Clinical Research

Variability in the Echocardiographic Evaluation of the Systemic Right Ventricle

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ABSTRACT

Background: Echocardiographic evaluation of the systemic right ventricle (sRV) remains challenging in patients with transposition of the great arteries (TGA) corrected by an atrial switch (AS) and with congenitally corrected TGA (ccTGA). The aim of this study was to determine the interobserver and intraobserver variability of echocardiographic parameters for sRV size and systolic function.

Methods: Six independent observers retrospectively interpreted 44 previously acquired echocardiograms (25 patients with TGA/AS and 19 patients with ccTGA). Quantitative parameters included inlet and longitudinal diameters, systolic and diastolic areas, fractional area change (FAC), and wall thickness. sRV dilatation and systolic function were qualitatively graded as normal, mild, moderate, or severe. sRV hypertrophy was graded as present or absent. Intraclass correlation coefficients (ICCs) and Kappa statistics were computed to assess

RÉSUMÉ

Contexte : L'évaluation par échocardiographie du ventricule droit systémique (VDs) demeure difficile chez les patients présentant une transposition des gros vaisseaux (TGV) corrigée par un « switch auriculaire » (SA) et dans les cas de TGV à correction congénitale (TGVcc). Cette étude avait pour objectif de déterminer la variabilité interobservateur et intraobservateur des paramètres échocardiographiques de la taille et de la fonction systolique du VDs.

Méthodologie : Six observateurs indépendants ont procédé à une interprétation rétrospective de 44 échocardiogrammes réalisés antérieurement (25 patients avec TGV/SA et 19 patients avec TGVcc). Les paramètres quantitatifs comprenaient le diamètre d'entrée et le diamètre longitudinal, les surfaces systolique et diastolique, la variation fractionnelle de la surface (VFS) et l'épaisseur des parois des vaisseaux. La dilatation et la fonction systolique du VDs ont fait l'objet

The right ventricle, in the subaortic position, supports the systemic circulation (systemic right ventricle [sRV]) in transposition of the great arteries repaired by an atrial switch (TGA/AS) and in congenitally corrected transposition of the great arteries (ccTGA). AS operations, developed by Åke Senning in 1959[1] and William Mustard in 1964,[2] have largely been supplanted by the arterial switch operation. Consequently, patients

with an AS have since reached adulthood and are subject to various late complications. sRV systolic dysfunction and remodelling are associated with increased mortality and heart failure, pulmonary hypertension, and atrial and ventricular arrhythmias.[3-9] Therefore, the evaluation of sRV size and systolic function is essential during the longitudinal follow-up of patients with TGA/AS and ccTGA to identify higher-risk patients, to target further investigations, and to plan for timely interventions.[10,11]

sRV evaluation remains challenging for congenital cardiologists. Cardiovascular magnetic resonance (CMR) imaging is regarded as the reference standard for sRV imaging, but access to CMR is limited by scanner availability, high cost, noncompatible cardiac implantable electronic devices and other metallic objects, the need for sedation in children, and claustrophobia.[12] Therefore, transthoracic echocardiography (TTE) is used in a

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interobserver variability. Images from 10 patients (5 TGA/AS and 5 ccTGA) were reinterpreted at a 1-month interval, and ICC and Kendall tau b statistics were computed to assess intraobserver variability.

Results: Interobserver and intraobserver agreement were good to excellent for sRV diameters, areas and FAC (ICC, 0.49-0.97), except for the sRV wall thickness (ICC < 0) and the FAC for 1 observer. Interobserver agreement was poor for the qualitative assessment of sRV size and systolic function (Kappa < 0.25), but with a good to excellent intraobserver agreement.

Conclusions: These findings suggest that overall appreciation of sRV size and systolic function relies on variable interpretation of measurements by observers. Readers experienced in CHD and with clear thresholds for quantitative parameters, along with a validated algorithm, are required to guide the evaluation of sRV.

d'une évaluation qualitative en quatre catégories : normale, légère, modérée ou grave. Les résultats possibles de l'hypertrophie du VDs étaient la présence et l'absence de cette pathologie. Les coefficients de corrélation intraclasse (CCI) et les indices Kappa ont été calculés pour évaluer la variabilité interobservateur. Les images obtenues auprès de 10 patients (5 TGV/SA et 5 TGVcc) ont été réinterprétées 1 mois plus tard, et le CCI et les statistiques tau b de Kendall ont été calculés pour évaluer la variabilité intra-observateur.

