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Original article

Echocardiographic and laboratory parameters in hypertensive patients with and without atrial fibrillation

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Abstract

Background. Arterial hypertension (AH) is the most common cause of atrial fibrillation (AF). During AF, the contractile function of the left atrium (LA) is lost, and structural and functional remodeling occur. AH contributes greatly to the development of this common arrhythmia. The main objective of our study was to compare echocardiographic and laboratory biomarkers in patients with AH with or without AF.

Methods We conducted a cross-sectional analysis with 97 consecutive patients (mean age, 64±9 years; 49 male) with AH, 56 patients (57.7%) with AF. All patients underwent a basic examination and measurement of blood pressure. Laboratory testing (brain natriuretic peptide (BNP), C-reactive protein (CRP)), and transthoracic echocardiography examination with assessment of the LA antero-posterior (AP) diameter from the longitudinal parasternal section, and medio-lateral (ML) and superior-inferior (SI) dimension from the four-cavity apical section was performed.

Results. In two groups, there was no difference in blood pressure values. Mean systolic arterial pressure was slightly higher in the group of patients with AF (133,1±17,4 mmHg) compared with the group without AF (129,3±20,6 mmHg; t=0,991; p=0,324). Diastolic blood pressure values did not differ between groups (with AF 77,5±12,7mmHg, without AF 78,4±10,8mmHg, t=-0,348; p=0,729). Slightly increased values of CRP were in the group of patients with AF, but the difference was not statistically significant (2.5±1.2mg/L; 3.6±2.1mg/L, Z=-1.618; p=0.106). Also, there was significant difference between groups regarding the BNP (46±23 pg/ml, 89±55 pg/ml, Z=-3,838; p<0,001). Between the two groups, all echocardiographic measurements of the LA showed significant differences (AP 45,43±5.02mm with AF; 39.37±6.05mm, t=5.392, p<0,01, ML 58.57±7.69mm with AF; 50.12±8.01mm, t= 5.253, p<0,001, SI 47.43±6.35 mm with AF, 43.85±5.47 mm, t=2.9, p=0.005). As predictors of AF in hypertensive patients we found echocardiographic parameter – ML dimension of the LA and laboratory marker BNP.

Conclusion. Hypertensive patients with AF have a significantly increased LA compared with hypertensive patients in sinus rhythm. Predictors of AF in AH are ML dimension of LA and elevated value of BNP.

Kew words arterial hypertension, atrial fibrillation, left atrial dimension, biomarkers

Introduction

Arterial hypertension (AH) is a disease characterized by elevated systolic and diastolic values of blood pressure (BP) ≥140/90 mmHg, only elevated systolic BP (isolated systolic hypertension) or taking antihypertensive therapy[1]. Arterial blood pressure is a product of minute volume and total peripheral vascular pressure resistance [2].

It is estimated that about 20-25% of the general population worldwide have AH and the frequency varies based on geographical, national, racial, gender, or age criteria [3-5]. AH is a risk factor for cardiovascular diseases (CVD) such as atrial fibrillation (AF), coronary heart disease, stroke, peripheral artery disease, congestive heart failure and sudden cardiac death[6,7].

A Framingham study showed that an increase in left ventricular mass (LVm 116 g/m^2) significantly increased the risk of cardiovascular (CV) events in both sexes and correlated positively with age[8]. CV events that positively correlate with left ventricular hypertrophy are: the occurrence of heart failure, arrhythmias, sudden cardiac death and cerebrovascular events[9]. Clinical studies also have shown that regression of left ventricular hypertrophy reduces the incidence of CV morbidity and mortality[8,10]. Structural disorders heart following uncontrol AH include myocyte hypertrophy, hypertrophy of media of intramyocardial coronary arteries as well as collagen accumulation leading to cardiac fibrosis[11]. Furthermore, coronary flow is normal at rest, but in exertion, the coronary vasodilatory reserve becomes insufficient, which leads to subendocardial ischemia in conditions of increased myocardial oxygen demand [10,11]. Subendocardial ischemia and cardiac fibrosis worsen diastolic relaxation leading to diastolic heart failure[12]. Enlargement of the left atrium (LA) is associated with

