ms)	16–108	44	46.4 (13.5)	0.026	0.669
P amplitude (mm)	0.2–2.6	1.1	1.1 (0.4)	(-0.141)	**0.020**
PRi (ms)	88–276	172	174.4 (29.9)	0.130	**0.032**
PPRi	0.3–1.2	0.7	0.7 (0.1)	(-0.078)	0.200
P-wave peak time (ms)	28–100	60	59.0 (13.2)	(-0.027)	0.656
P SD (ms)	4.3–29.3	14.2	14.4 (4.1)	0.053	0.379
P Variability	0.03–0.24	0.13	0.13 (0.04)	0.027	0.662
PVL1 (mm)	0.3–2.2	0.8	0.8 (0.3)	(-0.191)	**0.002**
LA (mm)	25–57	40	40.1 (5.1)	0.301	**<0.001**
LVEF (%)	22–79	62	57.9 (11.0)	(-0.344)	**<0.001**
LV (mm)	36–88	50	51.6 (6.9)	0.197	**0.001**
LV mass (g)	36–464	198	209.5 (63.3)	0.261	**<0.001**
LV indexed mass (g/m²)	34–243	113.1	117.2 (31.6)	0.340	**<0.001**

LA: left atrium; LV: left ventricle; LVEF: left ventricular ejection fraction; PPRi: P/PR ratio; PRi: PR interval; PVL1: p-wave voltage in lead I; PWD: P-wave duration; RHO: Spearman's rank correlation coefficient; SD: standard deviation. Statistically significant values are indicated in bold.

Table 3. P-wave indexes, echocardiographic parameters, and high or low CHA2DS2-VASc score.

Variable	Category/Measurements	CHA_2DS_2-VASc		p-Value
		Low	High	
PPRi	Mean (SD)	0.7 (0.1)	0.7 (0.1)	0.153*
Mean PWD (ms)	Mean (SD)	109.3 (13.3)	110.7 (14.6)	0.468*
P SD (ms)	Mean (SD)	13.9 (4.1)	14.6 (4.2)	0.224*
P variability	Median (variation)	0.13 (0.03–0.24)	0.13 (0.05–0.24)	0.292**
P-wave peak time (ms)	Median (variation)	60 (28–88)	60 (28–100)	0.946**
P dispersion (ms)	Median (variation)	44 (16–92)	48 (16–108)	0.339**
PVL1 (mm)	Median (variation)	0.8 (0.4–1.5)	0.7 (0.3–2.2)	0.220**
P amplitude (mm)	Median (variation)	1.1 (0.6–2.3)	1.1 (0.2–2.6)	0.183**
PRi (ms)	Median (variation)	164 (128–256)	176 (88–276)	**0.020****
Morris index		6 (7.6)	36 (18.6)	**0.022*****
LA (mm)	Mean (SD)	36.7 (4.5)	41.5 (4.7)	**<0.001***
LVEF (%)	Median (variation)	64 (32–75)	60 (22–79)	**<0.001****
LV (mm)	Median (variation)	49 (36–61)	51 (38–88)	**<0.001****
LV mass (g)	Median (variation)	172 (53.8–341)	213 (36–464)	**<0.001****
LV indexed mass (g/m²)	Median (variation)	99 (34–179.6)	118.7 (56.6–243)	**<0.001****

*p-value obtained by Student's t-test. **p-value obtained by the Mann-Whitney U test. ***p-value obtained by the chi-square test. LA: left atrium; LV: left ventricle; LVEF: left ventricular ejection fraction; PPRi: P/PR ratio; PRi: PR interval; PVL1: P-wave voltage in lead I; PWD: P-wave duration; SD: standard deviation. Statistically significant values are indicated in bold.

PVL1, when reduced, is associated with recent-onset AF in the population with coronary artery disease[10]. This finding may be related to the propagation of the electrical stimulus of the heart. By means of electrophysiological mapping, it was demonstrated that the electrical impulse of interatrial conduction is more displaced in the area of the Bachmann bundle in

individuals with low PVL1[16]. The negative correlation between PVL1 and CHA_2DS_2-VASc score in individuals without AF reinforces that this P-wave index should be valued in clinical practice.

