Original Article

Systemic Hypertension and Right Ventricle: Preliminary Echocardiographic Data

Anderson José Argemiro,[1,2] Ana Cristina Camarozano,[1,2] Daniela de Castro Carmo,[1,2] Jerônimo Antonio Fortunato,[1] Rubens Zenóbio Darwich,[1] Liz Andréa Villela Baroncini[1,2]

Hospital da Cruz Vermelha;[1] Instituto Saber e Aprender – Curso de Especialização em Ecocardiografia Transtorácica,[2] Curitiba, Paraná – Brazil

Summary

Background: Systemic arterial hypertension (SAH) has not yet been directly correlated with right ventricular hypertrophy (RV).

Objective: To assess the correlation between the presence of systemic arterial hypertension and right ventricular thickness, dimensions and function.

Methods: Cross-sectional and observational study. A total of 65 individuals were selected. They underwent echocardiogram with right ventricular evaluation in five aspects: free wall thickness; proximal diameter (RPD), mid diameter (RMD), basal diameter (RBD); tricuspid annular plane systolic excursion; and tissue doppler S′ wave. The subjects were divided into two groups: Control Group, without systemic arterial hypertension, with 24 subjects (17 women) and Study Group, with systemic arterial hypertension, with 41 subjects (29 women).

Results: Study Group presented older individuals in relation to Control Group (67 years ± 12 years and 47 ± 20 years; $p < 0.001$). In the Control Group, men presented higher values compared to women: proximal diameter (24.1 mm ± 1.3 mm vs. 20.1 mm ± 2.9 mm; $p = 0.002$), basal diameter (32.9 mm ± 2.7 mm vs. 26.5 mm ± 4.2 mm; $p = 0.001$), mid diameter (27 mm ± 2.1 mm vs. 21.2m ; $p = 0.005$); left ventricle diastolic diameter (49.6 mm ± 2.1 mm vs. 45.5 ± 4.3 mm; $p = 0.028$); left ventricle systolic diameter (30.1 mm ± 3.2 mm vs. 27.1 mm ± 2.9 mm; $p = 0.034$); and S′ wave (14.9 cm/s ± 2.4 cm/s vs. 13 cm/s ± 1.7 cm/s; $p = 0.04$). However, in the Study Group there were no significant differences between men and women in the same variables. These findings suggest greater impact of systemic hypertension in women.

Conclusion: The presence of systemic hypertension may cause different structural alterations in geometric ventricular patterns in men and women, possibly determining greater effects on the female sex. However, further studies are needed to confirm these findings. (Arq Bras Cardiol: Imagem cardiovasc. 2018;31(4):241-249)

Keywords: Hypertension/physiopathology; Hypertrophy, Right Ventricular; Echocardiography/methods; Heart Ventricles/diagnostic imaging.

Introduction

The diagnosis of Right Ventricular Hypertrophy (RVH) and Left Ventricular Hypertrophy (LVH) has been incorporated into the clinical practice as an important marker of cardiovascular disease.[1,2] The prevalence depends on the classification criteria adopted and the population studied, but it is around 3% among non-hypertensive patients and 75% among hypertensive patients.[3]

Echocardiography has been used clinically over the last 30 years, making it the most important noninvasive imaging method to evaluate the cardiac dynamics and morphology. However, the diagnosis and evolution of RVH is independent of pulmonary arterial hypertension and correlates both with pressure overload and with increased left ventricular thickness, suggesting other factors as stimuli to increase wall thickness.[4]

Nunez et al.[5] measured the right ventricular (RV) wall thickness of patients with LVH and compared them to hypertensive individuals with and without left ventricular (LV) hypertrophy and a group of normotensive individuals. RV free wall thickness in hypertensive patients with LVH was increased almost twice compared to normotensive individuals. On the other hand, hypertensive patients without LVH showed only a tendency to increase RV thickness, with no statistically significant difference.

Regarding the RV contractile function, several studies have reported its prognostic importance in many clinical situations.[6-11] Cohn et al.[12] summarized the mechanisms that could explain its dysfunction in hypertensive individuals: (1) chronic increase in pulmonary artery pressure secondary to LV dysfunction; (2) interventricular septum hypertrophy invading the RV and making it difficult to fill up; and (3) intrinsic RV capacity to change its emptying characteristics in order to prevent increased volume emission to the LV.

Mailing Address: Liz Andréa Villela Baroncini •
Hospital da Cruz Vermelha – Cruz Vermelha Brasileira- Filial do Estado do Paraná
Instituto Saber e Aprender – Curso de Especialização em Ecocardiografia Transtorácica
DEP-CVB-PR - Departamento de Ensino e Pesquisa
Av. Vicente Machado, 1310, Batel. Postal Code 80420-011, Curitiba, PR – Brazil
E-mail: lizandreabaroncini@hotmail.com
Manuscript received July 21, 2018; revised August 3, 2018; accepted August 20, 2018.

