ASSOCIATION BETWEEN HEART RATE VARIABILITY AND DIASTOLIC PERFORMANCE OF THE HEARTS OF THE PATIENTS WITH DIFFERENT KIND OF LEFT VENTRICULAR HYPERTROPHY AFTER AORTIC VALVE REPLACEMENT

Danov V.^{b,c}, Kutova Zv.^a, Simov D.^c, Dinov B.^a, Bayer M.^b

a - National Hospital of Cardiology - Sofia, b - Clinic of Cardio-Thoracic Surgery – Augsburg, Germany, Department of Ludwig Maximilian University Muenich. c - Cardiac Surgery Clinic – St. Marina University Hospital -Varna

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ABSTRACT

Aim. The aims of the study were to analyze the changes in heart rate variability (HRV) in patients after aortic valve replacement (AVR) with different patterns of left ventricular hypertrophy (LVH) and diastolic dysfunction. **Method.** We studied 36 patients after AVR. They were divided according to the left ventricular mass index and the relative wall thickness in three groups: eccentric LVH (group 1), concentric remodelled ventricle (group 2), concentric LVH (group 3). Additionally two groups were formed considering left ventricular diastolic function: group A ($E/A < 1$) and group B ($E/A > 1$). M-mode, B-mode echocardiography, PW – Doppler and 24-hour Holter ECG were performed. **Results.** We discovered significantly lower values of rMSSD and pNN50 in group 1, compared to groups 2 and 3. We found significantly lower values of rMSSD ($p = 0.039$) and pNN50 ($p = 0.04$) in group A, compared to group B. We discovered significant positive correlations between E/A ratio and SDNN index ($r = 0.519$, $p = 0.019$), rMSSD ($r = 0.495$, $p = 0.021$), VLF power ($r = 0.442$, $p < 0.049$) and LF power ($r = 0.512$, $p = 0.026$). Significant negative correlations exist between DT and rMSSD ($r = -0.475$, $p = 0.035$), pNN50 ($r = -0.464$, $p = 0.039$), IVRT and VLF power ($r = -0.476$, $p = 0.034$). **Conclusions.** We found that heart rate variability depends on the severity and the pattern of LV hypertrophy. Eccentric LV hypertrophy and the presence of LV diastolic dysfunction are associated with parasympathetic withdrawal and diminished HRV, hence poor prognosis and higher risk for sudden cardiac death.

BACKGROUND

The presence of left ventricular hypertrophy (LVH) is associated with increase of total and cardiac mortality. In such patients there is misbalance in the activity of autonomous nervous system (ANS). Heart rate variability (HRV) is significantly decreased in patients with LVH as result of arterial hypertension and aortic valve disease. Data from the Framingham study showed that HRV correlates with total mortality and has an independent prognostic significance to survival.^{1,4}

AIM

The Aim of this study is to analyse the activity of ANS in patients after aortic valve replacement (AVR) presented

with different types of LVH with particular attention paid to diastolic performance of the heart.

METHODS AND GROUPS

The studied population includes 36 patients after AVR – 25 females and 11 males, aged 66.28 ± 22 (53-82). The clinical characteristics of the patients are given in table 1.

Patients with angio proven coronary arterial disease, systolic left ventricular dysfunction, diabetes, atrial fibrillation, left ventricular conductive disturbances ($QRS > 120$ msec) and those with implanted permanent pacemaker were excluded from the study. Potassium plasma levels were in referent values in all patients.

In all studied patients M – mode, B – mode, Doppler echoCG and 24 Holter ECG was performed before discharge.

Left ventricular mass (LVM) was calculated with Devereux formula: $LVM (g) = 0.8 \times \{1.04 \times [(MVA + TDD + LVPW)^3 - TDD^3]\} + 0.6$. LVM index (g/ml) was cal-

Address for correspondence:

V. Danov, Cardiac Surgery Clinic, University Hospital “St. Marina”, 1st Nr. Smirnensky Blvd, Varna – 9010, BULGARIA

culated with LVM divided to body surface area. Relative Thickness of Left Ventricular Wall was calculated: $RTL\text{VW} = 2 \times \text{LVPW}/\text{EDD}$. Presence of LVH was accepted if $\text{LVMI} > 125 \text{ g/m}^2$. Patients were divided according to LVMI and RTL VW in three groups, equalised in age and sex:

Tabl. 1

HF ≥ 3 F.C. NYHA	Complex Ventricular Arrhythmia	Syncope and Presyncope	Angina ≥ 3 F.C.	Arterial Hypertension	P max. mmHg	P mean. mmHg	Effective Valve Area
31.4 %	19.4 %	19.4 %	2.86 %	58.3 %	90.2 $\pm$ 35	59.9 $\pm$ 21.5	0.74 $\pm$ 0.44

Group 1 – eccentric LVH - $\text{LVMI} > 125 \text{ g/m}^2$; $\text{RTL VW} < 0.45$ – 6 patients

Group 2 - concentric remodelled LV - $\text{LVMI} < 125 \text{ g/m}^2$; $\text{RTL VW} > 0.45$ – 12 patients

Group 3 – concentric LVH - - $\text{LVMI} > 125 \text{ g/m}^2$; $\text{RTL VW} > 0.45$ – 18 patients

Additionally the studied patients were divided according to the data collected from the PW – Doppler analysis of mitral flow into two groups.

Group A – $\text{E/A} < 1$ – aged 61.5 ± 8.54 years

Group B – $\text{E/A} > 1$ - aged 72.0 ± 6.96 years.