P-wave amplitude in lead II was also negatively correlated with the CHA_2DS_2-VASc score. The P-wave amplitude, when reduced, is associated with greater rates of early AF recurrence after electrical cardioversion[17].

Echocardiographic parameters and CHA_2DS_2-VASc score

In individuals with AF, echocardiographic abnormalities are commonly found such as changes in LA diameter, LA *strain*, left atrial appendage emptying velocity, presence of spontaneous contrast, and thrombus. Atrial abnormalities are also associated with thromboembolic risk and mortality[18].

$CHADS_2$ and CHA_2DS_2-VASc scores are associated with echocardiographic risk factors for thromboembolism, such as decreased left atrial appendage emptying velocity, presence of spontaneous contrast, and thrombus[19]. Left atrial stasis, the presence of thrombi, and complex aortic plaque were associated with an increased risk of stroke, regardless of $CHADS_2$ and CHA_2DS_2-VASc scores in patients with AF[20]. The addition of echocardiographic risk parameters can complement the clinical assessment to estimate stroke risk in patients with AF[19].

Ventricular abnormalities also predict thromboembolic risk in patients with AF, such as increased LV mass, LV hypertrophy, and left ventricular dysfunction[19,21].

Even in the absence of AF, increased LV mass, abnormal LV geometry, and reduced LVEF are independent risk factors for death and cardiovascular diseases such as myocardial infarction and stroke[13,14,22-24].

In this study, a significant correlation between all echocardiographic parameters and the CHA_2DS_2-VASc score was demonstrated, being positive for LA diameter, LV, LV mass, and LV indexed mass and negative for LVEF.

ECG and echocardiographic parameters in clinical practice

The results of this study highlight the importance of the association of clinical, electrocardiographic, and echocardiographic variables in the stratification of systemic thromboembolism in patients with sinus rhythm.

High-cost and less-available devices, such as implantable monitoring devices, have been gaining ground to identify individuals with silent AF as the identification can prevent stroke with early institution of anticoagulation. However, there is still no well-defined consensus on which patients such devices should be recommended considering health system costs[25].

There is still not enough evidence to establish anticoagulation as a preventive treatment for stroke in the absence of AF; however, the applicability of clinical, ECG, and echocardiographic parameters may be confirmed in the future with the development of randomized clinical trials.

Limitations

The unicentric, observational, and cross-sectional nature is the main limitation of this study. The sample size was not calculated before the start of the study because of insufficient data on the correlation of ECG parameters and CHA_2DS_2-VASc score. Moreover, information about AF and valve disease was based on medical records. Therefore, silent AF patients may be included in the study.

CONCLUSIONS

Prolonged PRi, Morris index, increased LA diameter, LV diameter, LV mass, and LV indexed mass values as well as lower P-wave amplitude, PVL1, and LVEF values were correlated with higher CHA_2DS_2-VASc scores.

AUTHORS' CONTRIBUTIONS

AVD: Conceptualization, Data curation, Formal Analysis, Methodology, Project administration, Writing – original draft. **LVA:** Conceptualization, Project administration, Supervision, Writing – review & editing. **DARM:** Conceptualization, Writing – review & editing. **MHS:** Formal Analysis, Investigation, Methodology. **KHV:** Formal Analysis, Investigation, Methodology. **PSG:** Formal Analysis, Investigation, Methodology. RAMB: Formal Analysis, Investigation, Methodology. **MAHV:** Formal Analysis, Investigation, Methodology. **MAD:** Formal Analysis, Investigation, Methodology. **GDC:** Formal Analysis, Methodology, Writing – review & editing.

