Decartographic and Echocardiographic Correlations in Patients with Pulmonary Arterial Hypertension

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Abstract. *In patients with pulmonary arterial hypertension (PAH) decartographic parameters of "recovery acceleration" are helpful for the detection of right ventricular (RV) overload and assessment of its severity. The aim of the work was to study the interrelations of "recovery acceleration" and echocardiographic parameters in PAH patients. We examined 30 PAH patients (87% females; age 38.0±2.0 years). Echocardiographic parameters including systolic pulmonary artery pressure (SPAP); RV anterior wall thickness (AWT); anterior-posterior (APD) and middle (MD) RV dimensions; tricuspid annular plane systolic excursion (TAPSE), RV fractional area change (FAC), RV peak systolic annular velocity (TVI-S); RV mean peak early diastolic period velocity (TVI-E); longitudinal strain (LS) were assessed using comprehensive echocardiographic examination, including Tissue Doppler Imaging. Magnitude G and spatial components Gx, Gy, Gz of the "recovery acceleration" vector were calculated using the derived orthogonal-lead ECG. All patients had SPAP>50 mm Hg. G, Gx and Gy had statistically significant moderate negative correlations with SPAP, RV dimensions, TVI-E and LS (r from -0.4 to -0.6, p<0.05) and positive correlations with FAC and TVI-S (r from 0.4 to 0.6, p<0.05). In patients with severe PAH decartographic parameters of "recovery acceleration" correlate with RV dimensions and parameters of RV systolic and diastolic function.*

Keywords: pulmonary arterial hypertension, right ventricular overload, repolarization, echocardiography

1. Introduction

In patients with pulmonary arterial hypertension (PAH) ventricular gradient and decartographic parameters of "recovery acceleration" were shown to be helpful for the detection of right ventricular overload and for the assessment of its severity [1], [2]; ventricular gradient was shown to predict mortality [3]. The aim of the work was to study the interrelations of "recovery acceleration" and echocardiographic parameters in patients with PAH.

2. Subject and Methods

Patients

We examined 30 PAH patients (87% females; age 38.0±2.0 years) in whom the presence of PAH was verified with clinical and instrumental methods. There were 2 patients with systemic sclerosis, one patient with residual PAH after operated septal defect, one patient with portal hypertension and one patient with chronic thromboembolic disease, in 25 patients after comprehensive clinical and instrumental examination PAH was considered to be idiopathic.

Echocardiography

Comprehensive echocardiographic examination, including Tissue Doppler Imaging was performed using a high-quality ultrasound machine (Vivid 7; GE, USA) with the subjects in the left lateral recumbent position. All measurements were made in accordance with current recommendations of European Society of Cardiology/American Society of Echocardiography (ESC/ASE) [4]. The estimated systolic pulmonary artery pressure (SPAP) was defined as the right ventricular (RV) to right atrial pressure gradient added to the right atrial pressure. Right atrial pressure was estimated 5 to 15 mm Hg, according to the diameter and inspiratory collapse of the inferior caval vein. RV anterior wall thickness (AWT), anterior-posterior (APD) and middle (MD) RV dimensions were estimated using parasternal and apical 4-chamber conventional 2-dimensional grayscale images. RV systolic function was assessed by calculating RV fractional area change (FAC), tricuspid annular plane systolic excursion (TAPSE) and peak systolic annular velocity by pulsed tissue Doppler (TVD) on tricuspid annulus lateral wall (S). RV diastolic function was assessed by calculating peak diastolic early period velocity and peak diastolic later period velocity by pulsed wave Doppler (E/A) and mean peak early diastolic period velocity by TVD on tricuspid annulus lateral wall (E'). The speckle-tracking analysis was performed with calculation of global right ventricular longitudinal strain (LS).

Electrocardiograpy

Conventional 10-s digital electrocardiograms were recorded by certified ECG technicians using the standard 12-lead electrode configuration on commercially available electrocardiograph, averaged into 1 single beat that was subsequently converted into a derived orthogonal-lead beat and processed by means of software developed in Cardiology Research Complex and Institute for Information Transmission Problems. We studied the magnitude G (in ms) and spatial components Gx, Gy, Gz of the "recovery acceleration" vector (directed to the left, inferior, and anterior). Decartographic "recovery acceleration" map shows the distribution of the dipole component of the depolarized state duration over the heart surface, projected onto the image sphere which encloses the heart ventricles. The image sphere radius is taken equal to the maximum magnitude of the heart vector in the QRS period. The use of the maximal QRS vector as a scale helps to understand more clearly internal interrelationships between different parts of QRST complex. Concerning the electrophysiological meaning, "recovery acceleration" vector is close to the ventricular gradient vector.

Statistical analysis

Data were analyzed using MedCalc Statistical Software version 12.7.8 (MedCalc Software bvba, Ostend, Belgium). Results are presented as mean ± standard deviation. To identify the relationship between variables Pearson correlation coefficient was calculated. A value of $p<0.05$ was considered to be statistically significant.

3. Results

All patients had severe PAH (SPAP>50 mm Hg). Mean heart rate was 74.2±12.5 bpm. Echocardiographic and decartographic characteristics of the patients are presented in Table 1.

Correlation coefficients of decartographic and echocardiographic parameters are presented in the Table 2. For all presented correlation coefficients $p<0.05$.

Table 1. Echocardiographic and decartographic characteristics of the group.

Parameter	Mean±SD
SPAP, mm Hg	98.6±4.8
AWT, mm	0.801±0.200
APD, mm	3.89±0.72
MD, mm	4.37±0.94
TAPSE, cm	1.392±0.336
FAC, %	20.7±7.3
TVI-S, cm/s	7.11±1.92
TVI-E, cm/s	-5.25±3.19
LS, %	-15.2±8.3
G, ms	32.8±17.5
Gx, ms	5.2±19.2
Gy, ms	7.7±13.8
Gz, ms	2.7±13.5

Table 2. Correlation coefficients of decartographic and echocardiographic parameters.

	G	Gx	Gy
SPAP	-0.6	-0.6	
AWT		-0.6	-0.4
APD		-0.5	-0.5
MD	-0.5	-0.6	-0.6
TAPSE	0.4		
FAC	0.4	0.6	0.4
TVI-S	0.4	0.4	0.6
TVI-E	-0.6	-0.4	-0.4
LS		-0.4	-0.6

4. Discussion

The ECG-derived ventricular gradient and decartographic parameters of "recovery acceleration" in PAH patients were shown to be accurate in detecting chronic increase in RV pressure load, and distinguishing between normal RV pressure load, mildly to moderately increased RV pressure load, and severely increased RV pressure load. The ventricular gradient projection on the x-axis (VGx) correlated inversely with pulmonary pressure, a severely decreased VGx was related with increased mortality in patients with PAH [1], [3]. Reduced RV function in PAH patients is also an important predictor of mortality. Patients with changes of ventricular gradient are likely to have more impaired RV function. In the present study decartographic parameters of "recovery acceleration" had statistically significant but moderate correlations with RV dimensions and parameters of RV systolic and diastolic function. The limitation of the study was that only patients with severe PAH were included. Ventricular gradient and "recovery acceleration" vector changes in PAH patients are likely to reflect changes in ventricular action potential duration heterogeneity related to RV remodelling, which may be a result of not only increased RV pressure load, but also biochemical and molecular changes. Clarifying mechanisms of ECG changes in ventricular hypertrophy may potentially give additional information about the pathogenesis of the disease [5], [6], [7].

5. Conclusions

In patients with severe PAH decartographic parameters of "recovery acceleration" have moderate correlations with RV dimensions and parameters of RV systolic and diastolic function.

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