ORIGINAL ARTICLE

Should we Quantify Right Heart Diameters in Relation to Body Surface Area?

¿Debemos cuantificar los diámetros de las cavidades derechas en relación a la superficie corporal?

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ABSTRACT

Background: The aim of this study was to establish the relationship between right heart chamber dimensions and body surface area in a population with no evidence of cardiopulmonary disease.
Methods: The study included patients attending the echocardiography laboratory for a regular health examination. Patients with cardiac disease, right or left ventricular dysfunction, significant valve diseases, known pulmonary disease or pulmonary systolic pressure ≥45 mmHg were excluded from the study. Patients' affiliation, weight (kg), height (meters), and body surface area (m2) data were recorded. Right heart measurements were based on guideline recommendations. The population was distributed in quartiles according to body surface area (25%-50%-75%-100%). Simple regression analysis was performed between each dimension of the right heart and body surface area.
Results: A prospective, consecutive, observational and descriptive cohort study was performed including 1,045 patients with the following characteristics: mean age 41±15.1 years, 53% men, mean weight 77.4±19.6 kg, height 1.69±0.09 and BSA 1.89±0.87 m^2. Significant differences were observed in each of the variables according to the distribution by quartiles. A positive correlation was demonstrated between all right heart dimensions and body surface area.
Conclusions: Body surface area is an important determinant of right heart dimensions measured by echocardiography.
We therefore suggest the use of measurements indexed by body surface area, since it could influence clinical decision making.

Key words: Right ventricle – Echocardiography - Body surface area

RESUMEN

Introducción: La evaluación de las cavidades derechas representa un desafío para la ecocardiografía, dada la imposibilidad de asimilación a un modelo geométrico. No existen recomendaciones sobre la necesidad de ajustar sus diámetros a la superficie corporal.
Objetivos: Determinar la relación entre los diámetros de las cámaras derechas y la superficie corporal, en una población sin evidencia de patología cardiopulmonar.
Material y métodos: Se incluyeron pacientes (p) que asistieron al laboratorio de ecocardiografía por examen periódico de salud. Se excluyeron los p con miocardiopatías, deterioro de la función sistólica del ventrículo derecho o ventrículo izquierdo, valvulopatías significativas, enfermedad pulmonar conocida o presión sistólica pulmonar ³ 45 mmhg. Se registraron los datos de filiación, peso (kg), altura (metros), y superficie corporal (SC, m^2). Se realizaron mediciones de las cavidades derechas en base a las recomendaciones de las guías. Se distribuyó la población en cuartilos de acuerdo a la SC (25%-50%-75%-100%). Se realizó análisis de regresión simple entre cada dimensión de las cavidades derechas y la SC.
Resultados: Estudio cohorte, prospectivo, consecutivo, observacional y descriptivo de 1045 p, edad media de 41 (±15.1) años, 53% hombres, peso 77.4 (±19.6) kg, altura 1.69 (±0.09) m y una SC promedio de 1.89 (±0.87) m^2. Se observó diferencias significativas en cada una de las variables de acuerdo a la distribución por cuartilos. Se demostró una correlación positiva entre todas las dimensiones de las cavidades derechas y la SC.
Conclusiones: La superficie corporal es un determinante importante de las dimensiones derechas, medida por ecocardiografía cardiaca.
Por lo tanto, sugerimos el uso de mediciones indexadas a la superficie corporal, ya que podría influir en la toma de decisiones clínicas.

Palabras claves: Ventrículo derecho - Ecocardiografia - Superficie corporal

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Abbreviations

LA	Left atrium	**RVOT**	Right ventricular outflow tract
RA	Right atrium	**LV**	Left ventricle
PA	Pulmonary artery	**RV**	Right ventricle
COPD	Chronic obstructive pulmonary disease	**BRV**	Basal right ventricle
BSA	Body surface area	**MRV**	Medial right ventricle

INTRODUCTION

Right ventricular assessment represents a challenge for echocardiography, because of technical difficulties compared with the left ventricle (LV).

Guidelines suggest that left ventricular, left atrial (LA) and aortic diameters should be indexed by body surface area (BSA). However, the assessment of right ventricular diameters is based on absolute values obtained from population studies and there are no recommendations on the need to adjust them to the BSA of each patient. (1, 2, 6, 7)

There is little information available on the echocardiographic analysis of the right ventricle (RV), especially on reference values in our region.

Clinical assessment of the right heart chambers is important in many heart diseases, requiring a deep understanding of physiology and anatomy, but the complex geometry of the RV limits its echocardiographic assessment.

Recently published guidelines for the echocardiographic assessment of the RV provide a set of normal values for commonly used ventricular dimensions and functional measurements. Normal values are derived from the pooled data of different studies and are not stratified by gender, age or biometric data.