DOI: 10.5935/2318-8219.20180046

The purpose of this study was to evaluate whether the presence of systemic arterial hypertension (SAH) with and without LVH changes the RV wall thickness and function.

Methods

Cross-sectional observational study. The study included 65 patients of both sexes, over 18 years of age, from the Cardiology Outpatient Clinic of Hospital da Cruz Vermelha in Curitiba (PR), of any ethnic group, who were referred by the attending physician to transthoracic echocardiography for any clinical indication. The choice of patients was for convenience.

For each patient, a protocol record, involving clinical and echocardiographic parameters, was filled out. The demographic data analyzed were: age, sex, Body Mass Index (BMI) and presence of SAH. Diagnosis of SAH was found in the patients' records (systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg or use of antihypertensive medication) and/or were reported by themselves. Medications being regularly used by the patient were also recorded.

The patients underwent a complete two-dimensional transthoracic echocardiography obtained from one of the echocardiography devices — Philips iE33, Envisor or Vivid E General Electric. All acoustic windows with all measurements and standard echocardiographic analyses were performed for each patient. The sound tests were conducted by two experienced echocardiographers with echocardiography certificates issued by the Department of Cardiovascular Imaging of the Brazilian Society of Cardiology (DIC-SBC).

In this study, the main echocardiographic variables analyzed were: RV free wall thickness (normal < 0.5 cm), measured at the subcostal window; basal and mid RV diameters (normal up to 42 mm and 35 mm, respectively), measured at the 4-chamber apical window; RV proximal diameter in the parasternal longitudinal window (RVP; normal up to 28 mm); tricuspid annular plane systolic excursion (TAPSE; normal > 17 mm); and lateral S' wave on tissue Doppler in the RV free wall (normal > 10 cm/s)[13-16] (Figure 1).Other variables analyzed were interventricular septum thickness and LV posterior wall, and LV systolic and diastolic diameters. Exclusion criteria were: patients with significant valvular diseases (moderate and severe); patients with valve prostheses; with segmental disorders of left ventricular contraction due to ischemic heart disease or other myocardial diseases;[7-10] with pulmonary emphysema or chronic obstructive pulmonary disease; with moderate to severe pulmonary arterial hypertension (Pulmonary Artery Systolic Pressure – PASP > 50 mmHg); and left ventricular contractile dysfunction (ejection fraction < 52% for men and < 54% for women). All quantifications and values considered in this study were based on the guidelines of the American Society of Echocardiography (ASE) and the European Association of Cardiovascular Imaging (EACVI).[17-19]

The individuals were divided into two groups: Control Group (GC) with 24 non-hypertensive individuals, including 17 women (47 years ± 20 years); and Study Group (SG) with 41 hypertensive individuals, including 29 women (67 years ± 12 years).

All patients signed two copies of an Informed Consent Form and kept one copy. This study was approved by the local Research Ethics Committee.

Statistical analysis

Quantitative variables were described by means, medians, minimum values, maximum values and standard deviations. The gender variable was described by frequencies and percentages. To compare the groups defined by sex, as for

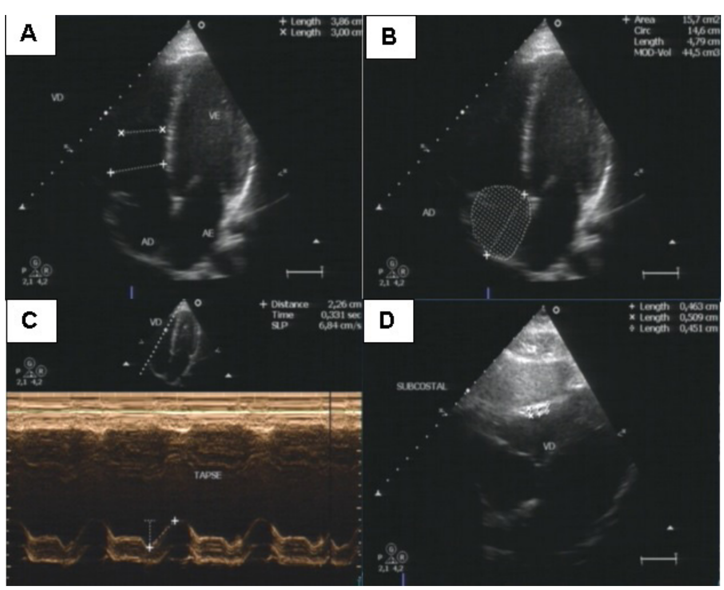

Figure 1 – *Echocardiographic image showing in (A) two-dimensional measurements of the basal and mean diameters. Four-chamber apical view of the right ventricle. (B) Apical 4-chamber view of the right atrial (RA) volume. (C) One-dimensional measurement of the tricuspid annular plane systolic excursion (TAPSE) in apical 4-chamber view. (D) Two-dimensional measurement of RV wall thickness from the subcostal view. LA: left atrium.*