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impaired systolic and diastolic function of the LA[13,14]. In patients with AH, the LA is chronically exposed to increased pressure during left ventricular diastole, which leads to increasing of pressure in the LA and a decrease in the conduction function of these chamber[15].
The frequency of AF increases with age. It is estimated that over 6% of the population older than 75 have this arrhythmia[16]. In 2016. approximately 43.6 million individuals worldwide have this arrhythmia, with a higher prevalence and incidence in more developed countries[16]. Also, one in four adults in Europe and the United States will develop AF later in life[17]. Recent estimation showed that by 2030, AF will have 14-17 million patients in the European Union with 120,000-215,000 newly diagnosed patients per year[18]. The prevalence of AF is higher in the elderly and in patients with AH, heart failure, coronary heart disease, valvular heart disease, obesity, diabetes mellitus, and chronic kidney disease[19]. AF is also associated with increased morbidity from heart failure and stroke[19]. In controlled studies, the average annual stroke rate was about 1.5% and the annual mortality was about 3% of anticoagulated AF patients[20].
It is important to assess the risk of AF in hypertensive patients, since AH is the most common predisposing factor for the development of this arrhythmia[21]. In the follow-up study by Manitoba et al., the incidence of AH was 53%, and the risk of AF was 1.42 times higher in hypertensive subjects compared with normotensive subjects[22]. However, despite its significance as a risk factor, little data are available on the predictors of AF in individuals with essential AH without coexisting disease such as valvular disease or coronary heart disease, heart failure, disease of thyroid gland or other predisposing conditions.
This aim of our study was to show the frequency of AF in patients with essential AH, and to comparatively analyze the echocardiographic and laboratory parameters between hypertensive patients with and without AF.

Methods

We conducted prospective cross-sectional analysis of 97 consecutive patients treated for hypertension with or without AF from 2018 to 2019 at the Cardiology Clinic, University Clinical Center of Serbia.
A total of 97 (mean age 64±9 years; 49 male) with AH, 56 patients (57.7%) had AF. The inclusion criteria was diagnosed essential hypertension according to the ESH (European Hypertension Association) guidelines[1]. The measurement of arterial blood pressure was performed according to the recommendations of the Joint Committee for Detection, Evaluation and Treatment of High Blood Pressure[6]. Exclusion criteria were secondary hypertension, the presence of heart failure, the presence of ischemic heart disease, and the presence of valvular heart disease.
All patients underwent a detailed physical examination with medical history exploration. Risk factors were analyzed: gender, age, previous hypertension, diabetes mellitus, hyperlipidemia, smoking, heredity, previous coronary event, previous infarction, or percutaneous coronary intervention or coronary artery bypass graft surgery. The clinical characteristics of the patients were analyzed: arterial pressure, heart rate, the presence of signs and symptoms of heart failure.
All patients underwent a twelve-channel ECG, after 20 min of rest in a supine position at a paper speed of 50 mm-s. Based on ECG examinations, patients with AH were divided into two groups: patients with a regular heart rhythm and patients with AF.
All patients had blood sampled for analysis. of laboratory markers: brain natriuretic peptide (BNP), C-reactive protein (CRP), and uric acid.
Transthoracic echocardiography was performed on a Vivid T8 GE Healthcare device, with 3.5 and 2.5 MHz probes, The measurements were performed according to the criteria of the American Echocardiographic Association[23]. Three consecutive cycles were recorded for each parameter. All subjects were examined echocardiographically by a physician who was instructed in all clinical characteristics and results.
The dimension of the LA: antero-posterior (AP) was measured in 2D mode from the longitudinal parasternal section, and the medio-lateral (ML) and superior-inferior (SI) dimension from the four - cavity apical section.