The most recent guidelines of the American Society of Echocardiography (ASE) and the European Association of Cardiovascular Imaging (EACVI) highlight the lack of indexed values for the right heart. (1, 2) They also acknowledge the need to have data from different populations to obtain reference values, as they have been shown to influence a series of echocardiographic parameters.

The purpose of this study is to establish the relationship between right heart chamber dimensions and BSA in our population without evidence of cardiopulmonary disease.

METHODS

Patients >18 years, who attended the cardiovascular echocardiography laboratory for a regular health exam, were consecutively included in the study between July 2015 and March 2017.

Patients with cardiomyopathy (hypertrophic, dilated, restrictive), right or left ventricular systolic function impairment (ejection fraction <53%), significant valve disease, evident pulmonary disease (chronic obstructive pulmonary disease (COPD), pulmonary fibrosis) or pulmonary systolic pressure ≥45 mmHg were excluded from the study.

Patients' affiliation, weight (Kg), height (meters), and BSA (m^2) (using the classic Dubois and Dubois formula) data were recorded.

Left lateral decubitus transthoracic echocardiograms were performed following current international guideline recommendations. All scans were carried out using a standard protocol, with two GE Vivid 5 and S70 ultrasound machines. Eight measurements were performed to evaluate the size and function of the right heart chambers. Diameters were assessed at end-diastole (Figure 1). The proximal right ventricular outflow tract (RVOT) diameter was measured in left parasternal short axis view at the level of the great vessels, and basal right ventricular (BRV, below the tricuspid valve) and medial right ventricular (MRV) diameters in strict apical 4-chamber view. All measurements were made from inner edge to inner edge.

Systolic function was assessed by means of M mode tricuspid annular plane systolic excursion (TAPSE in millimeters, with a normal value ≥17) and maximum pulsed wave tissue Doppler velocity at the level of the mitral annulus (S wave in cm/sec, with a normal value ≥9.5) using appropriate software. Right atrial (RA) area was assessed in 4-chamber apical view (with a normal value <18 cm^2). Similarly, the pulmonary artery trunk diameter was measured on a short axis view at the level of the great vessels (normal diameter <25 mm).

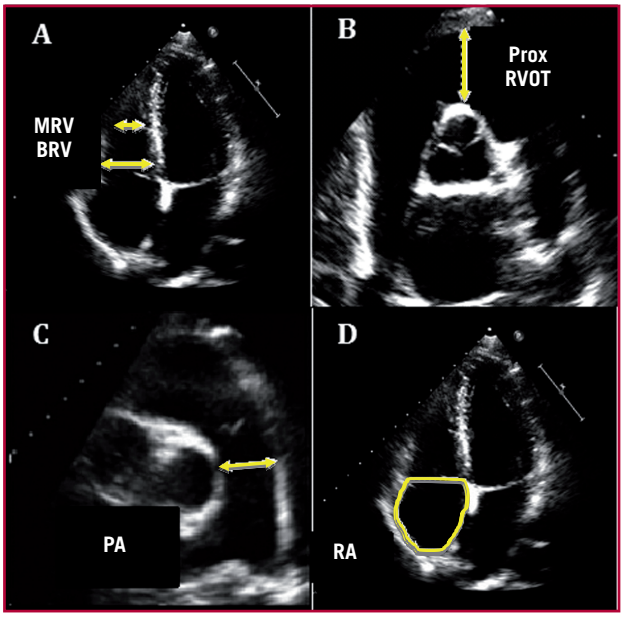

Fig. 1. Images displaying right ventricular measurements performed at end diastole. (A) Four chamber apical view exhibiting basal and medial right ventricular diameters (BRV and MRV, respectively). (B and C) Left parasternal short axis view performed at the level of the great vessels showing proximal right ventricular outflow tract (RVOT) and pulmonary artery (PA) trunk dimensions. (D) Apical 4-chamber view indicating right atrial (RA) area.

Left ventricular ejection fraction was calculated using the Simpson method, considering as normal a value ≥53%.

All quantifications were adapted to the current definitions and recommendations of international guidelines (ASE, EACVI). (1, 2)

The population was stratified into quartile groups according to BSA: Group 1: 1.43-1.69 m2, Group 2: 1.70-1.86 m2, Group 3: 1.87-2.02 m2 and Group 4:>2.02 m2.

Statistical analysis

The information was collected in an Excel database. The population distribution was determined using D'Agostino Pearson's normality test.

A linear regression analysis was performed to evaluate the association of each right heart quantitative variable with BSA. The population characteristics were distributed in quartiles according to BSA (25%-50%-75 %-100%).