quantitative variables, Student's t test for independent samples was used. The groups defined by the presence or absence of hypertension were compared using Analysis of Covariance (ANCOVA) model, including the variables age and sex as covariables. To analyze the association between age and other quantitative variables, Pearson correlation coefficients were estimated. The normality of the variables was evaluated by the Kolmogorov-Smirnov test. Statistical significance was considered when $p < 0.05$. The data were analyzed using the computer program IBM Statistical Package for Social Science (SPSS), version 20.

Results

The SG presented older individuals compared to the CG (67 years ± 12 years and 47 ± 20 years; $p < 0.001$), without significant difference in sex, weight, height and BMI (Table 1). No significant differences were found between the two groups for the echocardiographic variables analyzed (Table 2). Age did not influence the echocardiographic variables in the two groups (Table 3). In the CG, males presented higher proximal RV diameters compared to females (24.1 mm ± 1.3 mm vs. 20.1 mm ± 2.9 mm; p = 0.002), basal RV (32.9 mm ± 2.7 mm vs. 26.5 mm ± 4.2 mm; p = 0.001), mid RV (27 mm ± 2.1 mm vs. 21.2 m; p = 0.005), diastolic LV (49.6 mm ± 2.1 mm vs. 45.5 mm ± 4.3 mm; p = 0.028) and systolic LV (30.1 mm ± 3.2 mm vs. 27.1 mm ± 2.9 mm; p = 0.034) and lateral RV S' (14.9 cm/s ± 2.4 cm/s vs. 13 cm/s ± 1,7 cm/s; p = 0.04) (Table 4). However, in the HG, no significant differences were found between the sexes in the analyzed variables (Table 5).

Discussion

In this study, no significant differences were found between hypertensive and non-hypertensive individuals for RV measurements, nor for LV measurements. In this sample, even among hypertensive patients, there was no significant increase in left or right ventricular thickness. However, interesting data were found from the separate analysis of the two populations with and without SAH. In the CG, women presented smaller RV diameters, left ventricular end diastolic diameter, left ventricular end systolic diameter and lateral S' for males. This difference did not occur in the SG, in which men and women did not present significant differences for the same measurements. Since the proportion between men and women was similar between the groups, as well as the BMI, this finding may reflect the greater impact of SAH in the female sex.

Sandberg and Ji[20] found differences in systolic and diastolic blood pressure levels between men and women; men had higher values, regardless of race. However, this difference decreases until it disappears after 65 years of age, and women over 70 years of age have higher levels of systolic and diastolic pressures in all racial groups. These findings reinforce those of this study, according to which the group of hypertensive individuals was older (majority > 65 years) compared to the non-hypertensive group, with a predominance of females in both groups. Therefore, elucidating the mechanisms of the difference in the behavior of SAH between men and women may lead to the development of antihypertensive drugs based on sex, and prevent cardiac and systemic disorders and complications.

Zabalgoitia et al.[21] prospectively examined 508 hypertensive patients for LV mass, relative wall thickness and systolic and diastolic interaction in individuals aged 50 to 80, according to age and sex. In men, most of the measures were distributed similarly. However, women aged 65 or older had smaller LV systolic dimensions, greater ventricular thickness, greater percentage shortening and lower end-systolic wall stress. That is, structural and functional disorders were more pronounced in females. Although LV mass was higher in males, there was no difference in age within the same sex.