Résultats : L'accord interobservateur et l'accord intraobservateur allaient de bon à excellent pour le diamètre, la surface et la VFS (CCI, 0,49-0,97), sauf pour l'épaisseur des parois du VDs (CCI < 0) et la VFS pour 1 observateur. L'accord interobservateur était médiocre pour l'évaluation qualitative de la taille et de la fonction systolique du VDs (Kappa < 0,25), mais l'accord intraobservateur variait de bon à excellent pour ces paramètres.

Conclusion : Ces résultats portent à croire que l'évaluation globale de la taille et de la fonction systolique du VDs repose sur une interprétation variable des mesures par les observateurs. Pour encadrer l'évaluation du VDs, il est essentiel de faire appel à des praticiens spécialistes des cardiopathies congénitales pour l'interprétation des résultats, de définir des seuils clairs pour les paramètres quantitatifs et de disposer d'un algorithme validé.

high proportion of patients to evaluate the sRV[13] and, in most cases, on qualitative assessment by experienced echocardiographers. The lack of standardized and validated TTE parameters, and the absence of specific imaging guidelines for sRV assessment render repeated TTE examinations highly variable and center and operator dependent.[14-16]

The aim of this study was to determine the interobserver and intraobserver variability of echocardiographic parameters assessing the size and systolic function of the sRV in patients with TGA/AS and ccTGA.

Material and Methods

Study population

The study population was selected among 144 patients with simple (isolated) or complex (associated with other congenital lesions) TGA/AS and 68 patients with ccTGA without anatomic repair, aged 18 years or greater and followed at the Montreal Heart Institute Adult Congenital Center. Eligible patients were identified through the institutional tailored clinical and research informatics system for congenital heart disease (Congenital Evaluation, Reporting, and Tracking Endeavor [CONGENERATE]), which contains comprehensive diagnostic and procedural codes. The patients with TGA/AS included in this study were drawn from a cohort who also underwent catheterization (33/144 patients with TGA/AS under follow-up at our institution), as previously reported.[9] Patients without an available TTE examination were excluded (8/33 patients). Twenty patients with ccTGA were selected on the basis of their clinical TTE reports to ensure a balanced distribution of sRV systolic function (normal, mild, moderate, and severe dysfunction), sRV size (normal, mild, moderate, and severe dilatation), and image quality (excellent, good, acceptable, mediocre). One patient was excluded because of the absence of TTE images in our system. TTE performed after April 2014 was preferentially selected to ensure that images

were acquired according to most recent guidelines.[15] The study was approved by the local institutional review board.

Image analysis

All images were previously acquired on a General Electric (Boston, MA) Vivid 9 echocardiographic system using a 1.5-3 MHz transducer during regular follow-up. For the study analysis, images were anonymized and transferred to a workstation equipped with Aquarius Net Viewer (version 4.4.12.0; TeraRecon, San Mateo, CA). Six independent observers blinded to each other's evaluation retrospectively reanalyzed 44 selected clinical TTE examinations offline. Among these 6 observers, 4 were experienced adult congenital cardiologists and echocardiographers, and 2 were cardiologists with prior experience in echocardiography undergoing advanced training in adult congenital heart disease (ACHD). For assessment of intraobserver variability, 5 of the 6 observers fully reanalyzed 10 TTE exams; they were blinded to their first interpretation performed ≥ 1 month prior.

