The Egyptian Journal of Hospital Medicine (July 2023) Vol. 92, Page 6790- 6795

Assessment of Right ventricular Systolic and Diastolic Function in Rheumatic Heart Disease in Suez Canal University Hospital

Islam Zakareya Mahmoud[1], Eslam Hassan ElGamal[2], Fathy Abdelhamid Maklady[1], Omar Mohamed Saleh[1].
[1]Department of Cardiovascular Medicine, Faculty of Medicine, Suez Canal University, Ismailia, Egypt
[2]Department of Cardiovascular Medicine, Ministry of Health, South Sini, Egypt
***Corresponding author:** Eslam Hassan ElGamal, **Mobile:** (+20) 1283672412, **E-mail:** is.7sn88@gmail.com

ABSTRACT

Background: Right ventricular (RV) dysfunction, despite its importance as a prognostic factor, has been underestimated in patients with rheumatic valvular disease. Early detection of RV functional changes may improve the outcome of patients particularly if detected in early stages of rheumatic heart disease (RHD) (mild to moderate).

Objective: To assess RV function in patients with early stages of RHD and in order to observe changes in RV function, we repeated the measurements (follow up) at 6 months form baseline.

Patients and methods: 50 consecutive patients with mild to moderate valvular RHD were enrolled in this study in which we assessed the RV systolic and diastolic functions, LA and RA volume and sPAP.

Results: In RHD patients with mild to moderate valvular lesion RV systolic function was normal by using different methods (TAPSE, RIMP, FAC and S' wave). TAPSE was normal at baseline & follow up with increase at follow up but with statistical insignificant difference. 2D FAC is normal at baseline & follow up with decrease at follow up but with statistically insignificant difference. RIMP showed impaired RV systolic function at baseline with mean of 0.73 ± 0.26 & at follow up with mean of 0.56 ± 0.14 with statistically significant decrease at follow up. S' wave showed normal RV systolic function at baseline (mean 14.32 ± 2.36) & follow up (mean 13.09 ± 1.48) with statistical significant decrease at follow up.

Conclusion: There is association between RV functions and degree of valve disease in patients with RHD.

Keywords: RHD, RV function, TAPSE, FAC.

INTRODUCTION

The long-term effect of acute rheumatic fever (ARF), RHD, continues to be a problem in middle- and low-income nations. RHD is thought to impact at least 15 million people globally. According to the WHO report on the programme for the prevention of rheumatic fever and rheumatic heart disease in 16 developing countries, they reported prevalence of rheumatic heart disease in school children in Egypt between 1986 and 1990 was 5.1 per 1000 people [(1)].

Studies conducted in hospitals have shed light on RHD complications and case fatalities, and they have calculated the prevalence of problems throughout a 24-month period of observation. New-onset heart failure (38 per 1,000 patient-years) was the most common, followed by stroke or transient ischemic attack (8.5 per 1,000 patient-years) and infective endocarditis (3.7 per 1,000 patient-years). Incidence of recurrent RF was 3.5 per 1,000 patient/years in this population, and frequent use of secondary prevention was not linked to improved results. The case fatality rate at 24 months was greatest in low-income nations (21%) and much lower in middle-income countries (12% to 17%). The median age at death was 28 years [(2)].

The right ventricle (RV) is situated behind the sternum and anterior to the left ventricle (LV), which may affect its particular morbidity and mortality but also make it potentially accessible to surface imaging techniques like transthoracic echocardiography. The peculiar crescent form, the uneven endocardial surface, the complicated contraction mechanism, and the placement of the RV make assessing right heart function challenging despite advances in echocardiography technology [(3)].

Almost generally, RHD primarily affects the mitral valve, while it is possible that other valves are also affected. Involvement of the aortic valve is seen in 20–30% of cases, and the tricuspid valve may also be impacted although less frequently. A few years to more than 20 years may pass between the first bout of rheumatic fever and the appearance of clinical signs of valve dysfunction [(4)].

Pure mitral regurgitation is the most frequent RHD presentation, and mitral valve regurgitation is the most prevalent valvular lesion in individuals with RHD, especially in the early stages [(5)].

In the past, the significance of RV function has been undervalued, particularly in light of its ability to predict cardiac symptoms and exercise tolerance in those with left heart valve disease. In a variety of clinical circumstances, estimation of right ventricular function can be used to forecast prognosis [(6)]. There is lack of data about RV functions in rheumatic heart disease patients, which may deteriorate. Early detection of functional changes that can happen in the right ventricle in early stages of RHD have not been studied to our knowledge. Thus, we aimed in this study to assess RV systolic and diastolic functions in early stages of RHD (i.e. mild and moderate RHD).

SUBJECTS AND METHODS

This prospective study enrolled 50 patients who were diagnosed to have mild to moderate valvular heart disease by echocardiogram according to the EAE\ASE

Received: 22/03/2023
Accepted: 21/05/2023

guidelines due to rheumatic heart disease in Cardiology Department Suez Canal University Hospital Patients.