Table 1 – Comparison of the groups defined by the presence of hypertension, for age, height, weight, body mass index (BMI) and sex

Variable	Hypertension	n	Mean	Standard deviation	p* value
Age (years)	No	24	47.3	20.3	
	Yes	41	67.3	11.7	< 0.001
Height (m)	No	24	1.65	0.10	
	Yes	41	1.61	0.08	0.148
Weight (kg)	No	24	70.1	13.7	
	Yes	41	72.4	16.0	0.560
BMI (kg/m²)	No	24	25.7	3.7	
	Yes	41	27.7	5.5	0.129

	Hypertension	
Sex	No	Yes
Male (n/%)	7/29.2	12/29.3
Female (n/%)	17/70.8	29/70.7
Total	24	41

**Student's t-test for independent samples, p < 0.05.*

Table 2 – Comparison of the groups defined by hypertension for the ECHO variables

Hypertension	n	Mean	Standard deviation	p* value	p value†
LA (mm)					
No	24	35.0	4.9		
Yes	41	35.2	4.9	0.980	0.922
LRV (mm)					
No	24	21.3	3.2		
Yes	41	21.7	4.1	0.479	0.747
Basal RV (mm)					
No	24	28.4	4.8		
Yes	41	29.1	6.1	0.703	0.936
Mid RV (mm)					
No	24	22.9	4.9		
Yes	41	22.7	5.4	0.908	0.557
DLV (mm)					
No	24	46.7	4.2		
Yes	41	44.7	4.2	0.568	0.333
SLV (mm)					
No	24	28.0	3.3		
Yes	41	27.1	3.8	0.791	0.943
Interventricular septum (mm)					
No	24	9.08	1.41		
Yes	41	9.9	1.9	0.245	0.482
LV posterior wall (mm)					
No	24	8.46	1.25		
Yes	41	8.9	1.7	0.542	0.784
RV free wall (mm)					
No	24	0.37	0.07		
Yes	41	0.44	0.11	0.092	0.125
TAPSE (mm)					
No	24	22.5	3.9		
Yes	41	21.6	3.6	0.570	0.797
Lateral S' (mm)					
No	24	13.5	2.0		
Yes	41	12.4	2.1	0.435	0.538

** Analysis of Covariance adjusted for age; p < 0.05; † analysis of covariance adjusted for sex and age; p < 0.05. LA: left atrium; LRV: longitudinal right ventricle; RV: right ventricle; LVD: left ventricular end diastolic diameter; LVS: left ventricular end systolic diameter; LV: left ventricle; TAPSE: tricuspid annular plane systolic excursion.*

Sant'Anna et al.,[22] in a study of 90 clinical autopsies of individuals with a history of SAH, found a significant association between LVH and RVH. There was a predominance of RVH and LVH in men aged 60 to 79. In women of up to 49 years of age, the prevalence of LVH and/or HVD was 33.4%, and from the age of 50, it was 72.3%. In this study, although the group of hypertensive individuals was older, no significant difference was found in the left and right ventricular thicknesses, in both men and women. A possible explanation for this fact may be the lack of information about the time of SAH and its control in each individual, in addition to the small number of individuals analyzed.

Both the SAH disorders on the LV and on the RV are significant and of prognostic nature. Foppa et al.[23] emphasize LVH as an important risk factor for cardiovascular disease. With regard to RV, disorders and prognostic value in several clinical situations are recognized in many studies.[24-26]

Table 3 – Evaluation of the association between age (years) and the results of ECHO variables between the Control Group and the Study Group

Control Group			
Variables	n	Pearson correlation coefficient	p value
Age vs. LA	24	0.22	0.301
Age vs. LRV	24	-0.29	0.172
Age vs. Basal RV	24	-0.11	0.622
Age vs. Mid RV	24	-0.15	0.497
Age vs. LVD	24	-0.36	0.084
Age vs. LVS	24	-0.40	0.055
Age vs. interventricular septum	24	0.26	0.226
Age vs. LV posterior wall	24	0.28	0.193
Age vs. RV free wall	24	0.33	0.118
Age vs. TAPSE	24	-0.21	0.319
Age vs. Lateral S'	24	-0.37	0.079

Study Group			
Variables	n	Pearson correlation coefficient	p value
Age vs. LA	41	-0.16	0.314
Age vs. LRV	41	0.04	0.795
Age vs. Basal RV	41	0.10	0.514
Age vs. Mid RV	41	0.13	0.411
Age vs. LVD	41	-0.13	0.419
Age vs. LVS	41	-0.13	0.423
Age vs. interventricular septum	41	-0.02	0.900
Age vs. LV posterior wall	41	-0.03	0.842
Age vs. RV free wall	41	0.12	0.450
Age vs. TAPSE	41	0.09	0.595
Age vs. Lateral S'	41	-0.16	0.315

LA: left atrium; LRV: longitudinal right ventricle; RV: right ventricle; LVD: left ventricular end diastolic diameter; LVS: left ventricular end systolic diameter; LV: left ventricle; TAPSE: tricuspid annular plane systolic excursion.