Quantitative parameters. The quantitative parameters of sRV size and systolic function included sRV inlet and longitudinal diameters, systolic and diastolic areas, fractional area change (FAC) and wall thickness in a subcostal 4-chamber view (Fig. 1). The quantitative parameters were measured according to guidelines for evaluation of the subpulmonary right ventricle.[14-16] The observer was free to choose the most adequate image to make measurements. Values measured by the original sonographer at the time of image acquisition were retained for the tricuspid annular plane systolic excursion (TAPSE), the tricuspid annular peak systolic velocity on tissue Doppler imaging, the right ventricular index of myocardial performance (RIMP) or Tei index, the sRV global longitudinal strain (GLS), and presented as fixed and anonymized images in the analysis software. Although these parameters were not subject to variability analyses, they were used to
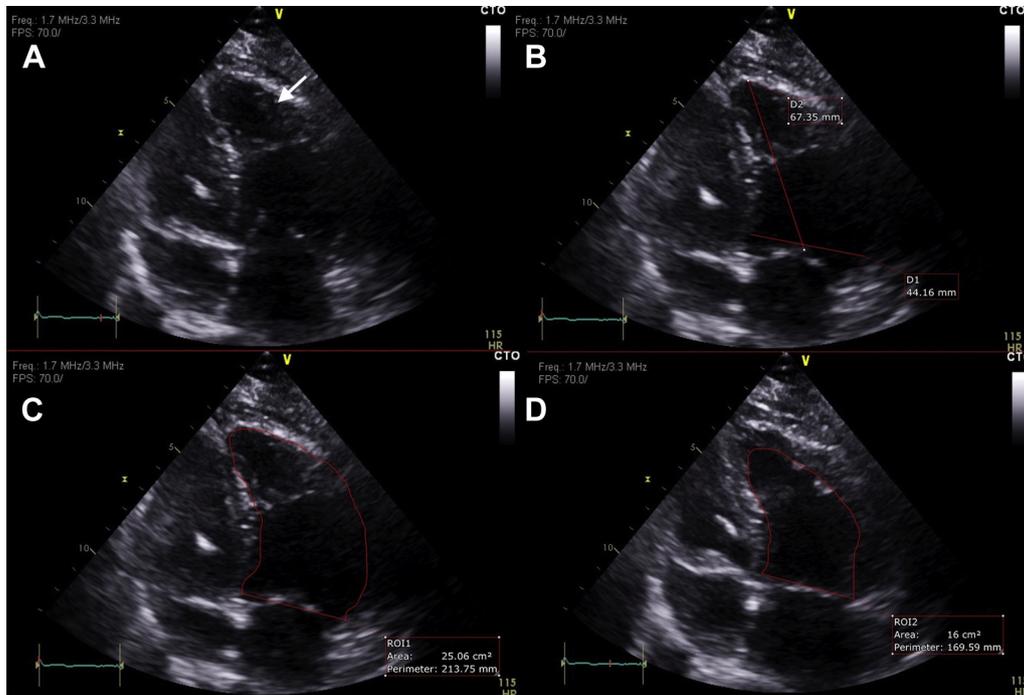
Figure 1. Quantitative transthoracic echocardiographic parameters for assessment of systemic right ventricle (sRV) size and systolic function. The measurements performed by each observer are shown in an apical view in a patient with congenitally corrected transposition of the great arteries (ccTGA). (**A**) The sRV is indicated by the **white arrow**. (**B**) Diameters. D1 represents the sRV basal diameter in centimeters. D2 represents the sRV longitudinal diameter in centimeters. (**C**) ROI1 represents the sRV end-diastolic area in centimeters squared. (**D**) ROI2 represents the sRV end-systolic area centimeters squared.

assess associations with other measurements. The analysis software (Aquarius Net Viewer) did not allow for additional longitudinal strain measurements.

Qualitative parameters. Observers were asked to visually grade sRV dilatation, sRV systolic dysfunction, and subpulmonary left ventricular systolic dysfunction as absent (normal), mild, moderate, or severe. Observers were free to integrate measurements and personal experience in their assessment. sRV hypertrophy was graded as present or absent. The septal curvature was described as reversed (normal, toward left ventricle), flat, or toward sRV.

