Analysis of Right Ventricular Systolic Function in Chagasic Patients through the Right Ventricular Outflow Tract Systolic Excursion

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Abstract

Background: Right Ventricular Outflow Tract Systolic Excursion (RVOT_SE) has proven to be accurate to assess the right ventricular (RV) systolic function. However, chronic Chagas' heart disease (CCHD) has its own characteristics, which generate the need to prove the RVOT_SE applicability to this group.

Objective: To assess RVOT_SE in CCHD patients and compare it against traditional parameters for RV systolic function assessment.

Methods: 131 CCHD patients were studied. The RVOT_SE was calculated by using M-mode echocardiography, from parasternal short-axis view at aortic valve level, in the RV outflow tract (RVOT), measuring the excursion of the endocardial surface of the posterior wall of the RVOT. The fractional area change (FAC), as the reference method, and tricuspid annular plane systolic excursion (TAPSE) for comparison were obtained. 27 patients were excluded for failure to obtain reliable images.

Results: Of the 104 patients, 38 had RV dysfunction, defined as FAC less than 35%. They were divided into two groups, where the first 52 patients corresponded to the method learning curve. In this series, values less than 5.6 mm showed better correlation with abnormalities. RVOT_SE results obtained from the method application group were: sensitivity = 94%, specificity = 97%, positive predictive value (PV+) = 94%, negative predictive value (PV-) = 97% and accuracy = 96%. TAPSE showed respectively 95%, 98%, 97%, 97% and 97%.

Conclusion: RVOT_SE results in the examinations performed after the learning curve showed sensitivity, specificity, PV+, PV- and accuracy similar to those of TAPSE, showing parameters similar to those of CCHD patients. (Arq Bras Cardiol: Imagem cardiovasc. 2016;29(4):124-131)

Keywords: Right Ventricular Function; Chagas Cardiomyopathy; Echocardiography/methods; Right Ventricular Dysfunction.

Introduction

The right ventricular (RV) systolic function information obtained from transthoracic echocardiography (TTE) has been a challenge for echocardiographers over time. This is due to the fact that its retrosternal location, which limits the acquisition of images from the parasternal windows, as well as its complex geometry, which appears triangle-shaped when viewed in the apical window and half-moon shaped in the parasternal short axis view. The RV geometry is also influenced by the interventricular septum position, which shows a concavity toward the left ventricle (LV) both during systole and diastole.[1,2]

Recently a new parameter, with a simple acquisition technique, referred to as Right Ventricular Outflow Tract Systolic Excursion (RVOT_SE), was tested to assess the RV systolic function. This method, when compared to the fractional area change (FAC) and tricuspid annular plane systolic excursion (TAPSE), has proven to be accurate for assessment of RV systolic function, in addition to confirming a worse prognosis for patients with values below the cut-off line for RV dysfunction.[3] However, this method has not been tested on patients with chronic Chagas' heart disease (CCHD). As this disease has its own characteristics, including segmental changes in the RV,[4] the need to prove the applicability of (RVOT_SE) to this population is of the essence. This study aims to assess RVOT_SE in CCHD patients and compare it against traditional parameters for RV systolic function assessment.

Methods

This study was conducted in the Echocardiography Service of the Hospital Nossa Senhora de Fátima de Patos de Minas, from 2012 to 2014. 131 patients underwent transthoracic echocardiography. The RVOT_SE was calculated by using M-mode echocardiography of the RV outflow tract (RVOT), from parasternal short-axis view at aortic valve level, measuring the excursion of the endocardial surface of the posterior wall of the RVOT (Figure 1).