Student's t-test was used for normal quantitative variables, the chi square test for qualitative variables and ANOVA for multiple quantitative variables. Statistical analyses were performed using STATA 14 software package. A value of $p<0.05$ was considered statistically significant.

Ethical considerations

The analysis was carried out following the recommendations of Good Clinical Practice Guidelines and current regulations, and with the approval of the Institutional Review Committee.

RESULTS

A prospective, consecutive, observational and descriptive cohort study was performed including 1,045 patients with the following characteristics: mean age 41±15.1 years, 53% men, mean weight 77.4±19.6 kg, height 1.69±0.09 m and BSA 1.89±0.87 m².

Echocardiographic findings showed that mean BRV and MRV diameters were 33.5±4.74 mm and 24.9±4.75 mm, respectively; RVOT was 28.09±4.87 mm, RA area 13.49±2.85 cm² and PA trunk diame-

Table 1. Results

BSA QUARTILES	BRV (mm)	MRV (mm)	LVOT (mm)	PA (mm)	RA (cm²)
GROUP 1 (1.43-1.69 m2) :	30	22	25	20	11.4
(<25)	(25.26–34.74)	(17.25–26.75)	(20.13–29.87)	(16.84–23.16)	(8.55–14.25)
GROUP 2 (1.70-1.86 m2):	34	24.8	28	22	13.05
(25-50)	(29.26–38.71)	(20.05–29.55)	(23.13–32.87)	(18.84–25.16)	(10.2–15.9)
GROUP 3 (1.87-2.02 m2):	37	28	31	24	15.1
(50-75)	(32.26–41.74)	(23.25–32.75)	(26.13–35.87)	(20.84–27.16)	(12.25–17.95)
GROUP 4 (>2.02 m2.):	44	37	42	28	21
(>75)	(29.26–48.74)	(32.25–41.75)	(37.13–46.84)	(24.84–31.16)	(18.15–23.85)
Reference values	25–41 mm	19–35 mm	21–35 mm	<25 mm	<18 mm

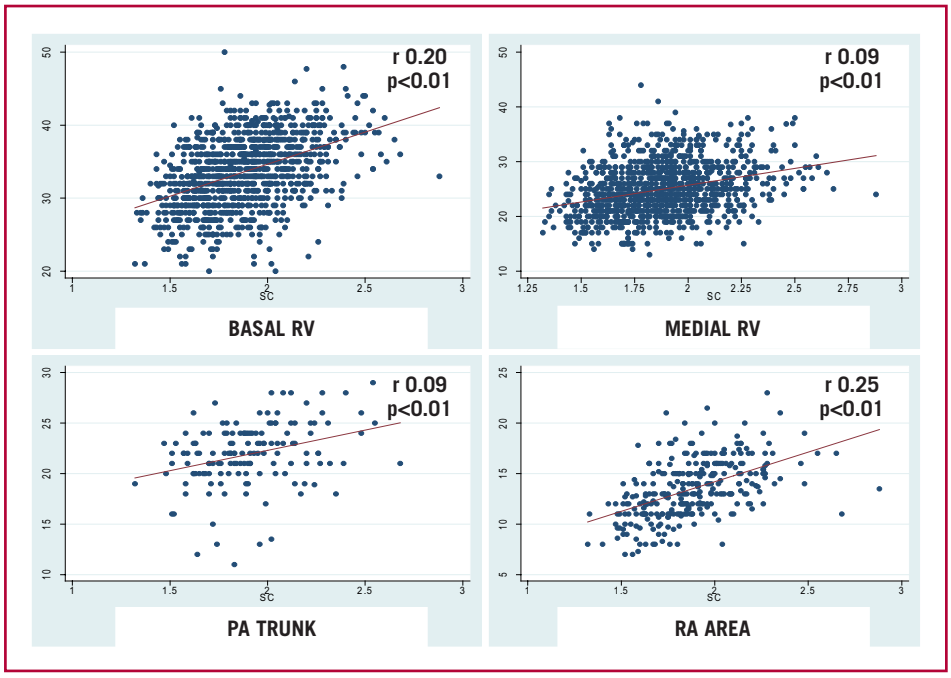

Fig. 2. Scatter diagrams illustrating the correlations between the right heart and body surface area. RV: Right ventricular diameter. PA: Pulmonary artery. RA: Right atrial

ter 21.92±3.16 mm. Right ventricular systolic function was preserved in all the patients: mean TAPSE was 23.57±4.07 mm and peak systolic velocity (Sdt) 13.94±2.45 cm/sec. Significant differences were observed in each of the variables according to quartile BSA distribution (Table 1).