Statistical analysis

Continuous variables are expressed as mean ± standard deviation or median and interquartile range (25th, 75th percentile), depending on the normality of distribution. Categoric variables are expressed as frequencies and percentages. Interobserver and intraobserver variabilities and reliabilities for continuous and categoric variables were assessed by the coefficient of variation (CV), intraclass correlation coefficient (ICC), Kappa statistics and ICC absolute agreement, and Kendall tau b statistics, as appropriate. Higher values for ICC (and Kappa statistics) indicate greater reliability, whereas larger CV values reflect greater variability and, thus, lower reliability. Kappa, ICC, and Kendall tau B values below 0.4 indicate poor agreement, values between 0.4 and 0.75 indicate fair to good agreement and values of 0.75 or higher indicate excellent agreement.[17-19] The ICC measurements were calculated using

mixed effect models through the proposed measurements of Shrout and Fleiss.[20] In case of missing data, the observer was removed from the statistical analysis for the corresponding echocardiographic examination. Two-tailed P values < 0.05 were considered statistically significant. Statistical analyses were performed using SPSS version 24.0 (Armonk, New York, NY) and SAS software version 9.4 (SAS Institute, Inc, Cary, NC).

Results

Population

Demographic and clinical characteristics of the study population are summarized in Tables 1 (TGA/AS) and 2 (ccTGA).

Quantitative parameters

For the interobserver comparison, ICC ranged from 0.491 to 0.752 corresponding to a fair to excellent agreement between the 6 observers for sRV inlet and longitudinal diameters, FAC, and systolic and diastolic areas (Table 3). The CV was < 15% for all previously described parameters except FAC. For the intraobserver comparison, the ICC ranged from 0.497 to 0.967 corresponding to a fair to excellent agreement. In most instances, the ICC was superior to 0.70 except for the FAC calculation by 1 observer (ICC = 0.133), a consequence of lower ICC for sRV end-diastolic and end-systolic areas for this observer (experienced ACHD cardiologist) compared with the others (Table 4). The interobserver and intraobserver

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Table 1. Demographic and clinical characteristics of patients with TGA/AS

	N = 25
Age (y)	41.0 ± 8.3
Sex (female), n (%)	9 (36.0%)
Mustard operation, n (%)	21 (84.0%)
Age at AS operation* (mo)	19.0 (12.5-38.8)
Associated heart lesions at birth,[†] n (%)	12 (48.0%)
Residual lesions after surgery,[‡] n (%)	4 (16.0%)
Hypertension, n (%)	9 (36.0%)
Active or past tobacco use, n (%)	7 (28.0%)
Dyslipidemia, n (%)	3 (12.0%)
Diabetes mellitus, n (%)	4 (16.0%)
Supraventricular arrhythmia, n (%)	21 (84.0%)
Ventricular arrhythmia, n (%)	10 (40.0%)
Conduction disorder, n (%)	19 (76,0%)
Permanent pacemaker, n (%)	18 (72.0%)
Implantable cardioverter defibrillator, n (%)	6 (24.0%)
Hospitalization for heart failure, n (%)	9 (36.0%)
Tricuspid valve replacement or repair, n (%)	4 (16.0%)
Pulmonary hypertension, n (%)	13 (52.0%)
Stenosis or thrombosis of the systemic baffle, n (%)	14 (56.0%)
Baffle leak, n (%)	6 (24.0%)

AS, atrial switch; TGA, transposition of the great arteries.

Normally distributed continuous variables are presented as mean (standard deviation).

*Non-normally distributed continuous variables are presented as median (interquartile range).

[†]The associated heart lesions at birth are pulmonary or subpulmonary valve stenosis (n = 4), persistent ductus arteriosus (n = 4), atrial septal defect (n = 2), and ventricular septal defect (n = 5). The groups are not inclusive.

[‡]The residual lesions after surgery are ventricular septal defect (n = 2), atrial septal defect (n = 1), and subpulmonary stenosis (n = 1).