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The fractional area change (FAC), as the reference method, and tricuspid annular plane systolic excursion (TAPSE) for comparison were obtained. FAC was obtained by tracing the endocardial RV borders both in systole and diastole from the annulus, along the RV free wall to the apex, and then along the interventricular septum back to the annulus. The FAC expressed as percentage was obtained by using the following formula: FAC = (RV end-diastolic area - RV end-systolic area)/ RV end-diastolic area) x 100. TAPSE was obtained using an M-mode cursor passed through the tricuspid annulus and measuring the amount of longitudinal displacement of the annulus at peak-systole. FAC < 35% and TAPSE<16 mm are considered abnormal values, according to the Guidelines for the Echocardiographic Assessment of the Right Heart in Adults of the American Society of Echocardiography.[5]

Echocardiographic studies of patients known to have CCHD, who had regional and global left ventricular (LV) systolic dysfunction were included. 27 patients were excluded for failure to obtain reliable images in at least one of the parameters, and in 11, for failure to calculate FAC; 8, for failure to calculate RVOT_SE, and 8, for failure to carry out both methods. In all of the 131 tests, the calculation of TAPSE was possible.

Statistical Analysis

To assess whether the patient sample from the learning group and patient sample from the application group derived from the same population, patients' characteristics were checked for similarities. The nonparametric Mann-Whitney test was used for continuous variables, and Pearson's chi-square test for discrete variables. Correlation between variables was assessed by Spearman's rank correlation coefficient. The Kappa's coefficient was used to assess whether the same diagnosis found by FAC would be found by other methods. A significance level of 5% was used and analyses were performed using SPSS statistics bundle, version 23.

Results

A total of 104 patients were analyzed, of which 48 were females and 56 were males at an average age of 63.2 years; 38 had RV dysfunction defined as FAC less than 35%, and 66 had normal systolic function. They were divided into two analysis groups: Learning and Application of the method. Both analysis groups showed the same behavior in all characteristics (Table 1). None of the characteristics shown in the table provided evidence that either the analysis group – Learning or method of application – or patients' genders are factors that have influence on patients' behavior. This makes it possible to affirm that the samples are homogeneous with respect to gender and method of analysis. As the learning group was used for training of the method, only the patients from the application group was used for analysis (n = 52).

To assess whether the methods are consistent, the Kappa concordance test was applied to each of them. The TAPSE showed a high degree of concordance with FAC (Kappa = 0.957, p = 0.000) (Table 2).

RVOT_SE also showed high concordance with FAC. When considering the value of 5.6 mm as an abnormality criteria for RVOT_SE, 91.3% showed concordance regarding patients' classification (p = 0.000). When considering the value of 6 mm as an abnormality criterion for RVOT_SE, 71.6% showed concordance regarding patients' classification. This indicates that using the limit value of 5.6 mm provides better classification of the patient in relation to FAC (Tables 3 and 4).FAC, TAPSE and RVOT_SE methods were strongly correlated.

In the study sample, the RVOT_SE values less than 5.6 mm showed better correlation with abnormalities. RVOT_SE results obtained from the method application group were: sensitivity = 94%, specificity = 97%, positive predictive value (PV+) = 94%, negative predictive value (PV-) = 97% and accuracy = 96%. TAPSE has shown: sensitivity = 95%, specificity = 98%, positive predictive value (PV+) = 97%, negative predictive value (PV-) = 97% and accuracy = 97%.

Regarding the influence of LV systolic function, there was a significant correlation between the LV ejection fraction and RV systolic function, calculated by the methods assessed (p = 0.000).

Discussion

The need for a more accurate diagnosis for RV systolic function becomes increasingly clear in the face of therapeutic and prognostic implications of this change in various heart diseases, such as ischemia,[6] dilated cardiomyopathy,[7] arrhythmogenic RV dysplasia (ARVD),[8] heart failure with normal ejection fraction (HFNEF),[9] as well as in Chagas' heart disease,[10] among others. The Guidelines for the Echocardiographic Assessment of the Right Heart in Adults of the American Society of Echocardiography establish that the S wave FAC of the tricuspid annular plane and TAPSE are appropriate parameters for assessment of RV systolic function, and the myocardial performance index (MPI) can also be performed as parameter for either systolic and diastolic or overall assessment of the RV.[5]

Despite the progress made over the past few years, it is clear that the multiparameter evaluation of RV is what leads to more reliable results.[11,12] In the study sample, the need for this multiparametric assessment is clear, as in 14.5% of CCHD patients, no reliable measurements were obtained in at least one of the parameters tested.