An important limitation of this study should be mentioned: the population studied was predominantly female (about 70% in both groups). A study evaluating only hypertensive and non-hypertensive women, analyzing the geometric patterns and functions of LV and RV, is necessary. Another significant limitation was the failure to measure RV fractional area. This evaluation reflects the overall RV function with a strong correlation with hemodynamic data, being more effective when compared to the TAPSE measurement, which only reflects RV longitudinal shortening.[27]

Conclusion

No significant differences were found between hypertensive and non-hypertensive individuals for the right ventricular measurements. In the non-hypertensive group, women presented lower values in the parameters of right ventricular size and function compared to men. However, this difference did not occur in the hypertensive group, possibly suggesting a greater repercussion of hypertension on the right ventricle in female patients. Further studies are needed to confirm these findings.

Authors' contributions

Research creation and design: Baroncini LAV, Argemiro AJ, Camarozano AC; Data acquisition: Baroncini LAV, Argemiro AJ, Camarozano AC, Carmo DC, Fortunato JA, Darwich RZ; Data analysis and interpretation: Baroncini LAV, Argemiro AJ, Camarozano AC, Carmo DC, Fortunato JA, Darwich RZ; Statistical analysis: Baroncini LAV, Argemiro AJ, Camarozano AC; Manuscript writing: Baroncini LAV, Argemiro AJ, Camarozano AC, Carmo DC, Fortunato JA, Darwich RZ; Critical revision of the manuscript as for important intellectual content: Baroncini LAV, Argemiro AJ, Camarozano AC, Carmo DC, Fortunato JA, Darwich RZ.

Table 4 – Comparison of sexes for the variables related to ECHO in the control group

Variables	n	Mean	Standard deviation	p* value
LA				
Female	17	34.9	5.3	
Male	7	35.3	3.9	0.859
RV				
Female	17	20.1	2.9	
Male	7	24.1	1.3	0.002
Basal RV				
Female	17	26.5	4.19	
Male	7	32.9	2.7	0.001
Mid RV				
Female	17	21.2	4.76	
Male	7	27.0	2.1	0.005
LVD				
Female	17	45.5	4.3	
Male	7	49.6	2.1	0.028
LVS				
Female	17	27.1	2.9	
Male	7	30.1	3.2	0.034
Interventricular septum				
Female	17	8.94	1.52	
Male	7	9.4	1.1	0.454
LV posterior wall				
Female	17	8.35	1.22	
Male	7	8.7	1.4	0.532
RV free wall				
Female	17	0.37	0.07	
Male	7	0.36	0.09	0.893
TAPSE				
Female	17	22.3	4.2	
Male	7	23.1	3.4	0.640
Lateral S'				
Female	17	13.0	1.7	
Male	7	14.9	2.4	0.040

**Student's t-test for independent samples; $p < 0.05$. LA: left atrium; RV: right ventricle; LVD: left ventricular end diastolic diameter; LVS: left ventricular end systolic diameter; LV: left ventricle; TAPSE: tricuspid annular plane systolic excursion.*

Potential Conflicts of Interest

There are no relevant conflicts of interest.

Sources of Funding

This study was self-funded.

Academic Association

This study is part of Anderson José Argemiro's Final Paper as a partial requirement to obtain the Certificate of Specialization in Transthoracic Echocardiography from Hospital da Cruz Vermelha – Cruz Vermelha Brasileira - Filial do Estado do Paraná and Instituto Saber e Aprender.

Table 5 – Comparison of sexes for the variables related to ECHO in the Study Group

Variables	n	Mean	Standard deviation	p* value
LA				
Female	29	35.0	4.3	
Male	12	35.7	6.3	0.711
RV				
Female	29	21.5	4.5	
Male	12	22.1	3.3	0.677
Basal RV				
Female	29	28.9	6.0	
Male	12	29.6	6.5	0.759
Mid RV				
Female	29	22.4	5.4	
Male	12	23.3	5.5	0.669
LVD				
Female	29	44.2	3.6	
Male	12	46.0	5.3	0.208
LVS				
Female	29	27.0	3.5	
Male	12	27.5	4.7	0.689
Interventricular septum				
Female	29	9.66	1.91	
Male	12	10.5	1.7	0.191
LV posterior wall				
Female	29	8.79	1.70	
Male	12	9.25	1.60	0.431
RV free wall				
Female	29	0.44	0.09	
Male	12	0.44	0.14	0.895
TAPSE				
Female	29	22.2	3.9	
Male	12	20.1	2.2	0.092
Lateral S'				
Female	29	12.6	2.3	
Male	12	11.8	1.5	0.241

**Student's t-test for independent samples; $p < 0.05$. LA: left atrium; RV: right ventricle; LVD: left ventricular end diastolic diameter; LVS: left ventricular end systolic diameter; TAPSE: tricuspid annular plane systolic excursion.*

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