Table 2. Demographic and clinical characteristics of patients with ccTGA

	N = 19
Age (y)	46.7 ± 15.3
Female, n (%)	9 (47.4%)
Age of diagnosis (y)	16.4 ± 20.8
Associated heart lesions at birth,* n (%)	11 (57.9%)
Surgery for associated CHD, n (%)	4 (21.1%)
Hypertension, n (%)	4 (21.1%)
Active or past tobacco use, n (%)	0 (0.0%)
Dyslipidemia, n (%)	1 (5.3%)
Diabetes mellitus, n (%)	2 (10.5%)
Coronary artery disease, n (%)	2 (10.5%)
Supraventricular arrhythmia, n (%)	9 (47.4%)
Ventricular arrhythmia, n (%)	6 (31.6%)
Conduction disorder, n (%)	6 (31.6%)
Permanent pacemaker,[†] n (%)	5 (26.3%)
Implantable cardioverter defibrillator, n (%)	3 (15.8%)
Prior hospitalization for heart failure, n (%)	4 (21.1%)
Tricuspid valve replacement or repair,[‡] n (%)	4 (21.1%)
Pulmonary hypertension, n (%)	3 (15.8%)

Normally distributed continuous variables are presented as mean (standard deviation).

ccTGA, congenitally corrected transposition of the great arteries; CHD, congenital heart disease.

*The associated heart lesions at birth are Ebstein-like anomaly of the tricuspid valve (n = 6), ventricular septal defect (n = 5), pulmonary or subpulmonary stenosis (n = 6), persistent superior left vena cava (n = 1), coarctation of the aorta (n = 1), and dextrocardia (n = 1). The groups are not inclusive.

[†]Two patients have cardiac resynchronisation therapy.

[‡]Surgical tricuspid valve replacement, tricuspid valve repair, and percutaneous tricuspid valve repair.

measurements of sRV wall thickness were highly variable with ICC < 0.

Qualitative parameters

The qualitative evaluation of sRV systolic function, dilatation and hypertrophy, and left ventricular subpulmonary systolic function showed poor interobserver agreement ICC between 0.067 and 0.364 (Table 5). However, for the intraobserver comparison of sRV systolic function and dilatation, intraobserver Kendall tau b varied from 0.408 to 0.843 corresponding to a fair to excellent agreement for the 5 observers (Table 6). There was complete intraobserver agreement for sRV hypertrophy, septal curvature, and subpulmonary left ventricular systolic function; therefore, the Kendall tau b correlation coefficient could not be calculated.

Discussion

Variability in qualitative and quantitative sRV evaluation

In this study of interobserver and intraobserver variability of quantitative and qualitative echocardiographic parameters for sRV size and systolic function, the main findings are as follows: (1) fair to excellent interobserver (ICC, 0.491-0.752, Table 3) and intraobserver correlations (ICC, 0.497-0.967, Table 4) for most quantitative parameters (sRV inlet and longitudinal diameters, systolic and diastolic area, FAC calculation); (2) very

strong intraobserver agreement for measurements of sRV end-diastolic and end-systolic areas, which are required to calculate FAC; (3) poor interobserver and intraobserver correlations for sRV wall thicknesses, which may reflect complexities introduced by extensive sRV trabecular hypertrophy; and (4) very poor interobserver agreement for the qualitative evaluation of sRV size, systolic function and hypertrophy, and subpulmonary left ventricular systolic function despite good intraobserver agreement. These findings suggest that an overall appreciation of sRV size and systolic function relies on variable interpretation of measurements by observers combined with individual judgement. They underscore the challenges of assessing and interpreting sRV systolic function and dilatation in these patients. They also raise the problem of inconsistent reporting

Table 3. Interobserver agreement for systemic right ventricular quantitative parameters

	CV (%)	Interobserver ICC (95% CI)
sRV basal diameter (mm)	9.976	0.491 (0.319-0.610)
sRV longitudinal diameter (mm)	8.078	0.639 (0.456-0.745)
sRV end-diastolic area (cm²)	11.390	0.697 (0.531-0.796)
sRV end-systolic area (cm²)	14.479	0.757 (0.559-0.846)
Fractional area change (%)	23.508	0.584 (0.406-0.692)
sRV subcostal wall thickness (mm)	22.339	−0.015 (−0.090 to 0.049)

CI, confidence interval; CV, coefficient of variation; ICC, intraclass correlation coefficient; sRV, systemic right ventricle. The ICC represents the absolute agreement.