New echocardiographic methods have been tested in the evaluation of RV myocardial contractility, such as myocardial deformity rates[13] and three-dimensional echocardiography (3DEcho).[14] However, these new technologies are not available in all echocardiography laboratories, thus limiting their use. Furthermore, they require excelent images and longer training period in order to be correctly carried out.

The use of the RVOT_SE for assessment of RV systolic function offers capabilities inherent in the evaluation methods by means of M-mode, which may still have a role in the current echocardiography.[15] Ease of learning to handle the technique, available access to any echocardiography apparatus, little inter and intraobserver variability and potential use even in the face of suboptimal acoustic windows are arguments in favor of M-mode based methods. The results published by Asmer et al.[3] sparked optimism due precisely to the methodological simplicity combined with such a satisfactory accuracy, so much

Table 1 – Distribution according to demographic data and echocardiographic parameters

	Learning Group	Application Group	P
Gender	N	N	
Female	29 55.8%	19 36.5%	0.076
Male	23 44.2%	33 63.5%	
Age	Mean ± SD	Mean ± SD	
Female	64.83 ± 11.59	62.63 ± 10.16	0.654
Male	66.00 ± 8.44	65.30 ± 10:32	
p	0.985	0.291	
Left ventricular ejection fraction - LVEF (%)	Mean ± SD	Mean ± SD	
Female	45.17 ± 13.66	40.26 ± 16.43	0.131
Male	37.78 ± 14.61	37.03 ± 14.33	
p	0.086	0.655	
Right ventricular diameter (mm)	Mean ± SD	Mean ± SD	
Female	30.59 ± 7.22	30.68 ± 6.49	0.925
Male	32.87 ± 5.01	32.00 ± 5.95	
p	0.062	0.458	
Fractional area change - FAC (%)	Mean ± SD	Mean ± SD	
Female	40.66 ± 15.20	38.84 ± 13.55	0.628
Male	35.04 ± 11.84	36.85 ± 9.97	
p	0.148	0.827	
Tricuspid annular plane systolic excursion - TAPSE (mm)	Mean±SD	Mean ± SD	
Female	17.41 ± 4.99	18.37 ± 4.92	0.283
Male	16.00 ± 5.28	17.70 ± 5.18	
p	0.292	0.511	
Right Ventricular Outflow Tract Systolic Excursion - RVOT_SE (mm)	Mean±SD	Mean ± SD	
Female	6.55 ± 2.44	5.60 ± 1.56	0.873
Male	5.75 ± 2.16	6.43 ± 2.23	
p	0.227	0.171	
Systolic pressure in the pulmonary artery (mmHg)	Mean ± SD	Mean ± SD	
Female	42.84 ± 12.42	42.76 ± 15.44	0.795
Male	43.27 ± 12.62	43.32 ± 14.93	
p	1.000	0.878	

Table 2 – TAPSE and FAC concordance ratio

Fractional area Change - FAC * *Systolic excursion of the tricuspid ring plane - TAPSE * Systolic excursion of the tricuspid ring plane - TAPSE * Cross Tabulation Group Systolic excursion of the tricuspid ring plane - TAPSE					
Group			less than 16 mm	greater than or equal to 16 mm	total
Learning	FAC	less than	19	2	21
		35%	(36,5%)	(3,8%)	(40,4%)
		Higher or equal to	0	31	31
		at 35%	(0,0%)	(59.6%)	(59.6%)
	Total		19	33	52
			(36,5%)	(63,5%)	(100%)
Application	FAC	less than	17	0	17
		35%	(32,7%)	(0,0%)	(32,7%)
		Higher or equal to	1	34	35
		at 35%	(1,9%)	(65.4%)	(67,3%)
	Total		18	34	52
			(34,6%)	(65,4%)	(100%)
Total	FAC	less than	36	2	8
		35%	(34,6%)	(1,9%)	(36,5%)
		Higher or equal to	1	65	66
		at 35%	(1,0 %)	(62,5%)	(63,5%)
	Total		37	67	104
			(35,6%)	(64,4%)	(100%)