REFERENCES

1. Lip GY, Nieuwlaat R, Pisters R, Lane DA, Crijns HJ. Refining clinical risk stratification for predicting stroke and thromboembolism in atrial fibrillation using a novel risk factor-based approach: the euro heart survey on atrial fibrillation. Chest. 2010;137(2):263-72. https://doi.org/10.1378/chest.09-1584

2. Staa TP, Setakis E, Tanna GL, Lane DA, Lip GY. A comparison of risk stratification schemes for stroke in 79,884 atrial fibrillation patients in general practice. J Thromb Haemost. 2011;9(1):39-48. https://doi.org/10.1111/j.1538-7836.2010.04085.x

3. Mitchell LB, Southern DA, Galbraith D, Ghali WA, Knudtson M, Wilton SB, et al. Prediction of stroke or TIA in patients without

atrial fibrillation using CHADS2 and CHA2DS2-VASc scores. Heart. 2014;100(19):1524-30. https://doi.org/10.1136/heartjnl-2013-305303

4. Melgaard L, Gorst-Rasmussen A, Lane DA, Rasmussen LH, Larsen TB, Lip GY. Assessment of the CHA2DS2-VASc score in predicting ischemic stroke, thromboembolism, and death in patients with heart failure with and without atrial fibrillation. JAMA. 2015;314(10):1030-8. https://doi.org/10.1001/jama.2015.10725
5. Wu JT, Wang SL, Chu YJ, Long DY, Dong JZ, Fan XW, et al. CHADS2 and CHA2DS2-VASc scores predict the risk of ischemic stroke outcome in patients with interatrial block without atrial fibrillation. J Atheroscler Thromb. 2017;24(2):176-84. https://doi.org/10.5551/jat.34900
6. Ntaios G, Lip GY, Makaritsis K, Papavasileiou V, Vemmou A, Koroboki E, et al. $CHADS_2$, $CHA_2S_2DS_2$-VASc, and long-term stroke outcome in patients without atrial fibrillation. Neurology. 2013;80(11):1009-17. https://doi.org/10.1212/WNL.0b013e318287281b
7. Renda G, Ricci F, Patti G, Aung N, Petersen SE, Gallina S, et al. CHA2DS2VASc score and adverse outcomes in middle-aged individuals without atrial fibrillation. Eur J Prev Cardiol. 2019;26(18):1987-97. https://doi.org/10.1177/2047487319868320
8. Alexander B, Milden J, Hazim B, Haseeb S, Bayes-Genis A, Elosua R, et al. New electrocardiographic score for the prediction of atrial fibrillation: The MVP ECG risk score (morphology-voltage-P-wave duration). Ann Noninvasive Electrocardiol. 2019;24(6):e12669. https://doi.org/10.1111/anec.12669
9. Cortez D, Baturova M, Lindgren A, Carlson J, Shubik YV, Olsson B, et al. Atrial time and voltage dispersion are both needed to predict new-onset atrial fibrillation in ischemic stroke patients. BMC Cardiovasc Disord. 2017;17(1):200. https://doi.org/10.1186/s12872-017-0631-1
10. Alexander B, Haseeb S, Rooy H, Tse G, Hopman W, Martinez-Selles M, et al. Reduced P-wave voltage in lead i is associated with development of atrial fibrillation in patients with coronary artery disease. J Atr Fibrillation. 2017;10(4):1657. https://doi.org/10.4022/jafib.1657
11. Dilaveris PE, Gialafos EJ, Sideris SK, Theopistou AM, Andrikopoulos GK, Kyriakidis M, et al. Simple electrocardiographic markers for the prediction of paroxysmal idiopathic atrial fibrillation. Am Heart J. 1998;135(5 Pt 1):733-8. https://doi.org/10.1016/s0002-8703(98)70030-4
12. Gupta N, Haft JI, Bajaj S, Samuel A, Parikh R, Pandya D, et al. Role of the combined CHADS2 score and echocardiographic abnormalities in predicting stroke in patients with paroxysmal atrial fibrillation. J Clin Neurosci. 2012;19(9):1242-5. https://doi.org/10.1016/j.jocn.2011.12.008
13. Bouzas-Mosquera A, Broullón FJ, Álvarez-García N, Peteiro J, Mosquera VX, Castro-Beiras A. Association of left ventricular mass with all-cause mortality, myocardial infarction and stroke. PLoS One. 2012;7(9):e45570. https://doi.org/10.1371/journal.pone.0045570