Table 4. Intraobserver agreement for sRV quantitative parameters

Observer	Intraobservers ICC (95% CI)				
	I	II	III	IV	V
sRV basal diameter (mm)	0.683 (0.169-0.909)	0.704 (0.169-0.923)	0.619 (0.017-0.897)	0.642 (0.056-0.905)	0.705 (0.123-0.932)
sRV longitudinal diameter (mm)	0.759 (0.317-0.933)	0.800 (0.330-0.956)	0.600 (-0.063-0.903)	0.912 (0.684-0.979)	0.901 (0.618-0.979)
sRV end-diastolic area (cm^2)	0.759 (0.280-0.939)	0.938 (0.679-0.991)	0.949 (0.808-0.988)	0.955 (0.811-0.991)	0.908 (0.671-0.978)
sRV end-systolic area (cm^2)	0.805 (0.342-0.959)	0.946 (0.663-0.994)	0.929 (0.737-0.983)	0.967 (0.870-0.992)	0.890 (0.615-0.974)
Fractional area change (%)	0.133 (−0.593 to −0.763)	0.934 (0.595-0.993)	0.645 (0.0601-0.905)	0.630 (0.035-0.901)	0.497 (−0.158 to 0.857)

ICC, intraclass correlation coefficient; sRV, systemic right ventricle.

between serial TTE exams during longitudinal follow-up in an echocardiography laboratory with multiple observers, particularly when qualitative interpretation is relied upon.

To our knowledge, our study is the first to measure the reproducibility of sRV evaluation between more than 2 independent observers and to evaluate the agreement of qualitative assessment of sRV dilatation and systolic function, which is commonly used in clinical practice. Our CV for 6 observers is consistent with those reported for 2 observers. In one study, the 2 observers' CV ranges between 6% and 19% for FAC, TAPSE, S', RIMP, and dP/dt.[21] Another study reported an interobserver variability between 5.7% and 15.5% for FAC, dp/dt, TAPSE, S', and RIMP.[22]

Need for specific thresholds in the sRV evaluation

In clinical practice, we tend to apply guidelines published for the subpulmonary right ventricle (RV) to the sRV evaluation for lack of specific metrics.[14,15] The sRV bears similarities with the subpulmonary RV, but its adaptation to the systemic position also induces structural modifications. For example, the expected "normal" size of the sRV may be different; thresholds for "normal" diameters and areas are likely higher.[16,23] The guidelines highlight the importance of GLS and 3-dimensional (3-D) echocardiography for the subpulmonary RV.[14,15] An RV free wall GLS higher than −20% is associated with a worse prognosis in heart failure, myocardial infarction, hypertension, and amyloidosis; it also predicts RV failure after implantation of a left ventricular assist device.[14] For the sRV, poor echogenicity and substantial sRV dilatation may hamper GLS measurement. Iriart et al.[21] could not integrate the lateroapical and septoapical segments of the sRV in the GLS measurement in 80% of their patients. Chow et al.[24] reported very low interobserver (1.77%) and intraobserver (1.39%) variability for GLS measurements in 20 patients with TGA, but the study was limited to 2 observers with 2 consecutive measurements. In the subpulmonary RV, the longitudinal contraction represents the majority of contractile force; however, in the sRV, circumferential contraction increases at the expense of longitudinal contraction.[25] Circumferential strain exceeds longitudinal strain in the sRV free wall; on the contrary, strain in the interventricular septum is not different from the normal RV.[25] The sRV contraction pattern resembles that of the systemic left ventricle. This pattern could represent an adaptation to pressure overload[25] leading to decreased GLS in sRV compared with the subpulmonary RV. Therefore, a specific normal threshold is required for sRV strain analysis.[24,26] A GLS less than −16.7% correlates with an sRV ejection fraction > 45% by CMR imaging in patients with ccTGA.[13] Kalogeropoulos et al[27] proposed a threshold of −10% to predict heart failure and arrhythmias in patients

with TGA. In contrast to the subpulmonary RV, most studies measured the GLS integrating the free wall and interventricular septum of the sRV. Ladouceur et al.[28] reported a decrease of sRV GLS in patients with TGA patients with VO2 ≤ 64.5% mostly due to a significant decrease in interventricular septum longitudinal strain. Three-dimensional echocardiography remains difficult in adults when the dilated RV does not fit in the region of interest or analysis box.[29] Iriart et al.[12] proposed specific thresholds to define sRV systolic dysfunction based on prior studies, including TAPSE < 14 mm,[22] S' < 10 cm/s,[22] GLS > −10 to −14.5%,[24,27,30] FAC < 29.5%-33%,[22] 3-D ejection fraction < 45%.[29]