Statistical analysis

The obtained data were first processed by descriptive statistical analysis, and then the statistical significance of the difference between the examined groups was analyzed by appropriate tests depending on the distribution of data (Student's T test for parametric data, Mann-Whitney U test, Hi-square test and Fisher's test of exact probability for non-parametric data). Of the descriptive statistical methods, measures of central tendency (arithmetic mean, measures of variability, standard deviation and relative numbers expressed in percentages) were used. Statistically significant variables from individual models formed multivariate logistic regression models, on the basis of which variables were determined that significantly predict the occurrence of atrial fibrillation in the examined population. A logistic regression analysis was performed to test the correlation of the examined independent variables with the dependent AF. Statistical significance was assessed at two levels: 0.05 (statistically significant difference) and 0.01 (highly significant statistical difference).

Results

A total of 97 patients entered the study, 49 male (50.5%). The average age of the patient was 64±5 years (range 20-85). Out of the total number of patients, 56 patients (57.7%) had AF. The mean value of systolic arterial blood pressure was slightly higher in the group of patients with AF, although this difference was not statistically significant (133,1±17,4 mmHg with AF; 129,3±20,6 mmHg without AF; $t = 0.991$; $p = 0.324$). The mean value of diastolic arterial blood pressure was also slightly higher in the group of patients with AF, again this difference was not statistically significant (with AF 77,5±12,7mmHg, without 78,4±10,8mmHg; $t = -0.348$; $p = 0.729$).

Table 1. Descriptive statistics of CRP values in patients with and without atrial fibrillation

		CRP			
	N	Median	Perc. 25	Perc.75	
AF	No	41	2.50	1.50	4.60
	Yes	56	3.60	2.10	10.05

AF No - patients without atrial fibrillation, AF Yes - patients with atrial fibrillation, CRP - C reactive protein, N - total number of patients, Perc - percentiles

Table 2. Descriptive statistics of BNP values in patients with and without atrial fibrillation

		BNP			
	N	Median	Perc. 25	Perc.75	
AF	No	41	46.00	23.00	80.00
	Yes	56	89.00	55.50	119.00

AF No - patients without atrial fibrillation, AF Yes - patients with atrial fibrillation, BNP - brain natriuretic peptide, N - total number of patients, Perc - percentiles-

Table 3. Descriptive statistics of uric acid values in patients with and without atrial fibrillation

AF	N	A.M.	SD	Median	Minimum	Maximum
No	41	275.9	106.6	275	86	602
Yes	56	330.6	126.3	325	54	807
Total	97	307.5	120.9	305	54	807

AF No - patients without atrial fibrillation, AF Yes - patients with atrial fibrillation, N - total number of patients, A.M. - arithmetic mean, Minimum - the lowest value of uric acid levels in the blood, Maximum - the highest value of uric acid levels in the blood

There was no statistically significant difference in CRP values in patients with and without AF (Mann-Whitney U test Z = -1.618; p = 0.106), presented in Table 1. Difference of BNP values was statistically significant in investigated groups (Mann-Whitney U test Z = -3.838; p <0.001), presented in Table 2. Also, there were significant differences in levels of uric acid between study groups (t = 2.246; p = 0.027) presented in Table 3.

In univariant regression analysis the value of the AP dimension of the LA was larger in group of patients with AF (45.43±5.02; t = 5.392; p <0.001). Furthermore, the ML dimension and the SI dimension of the LA were also larger in group with AF respectively (58.57±7.69; t = 5.253; p <0.001; 47.43±6.35; t = 2.900; p = 0.005). Echocardiographic parameters are presented in Table 4. Significant predictors of AF in hypertensive patients were: echocardiographic parameter - ML of the LA measured from the apical four-cavity section and laboratory marker - BNP, presented in Table 5. The multivariable regression model shown in Table 6 was obtained by the Backward method, by eliminating individual predictors.