A positive correlation was demonstrated between BRV diameter and BSA ($p < 0.01$) Similarly, positive and statistically significant correlations with BSA were also observed for the rest of the measurements: MRV ($p < 0.01$), RVOT ($p < 0.01$), RA area ($p < 0.01$) and PA trunk diameter ($p < 0.01$) (Figure 2).

A great percentage of patients showed values higher than those recommended by the current guidelines. We found that in 2.9% of cases BRV diameters were ≥42 mm, 2.1% had MRV diameters ≥36 mm, in 8.2% the RVOT was ≥36 mm, 5.4% had RA area ≥18 cm², and 2.5 % presented PA diameter ≥25 mm.

The RV diameter over BSA ratio was 18.04±5.1 (95% CI 12.94-23.14) for BRV/BSA, 13.40±5.2 (95% CI 8,2-18,6) for MRV/BSA and 15.11±5.54 (95% CI 9,56-20,64) for RVOT/BSA (Figure 3 - Table 2).

DISCUSSION

The purpose of this study was to determine the impact of BSA on frequently used right heart dimensions in patients without known cardiovascular disease.

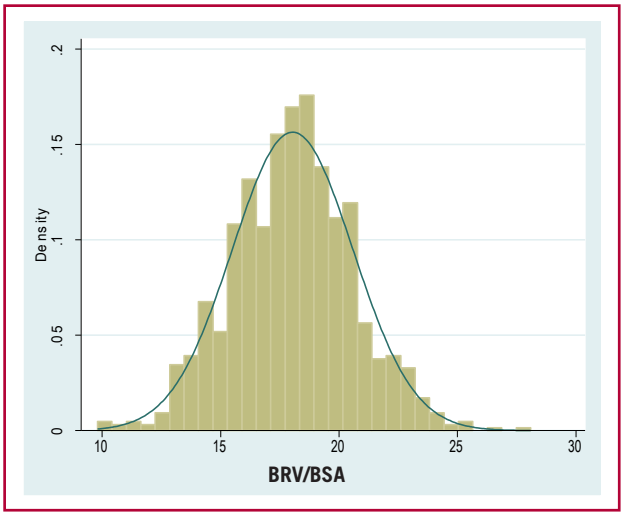

Fig. 3. Bar graph illustrating basal right ventricular diameter/body surface area ratio

Table 2. Diameters indexed according to body surface area and their 95% confidence interval

RV DIAMETER/BSA	
BASAL RVD	18,04 ± 5,1 (IC 95% 12.94-23.14)
MEDIAL RVD	13,40 ± 5,2 (IC 95% 8.2-18.6)
RVOT	15,11 ± 5,54 (IC 95% 9.56-20.64)

In our population with no history of cardiopulmonary disease, the assessment of right heart diameters and systolic function is consistent with international registries. (9, 10)

The results evidence a series of considerations to be taken into account when assessing the right heart. Reference values are based on data obtained from normal individuals with no history of heart disease and not indexed by BSA. Therefore, according to this simplification, the RV could be classified as normal in patients with low BSA or conversely, interpreted as right heart dilation in patients with high BSA.

There is great disparity between the dimensions of right heart chambers according to BSA through a wide range of measurements. This study shows there are important differences depending on the patients' BSA. The comparison among quartiles showed significant differences between each of the groups. The evaluation of the BSA upper quartile (2.02 m2) indicates that dimensions are above the maximum reference values suggested by the guidelines. These results suggest that, as in the left chambers, the evaluation of the right heart needs these indexed measurements.(5) Echocardiography remains the main tool for the anatomical and functional assessment of the right heart. The RV plays an important role in the morbidity and mortality of patients with pulmonary hypertension, pulmonary thromboembolism, right-sided failure and right ventricular dysfunction. (3) The identification of a dilated RV is important for the diagnosis of cardiomyopathies, shunts or congenital heart diseases. Therefore, having reliable data for normal values is of great clinical importance in these patients. (4)

In the clinical practice, it is common to observe patients with right ventricular and pulmonary artery diseases, with scarce biometric surface, that have adequate diameters according to the guidelines. These findings lead us to underestimate the impact on the right heart. Similarly, right heart chamber dimensions above reference values in patients with high BSA could lead to unnecessary complementary studies. The use of stratified reference values for BSA allows a more accurate identification of patients with dilated RV. According to these findings, the use of normal values stratified by BSA can influence clinical decision making.

CONCLUSIONS

Body surface area measured by echocardiography is an important factor to assess right heart dimensions. Therefore, we suggest the use of measurements indexed by BSA, since it could influence clinical decision making.

Conflicts of interests

None declared.
(See authors' conflicts of interest forms on the web/Supplementary material).

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