Toward a consistent and reproducible analysis of the sRV

Information on sRV size and systolic function is vital for clinical decision-making. Even in experienced echocardiography laboratories, imagers have access to limited objective tools to evaluate the sRV. Poor echogenicity, the need for special analysis software and time-consuming 3-D or GLS analyses further hamper echocardiographic sRV evaluation. Our study shows that a basic evaluation of diameters and areas is reproducible. The real problem remains the personal processing and interpretation performed by each observer, which leads to a qualitative assessment of sRV size and systolic function with poor reproducibility. Our study suggests that it is important to standardize the evaluation of the sRV between multiple observers to provide meaningful and coherent longitudinal follow-up. Standardization would require establishing clear thresholds for quantitative parameters and a validated algorithm to guide the multiparametric evaluation of sRV size and systolic function. At the very least, all quantitative measurements should be performed at each exam, listed in the final report, and compared with the previous exam. We also suggest that the sRV analysis and congenital heart diseases echocardiograms have to be performed by sonographers and cardiologists trained in ACHD and read by ACHD cardiologists with expertise in echocardiography to maximize the

Table 5. Interobserver agreement of for qualitative assessment

	Kappa values	P value
sRV function	0.253	< 0.001
sRV dilatation	0.128	< 0.001
sRV hypertrophy	0.067	0.184
Septal curvature	0.164	< 0.001
Subpulmonary LV function	0.364	0.002

LV, left ventricle; sRV, systemic right ventricle.

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Table 6. Intraobserver agreement for qualitative assessment

Observer	Intraobserver Kendall tau b				
	I	II	III	IV	V
sRV function	0.605	0.833	0.803	0.843	0.594
sRV dilatation	0.668	0.814	0.801	0.634	0.408

sRV, systemic right ventricle.

exposure and establish a more coherent longitudinal follow-up of the sRV.[31]

Study limitations

Although the statistical analysis took account of the missing data and values by removing the observer from the analysis for the corresponding echocardiographic assessment, the statistical power of the analysis could be reduced. Qualitative assessments were missing in less than 10% (only 1 missing assessment for sRV systolic function and sRV dilatation, and subpulmonary left ventricle systolic function in 2 observers), except for the septal curve assessment and the sRV hypertrophy measure for 1 observer (27% and 34%, respectively). Quantitative values were missing in less than 20% of the examinations, except for the sRV wall thickness, which was poorly measured probably linked to the absence of a subcostal view and poor echogenicity.

Because images were acquired before interpretation, each observer did not measure TAPSE, S', RIMP, and GLS but had to rely on previously stored measurements. Therefore, the variability of these parameters could not be assessed. The analysis software did not allow additional measurements of GLS, but poor echogenicity would have further limited its measurement in many patients. Of note, our practice is to review the clinical echocardiograms with the patient present, allowing the reading cardiologist to acquire additional images if needed. Therefore, stored exams contain the best obtainable images by both an experienced sonographer and an ACHD cardiologist. Thus, in the majority of cases, we are confident that stored measurements are clinically reliable.

Conclusions

Quantitative parameters of sRV size and systolic function have a good agreement between observers. Qualitative appreciation of sRV size and systolic function show good intraobserver agreement albeit with discordant results between observers. These findings suggest that an overall appreciation of sRV size and systolic function relies on variable interpretation of measurements by observers combined with individual judgement and experience. These findings support the notion of standardizing the echocardiographic evaluation of the sRV to improve reporting, particularly in large echocardiography practices with multiple observers. Emphasis should be made on simple measurements that do not rely heavily on observer experience. The establishment of clear thresholds for quantitative parameters and a validated algorithm to guide the evaluation of sRV size and systolic function would be welcomed both in clinical practice and in research.

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Disclosures

The authors have no conflicts of interest to disclose.

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