Discussion

Due to the high prevalence in the population, AH is independently responsible for the development of AF more than any other risk factor.[1] Prolonged uncontrolled AH can lead to remodeling of the heart anatomy and

Table 4. Descriptive statistics of left atrium dimension in patients with and without atrial fibrillation

AF	N	A.M.	SD	Median	Minimum	Maximum
Anteroposterior dimension						
No	41	39.37	6.05	39	28	59
Yes	56	45.43	5.02	45	34	57
Total	97	42.87	6.22	43	28	59
Medio-lateral dimension						
No	41	50.12	8.01	48	36	69
Yes	56	58.57	7.69	60	42	80
Total	97	55.00	8.84	55	36	80
Superior-inferior dimension						
No	41	43.85	5.47	43	35	64
Yes	56	47.43	6.35	46	39	69
Total	97	45.92	6.22	44	35	69

AF No - patients without atrial fibrillation, AF Yes - patients with atrial fibrillation, N - total number of patients, SD - standard deviation, Minimum - minimum value of left atrium dimension measured from longitudinal parasternal section (cm) Maximum - maximum value dimensions of the left atrium measured from the longitudinal parasternal section (cm)

Table 5. Multivariable logistics model with atrial fibrillation as dependent

	p	OR	95% IP for OR	
Uric acid	0.312	1.002	0.998	1.007
ML	0.004	1.132	1.041	1.231
SI	0.448	0.955	0.848	1.076
CRP	0.122	2.169	0.812	5.790
BNP	0.070	3.785	0.896	15.989

ML - mediolateral dimension of the left atrium measured from the apical four-cavity section, SI - superior-inferior dimension of the left atrium measured from the apical four-cavity section, CRP – C reactive protein, BNP – brain natriuretic peptide.

electrophysiological changes. Also, it can cause left ventricular hypertrophy, which leads to loading of the LA and consequently to remodeling of this chamber[13]. In our study groups, the average value of systolic pressure was slightly higher in the group of patients with AF. However, statistical analysis showed that this difference was not statistically significant (p = 0.324). Also, the average value of diastolic pressure was slightly higher in the group of patients with AF without significances (p = 0.729).

Watson and colleagues[24] looked for predictors of AF in natruretic peptide and fibroinflammatory gene expression, as well as fibrosis and CD163+. As a result, peptides have been seen to increase in patients with AF. AF patients had a greater LA volume index, more valve disease, higher BNP, and altered collagen turnover markers versus controls (all <P 0.05).

Abhayaratna et al.[25] found that decreased LA reservoir function significantly increased the risk of first paroxysmal AF or atrial flutter in a population over 65 as much as 9.2-fold, regardless of left ventricular systolic function, and clinical factors. Structural remodeling, which has been shown to increase the size of the LA, is a strong predictor of atrial arrhythmia.

Table 6. Multivariable regression model obtained by predictor elimination (backward method)

	p	OR	95% IP for OR	
ML	0.001	1.114	1.045	1.188
BNP	0.049	4.410	1.006	19.336

ML - mediolateral dimension of the left atrium measured from the apical four-cavity section, BNP – brain natriuretic peptide

Most studies of inflammatory activity in AF have focused on the clinically established biomarker CRP and interleukin-6.[26] To date, studies with biomarkers and AF have been based on a single measurement at study entry. However, repeated measurements may provide additional information regarding the determinants for the increase of these biomarkers and the subsequent risk of AF. Continuous increases in NT-proBNP concentrations over time have been shown to be associated with cardiovascular comorbidities and give an even higher risk of stroke and mortality. It is shown that at 90 days, a higher proportion of patients with AF (89.4% vs 81.5%; *P*=.002) had an NT-proBNP level above 1000 pg/mL (to convert NT-proBNP values to pmol/L, multiply by 0.1182), and AF patients had higher NT-proBNP levels at all time points through 2 years of follow-up[27]. In our study, the average value of CRP was higher in the group of patients with AF, however, the difference was not statistically significant as evidenced (p = 0.106).

Also, according to the Framingham study[8], LA remodeling was defined as an increment of LA diameter (as a continuous variable and quartile-based analysis) and was 1 of 3 independent echocardiographic predictors for future AF development. Yoon et al[28] evaluated LA volume and function by strain analysis showing that the volume of indexed LA> 34 ml / m2 and LA strain <31% had a two-fold and four-fold increase in the likelihood for patients with paroxysmal AF to develop permanent AF during the follow-up period of 26 months. However, the definitive cut-off for monitoring LA remodeling, as an indicator of AF development, is not clearly defined [29]. Our findings suggest that LA dilatation in hypertensive subjects who are in sinus rhythm is valuable for identifying those individuals who are more prone to AF.