14. Loh E, Sutton MS, Wun CC, Rouleau JL, Flaker GC, Gottlieb SS, et al. Ventricular dysfunction and the risk of stroke after myocardial infarction. N Engl J Med. 1997;336(4):251-7. https://doi.org/10.1056/NEJM199701233360403
15. Cheng S, Keyes MJ, Larson MG, McCabe EL, Newton-Cheh C, Levy D, et al. Long-term outcomes in individuals with prolonged pr interval or first-degree atrioventricular block. JAMA. 2009;301(24):2571-7. https://doi.org/10.1001/jama.2009.888
16. Park JK, Park J, Uhm JS, Joung B, Lee MH, Pak HN. Low P-wave amplitude (<0.1 mV) in lead I is associated with displaced inter-atrial conduction and clinical recurrence of paroxysmal atrial fibrillation after radiofrequency catheter ablation. Europace. 2016;18(3):384-91. https://doi.org/10.1093/europace/euv028
17. Gorenek B, Birdane A, Kudaiberdieva G, Goktekin O, Cavusoglu Y, Unalir A, et al. P wave amplitude and duration may predict immediate recurrence of atrial fibrillation after internal cardioversion. Ann Noninvasive Electrocardiol. 2003;8(3):215-8. https://doi.org/10.1046/j.1542-474x.2003.08308.x
18. Khumri TM, Idupulapati M, Rader VJ, Nayyar S, Stoner CN, Main ML. Clinical and echocardiographic markers of mortality risk in patients with atrial fibrillation. Am J Cardiol. 2007;99(12):1733-6. https://doi.org/10.1016/j.amjcard.2007.01.055
19. Providência R, Botelho A, Trigo J, Quintal N, Nascimento J, Mota P, et al. Possible refinement of clinical thromboembolism assessment in patients with atrial fibrillation using echocardiographic parameters. Europace. 2012;14(1):36-45. https://doi.org/10.1093/europace/eur272
20. Sasahara E, Nakagawa K, Hirai T, Takashima S, Ohara K, Fukuda N, et al. Clinical and transesophageal echocardiographic variables for prediction of thromboembolic events in patients with nonvalvular atrial fibrillation at low-intermediate risk. J Cardiol. 2012;60(6):484-8. https://doi.org/10.1016/j.jjcc.2012.09.001
21. Boyd AC, McKay T, Nasibi S, Richards DA, Thomas L. Left ventricular mass predicts left atrial appendage thrombus in persistent atrial fibrillation. Eur Heart J Cardiovasc Imaging. 2013;14(3):269-75. https://doi.org/10.1093/ehjci/jes153
22. Handke M, Harloff A, Hetzel A, Olschewski M, Bode C, Geibel A. Predictors of left atrial spontaneous echocardiographic contrast or thrombus formation in stroke patients with sinus rhythm and reduced left ventricular function. Am J Cardiol. 2005;96(9):1342-4. https://doi.org/10.1016/j.amjcard.2005.06.085
23. Verma A, Meris A, Skali H, Ghali JK, Arnold JM, Bourgoun M, et al. Prognostic implications of left ventricular mass and geometry following myocardial infarction: the VALIANT (VALsartan In Acute myocardial iNfarcTion) Echocardiographic Study. JACC Cardiovasc Imaging. 2008;1(5):582-91. https://doi.org/10.1016/j.jcmg.2008.05.012
24. Ghali JK, Liao Y, Simmons B, Castaner A, Cao G, Cooper RS. The prognostic role of left ventricular hypertrophy in patients with or without coronary artery disease. Ann Intern Med. 1992;117(10):831-6. https://doi.org/10.7326/0003-4819-117-10-831
25. Halcox JPJ, Wareham K, Cardew A, Gilmore M, Barry JP, Phillips C, et al. Assessment of remote heart rhythm sampling using the alivecor heart monitor to screen for atrial fibrillation: the REHEARSE-AF study. Circulation. 2017;136(19):1784-94. https://doi.org/10.1161/CIRCULATIONAHA.117.030583