Kappa concordance test

group	Kappa	Approx. Sig
Learning	,919	,000
Application	,957	,000
Total	**,937**	**,000**

Table 3 – RVOT_SE, with normality reference value higher or equal to 5.6 mm, and FAC concordance ratio

Variação Fracional da Área - FAC * Excursão sistólica da via de saída do VD - ES_VSVD* Grupo Tabulação Cruzada Excursão sistólica da via de saída do VD - ES_VSVD					
Group			**less than 5,6 mm**	**higher or equal to 5,6 mm**	**total**
Aprendizado	FAC	less than	18	3	21
		35%	(34,6%)	(5,8%)	(40,4%)
		higher or equal to	5	26	31
		at 35%	(9,6%)	(50,0%)	(59.6%)
	Total		23	29	52
			(44,2%)	(55,8%)	(100%)
Learning	FAC	less than	16	1	17
		35%	(30,8%)	(1,9%)	(32,7%)
		higher or equal to	1	34	35
		at 35%	(1,9%)	(65.4%)	(67,3%)
	Total		17	35	52
			(32,7%)	(67,3%)	(100%)
Total	FAC	less than	34	4	38
		35%	(32,7%)	(3,8%)	(36,5%)
		higher or equal to	6	60	66
		at 35%	(5,8 %)	(57,7%)	(63,5%)
	Total		40	64	104
			(38,5%)	(61,5%)	(100%)

Kappa concordance test

group	Kappa	Approx. Sig
Learning	,685	,000
Application	,913	,000
Total	**,795**	**,000**

Table 4 – RVOT_SE, with normality reference value higher or equal to 6.0 mm, and FAC concordance ratio

Fractional area Change - FAC * Right Ventricular Outflow Tract Systolic Excursion - (RVOT_SE) * Cross Tabulation Group Right Ventricular Outflow Tract Systolic Excursion - RVOT_SE					
Group			**less than 6,0 mm**	**higher or equal to 6,0 mm**	**total**
Learning	FAC	less than 35%	18 (34,6%)	3 (5,8%)	21 (40,4%)
		higher or equal to at 35%	9 (17,3%)	22 (42,3%)	31 (59.6%)
	Total		27 (51,9%)	25 (48,1%)	52 (100%)
Application	FAC	less than 35%	16 (30,8%)	1 (1,9%)	17 (32,7%)
		higher or equal to at 35%	6 (11,5%)	29 (55,8%)	35 (67,3%)
	Total		22 (42,3%)	30 (57,7%)	52 (100%)
Total	FAC	less than 35%	34 (32,7%)	4 (3,8%)	38 (36,5%)
		higher or equal to at 35%	15 (14,4 %)	51 (49,0%)	66 (63,5%)
	Total		49 (47,1%)	55 (52,9%)	104 (100%)

Kappa concordance test

group	**Kappa**	**Approx. Sig**
Learning	,542	,000
Application	,716	,000
Total	**,629**	**,000**