Univariate analysis of echocardiographic markers of study population showed that the average value of the LA dimension from PLAX was higher in the group of patients with AF and that there was a statistically significant difference (p <0.001). It is also seen that the mean value of the ML dimension of the left atrium measured in the apical four-cavity section is higher in the group of patients with AF (p <0.001). Furthermore, the average value of the SI dimension of the LA measured in the apical section of four cavities is larger in the group of patients with AF (p = 0.005).

Limitation of the study

This analysis had a few limitations. The number of patients recruited in our study was limited and study wes conducted in single center.

Conclusion

Hypertensive patients with AF have a significantly increased LA compared with hypertensive patients in sinus rhythm. Predictors of AF in group of patients with AH are echocardiografic ML dimension of LA and elevated value of blood biomarker BNP.

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Sažetak

Ehokardiografski laboratorijski parametri kod hipertenzivnih pacijenata sa i bez atrijalne fibrilacije

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Uvod. *Arterijska hipertenzija (AH) predstavlja jedan od najčešćih uzroka atrijalne fibrilacije (AF). Tokom AF kontraktilna funkcija leve pretkomore (LP) je izgubljena,* ***što*** *vodi strukturnom i funkcionalnom remodelovanju ovog dela srca. AH značajno doprinosi razvoju same aritmije i daljem remodelovanju srčanih* ***šupljina****. Cilj našeg istraživanja je poređenje ehokardiografskih i laboratorijskih parametara kod pacijenata sa AH sa i bez AF uz analizu predikotra AF u AH.*

Metode. *Sproveli smo studiju preseka sa 97 konsekutivnih pacijenata (srednjih godina 64±9; 49 muškaraca) sa AH od čega je 56 pacijenata (57%) imalo AF. Svim ispitanicima je izvršen fizikalni pregled, izmeren im je arterijski pritisak i laboratorijske analize (brain natriuretski peptid –BNP, C reaktivni protein – CRP) uz ehokardiografski pregled sa analizom LP (merenje antero-posteriorne dimenzije (AP) iz longitudinalnog parasternalnog prozora, medio-lateralne (ML) i superiorno-inferiorne (SI) dimenzije iz prozora sa četiri srčane šupljine.*

Rezultati. *Analizom grupa hipertenzivnih pacijenata sa i bez AF, registrovane su nešto više vrednosti sistolnog pritiska u grupi bolesnika sa AF ali bez statističke značajnosti (133,1±17,4 mmHg sa AF; 129,3±20,6 mmHg bez AF; t = 0,991; p = 0,324). Vrednost dijastolnog pritiska se nije razlikovala među grupama (77,5±12,7mmHg sa AF, 78,4±10,8mmHg bez AF, t=-0,348; p=0,729). Blago povišene vrednosti CRP su registrovane u grupi ispitanika sa AF, ali razlika nije bila statistički značajna (2.51.2mg/L; 3.62.1mg/L, Z=-1.618; p=0.106). Registrovana je značajna razlika među grupama u vrednosti BNP-a (46±23 pg/ml, 89±55 pg/ml, Z=-3,838; p 0,001). Između grupa hipertoničara sa i bez AF svi mereni ehokardiografski parametri LP bili su značajno veći u grupi sa AF (AP 45,43±5.02mm sa AF; 39.37±6.05mm bez AF, t=5.392, p<0,01, ML 58.57±7.69mm sa AF; 50.12±8.01mm bez AF, t= 5.253, p<0,001, SI 47.43±6.35 mm sa AF, 43.85±5.47 mm bez AF, t=2.9, p=0.005). Kao prediktori nastanka AF u grupi pacijenata sa AF uočeni su ML dijametar LP i vrednost BNP-a.*

Zaključak. *Hipertenzivni pacijenti sa AF imaju značajno uvećanu LP u poređenju sa hipertenzivnim pacijentima u sinusnom ritmu. Prediktori nastanka AF kod hipertoničara su ML dijametar LP i vrednost BNP-a.*

Ključne reči: *arterijska hipertenzija, atrijalna fibrilacija****,*** *leva pretkomora, biomarkeri*