Age difference is significant ($p = 0.003$). Taking into account the younger age of the patients $\text{E/A} < 1$ in group A is pathologic and shows diastolic dysfunction of the type – delayed relaxation, $\text{E/A} > 1$ in Group B, where mean age is over 70^y years is also pathologic finding –impaired diastolic function – pseudo normalisation.

24 hour Holter ECG was used to analyse HRV. In our study the main parameters of time-domain analysis – SDNN24, SDANNindex, SDNN index, rMSSD, pNN50, as well as some basic characteristics of frequency-domain analysis – VLF power, LF power, HF power, LF/HF were used.

RESULTS

Data processing was made with statistical software SPSS 10.0.

At relative analysis of groups according to the geometry of LV significantly lower values of rMSSD ($p = 0.008$) and pNN50 ($p = 0.013$) were found in eccentric LVH (group 1) according to concentric remodelled LV (group 2). The results were analogous in comparison between groups 1 and 3. In eccentric LVH group there were significantly lower values of rMSSD ($p = 0.018$) and pNN50 ($p = 0.012$).

Analysis of groups A и B proved significantly lower values of rMSSD ($p = 0.039$) and pNN50 ($p = 0.040$) in group with impaired relaxation ($\text{E/A} < 1$), compared to pseudo-normal left ventricular filing model group ($\text{E/A} > 1$). There were not significant differences in other HRV characteristics in two groups.

In addition our results pointed out significantly lower values of fraction of shortening at middle segments (FSm%) ($p = 0.012$) and larger diameter of aorta ascendens ($p = 0.018$) in group A. There were no significant differences in the two groups in LVMI and left atrial dimensions.

Regression analysis showed presence of significant linear

correlation between FSm % and some of the parameters of HRV (Tabl. 2.).

Tabl. 2.

FSm %	SDNN index	R = 0.672	P = 0.033
	rMSSD	R = 0.733	P = 0.016
	pNN50	R = 0.764	P = 0.01
	HF power	R = 0.669	P = 0.034

Borderline significant linear correlation was found between E/A ratio and HRV (Tabl. 3.).

Tabl. 3.

E/A ratio	SDNN index	R = 0.519	P = 0.019
	rMSSD	R = 0.495	P = 0.021
	pNN50	R = 0.445	P = 0.05 NS
	VLF power	R = 0.442	P = 0.049
	LF power	R = 0.512	P = 0.026

Trough regression analysis significant inverse correlations were pointed out between other Doppler-echoCG characteristics of mitral valve flow (MVF) and HRV (Tabl. 4.).

Tabl. 4.

DT ms.	rMSSD	R = - 0.475	P = 0.035
	pNN50	R = - 0.464	P = 0.039
IVRT ms.	VLF power	R = - 0.476	P = 0.034

DISCUSSION

Patients presenting with aortic stenosis (AVS) are at increased risk of sudden cardiac death (SCD). Probable

pathological substance of malignant arrhythmias in these patients is LVH.^{2,4} The electrophysiology mechanisms leading to ventricular tachyarrhythmias in LVH are complex and partly studied. Interstitial fibrosis of the myocardium has an important role in making possible inhomogeneous propagation of electric impulses and reentrant ventricular arrhythmia. It was proved in an experimental model that hypertrophied cardiomyocytes have elongated action potential, which predispose to early and late afterdepolarisations.⁵ The impact of ANS of the heart is of great importance for electrogenesis of ventricular arrhythmia. Increased sympathetic drive increases dispersion and refractivity of the myocardium and has proarrhythmic action. On the other side parasympathetic ANS has a protective function increasing the ventricular fibrillation threshold.^{6,7} The analysis of HRV is widely used method for evaluation activity and balance of sympathetic and parasympathetic ANS. The method has a prognostic value for evaluation of SCD risk.³

In this study we proved the presence of significant correlation between FSm % and rMSSD, pNN50, HF power. This parameters from time - domain and frequency - domain analysis of HRV show predominantly parasympathetic influence on the heart.³ Consequently decreasing FSm % could be associated with decreasing of protective parasympathetic drive, respectively increasing the risk of ventricular arrhythmia. More comprehensive analysis pointed out significant correlation between E/A ratio and HRV as diminishing E/A is associated with lowering HRV. Also significant but reversed correlation were found between DT, IVRT and rMSSD, pNN50, VLF power. This results were confirmed by the relative analysis of groups A (E/A <1) and B (E/A >1). In the impaired relaxation group (evaluated by PW Doppler spectrogram of mitral valve flow) the parameters showing the parasympathetic drive to the heart are significantly decreased. In the same population we found significantly diminished values of FSm % and larger diameter of aorta asc..

At the analysis of groups with different LV geometry significantly lower values of rMSSD, pNN50 in group with eccentric LVH, consequently in this patients there is marked misbalance in ANS activity with sympathetic drive predominating, respectively the risk of malignant ventricular arrhythmia is increased.

CONCLUSION

The activity of ANS in patients with LVH depends on severity of LVH and on LV geometry as well. Eccentric LVH is associated with decreased protective parasympathetic influences over the heart and respectively increasing SCD risk. We pointed out that impaired diastolic function of the heart is accompanied by misbalance of ANS activity. Echocardiographically evaluation of severity of LVH, geometry and diastolic function of LV could be predictive in regard of survival of patients with aortic valve stenosis before and after surgery.⁷

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