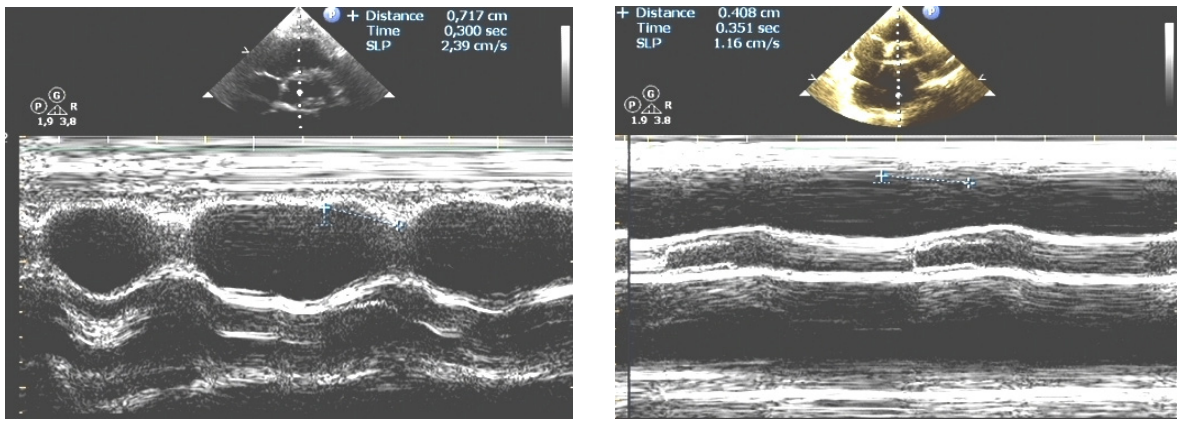

Figure 1 – *Right ventricular outflow tract systolic excursion (RVOT_SE) was calculated by using M-mode echocardiography in the RV outflow tract (RVOT), from parasternal short-axis view at aortic valve level, measuring the excursion of the endocardial surface of the posterior wall of the RVOT. A: Normal RV systolic function (RVOT_SE = 7.17 mm); B: Depressed RV systolic function (RVOT_SE = 4.08 mm).*

so that other authors have already published the RVOT_SE reference values in children[16]

The RVOT_SE normality reference value in the original work by Asmer et al.[3] was 6 mm, other than that found in chagasic patients' samples. This difference between the cutoffs may have several reasons: the characteristics of RV involvement in CCHD patients; interobserver variation; populations with varying degrees of body mass and ventricular mass. However, it is not possible to say at this moment which is the optimal cutoff point on the basis of these two studies only, although the results show that RVOT_SE values > 6.0 mm or <5.6 mm have high accuracy for normality and abnormality, respectively, of RV systolic function.

The use of FAC as the reference method for RV systolic function is due to its proven efficacy as a parameter independent from age, LV ejection fraction and heart failure, among others.[17] The results obtained support the RVOT_SE as a highly accurate method also in the population of chagasic patients, confirming the findings by Asmer et al.[3]in the population of non-chagasic patients. It is also important to highlight the similar accuracy of RVOT_SE as compared to TAPSE, a widely established method of assessment of RV systolic function, whose implementation also uses the M-mode as a tool.

Finally, this study highlights the importance of taking a learning period when starting the implementation of a new methodology in cardiovascular imaging. The results obtained in the first phase of acquisition of RVOT_SE were inferior in relation to those of the second phase (concordance with FAC ratio: 71.6% X 95.7%). This information confirms the need for the learning curve in the improvement of echocardiographers' skills using new methods, which helps to reinforce that the results below those found in the literature at an early stage should not be a reason not to believe in the new method, but rather to persist in achieving adequate accuracy.

Conclusion

The RVOT_SE is a new assessment method for RV systolic function, with excellent results in the CCHD, which has shown in this study sensitivity, specificity, PV+, PV- and accuracy similar to those of TAPSE, thus indicating similarity between the parameters. New studies are required to confirm an RVOT_SE value less than 5.6 mm as the cutoff point for assessment of RV systolic function in the CCHD. It is worth remembering that just as in the general population, the assessment of RV function should also be multiparametric in the chagasic patients' group.

Authors' contributions

Research conception and design: Santana GF; Obtenção de dados:Santana GF,Leite DC; Data Analysis and Interpretation: Santana GF, Freitas OGA; Statistical analysis: Santana GF, Freitas OGA; Manuscript writing: Santana GF, Freitas OGA; Critical revision of the manuscript's major intellectual content: Santana GF, Leite DC,Milagre JON, Fonseca MAC, Coelho GN, Gomes TO, Branco SD, Parreira DR, Reis A,Freitas OGA.

Potential Conflicts of Interest

No relevant conflicts of interest.

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Academic Association

This study is not associated to graduate programs.

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