Exclusion criteria: Patients who were below the age of 18, patients with concomitant coronary heart disease, atrial fibrillation, LV dilation with ejection fraction (EF) less than 50 percent, severe RHD, prosthetic valve, and non-rheumatic valvular disease (congenital, degenerative and ischemic).

All participants were evaluated at baseline, the beginning of the study and after six months.

Methods:

A) Echocardiographic assessment:

- Trans-thoracic echocardiography was performed for all subjects included in the study in the standard technique using four standard positions (Parasternal, apical, subcostal and suprasternal positions) by Phillips Epiq 7 Echo Machine including LV dimensions, LV systolic function parameters, RV systolic function (TAPSE , RIMP , 2D FAC & Lateral S' wave velocity).
- Left atrium volume & functions: From the 4-chamber and 2-chamber perspectives at the apex. To avoid foreshortening the atrium, much care was used when taking the photos. Biplane planimetry was used to measure the LA_{max} and LA minimum volume (LA_{min}). Pulmonary veins were not included in the LA tracing, and the mitral annulus' plane served as a proxy for the LV cavity's edge. Measurements were taken at the end of systole from the frame before mitral valve opening for LA_{max}, the first frame following mitral valve closure for LA_{min}, and LA preA, which is tracing LA before P wave on ECG [(7)].
- RA volume (Single plane): Tracing the RA inner boundary omitting the area under the TV annulus from an apical 4 chamber view that contains the whole RA and was not foreshortened (dedicated right heart view) [(8)].
- Systolic PAP (sPAP): by assessment of TR velocity & IVC size & collapsibility [(9)].

Ethical approval

Every instance shared in the research required written consent. Any patient who was contemplating participating in this study was given a thorough explanation of all the test stages, provided in a way that they could comprehend. The Suez Canal University Ethical Committee Council gave their approval to the study. The Helsinki Declaration was followed throughout the study's conduct.

Statistical analysis

SPSS version 25 was used to enter and analyse the gathered data. For categorical variables, the frequencies and percentage distributions for each variable were determined, and the Chi square test was used to determine the degree of significance. Continuous variables were given as mean ± standard deviation for normally distributed data and as median with standard error of mean for skewed data, and the Man-Whitney test was used to compare them.

Linear regression analysis was utilised to examine confounders and determine the effect of illness on RV function. P values were computed, and values ≤ were deemed statistically significant.

RESULTS

Table (1) described demographic characteristics of the patients. Females represented 84% of the study participants and males represented 16%.

The mean age was 44.46 years, it ranged from 20 to 66 years. Patients presented with mitral stenosis (82%) and mitral regurge (86%). While 54% had aortic regurge and 28% had tricuspid regurge. Single valve were 12%, double valve were 40% & triple valve were the most of cases (48%). Concerning RHD severity, 30% of cases were mild and 70% were moderate cases.

Table (1): Distribution of the studied cases according to Basic data of patients (n = 50)

	No.	%
Gender		
Male	8	16.0
Female	42	84.0
Age (years)		
Mean ± SD.	44.66 ± 8.94	
HTN	26	52.0
DM	8	16.0
Smoking	7	14.0
Shortness of breath	50	100.0
Lung disease	0	0.0
CKD	0	0.0
Stroke	0	0.0
NYHA classification		
I	22	44.0
II	22	44.0
III	6	12.0
Medication		
B Blockers		
Baseline	15	30.0
Follow up	17	34.0
Antihypertensive Rx	25	50.0
Antidiabetic Rx	8	16.0
RHD severity		
Mild	15	30
Moderate	35	70
Valve affected.		
Single valve	6	12
Double valve	20	40
Trible valve	24	48

LA volume & functions parameters follow-up results showed insignificant differences at baseline and

after follow-up except for LA passive EF, which increased at follow up with statistical significant difference. TAPSE and 2D FAC values were normal at baseline and follow up.

RIMP showed impaired RV function at baseline and follow up (0.73 ± 0.26 and 0.56 ± 0.14 respectively). S' wave showed normal RV systolic function at baseline and follow up (14.32 ± 2.36 and 13.09 ± 1.48 respectively).

E/A ratio increased at follow up but with statistical insignificant differences. Deceleration time increased numerically, which may indicate deterioration in diastolic function but with statistical insignificant differences. E/e' ratio decreased at follow up with statistically significant difference. IVC size statistically raised significantly at follow up.

RA major and minor diameters increased significantly at follow-up. Group with RV diastolic dysfunction had lower RA major and minor measurements than normal group at baseline & follow up with statistical insignificant differences regarding RA Major & with statistical significant decrease in RA Minor (Table 2).

Baseline & follow up with systolic & diastolic RV functions in Mitral stenosis in which there was statistical significant increase regarding TAPSE, IVC size in follow up, statistical significant decrease S wave , RIMP & E/e' ratio in follow up & statistical insignificant regarding 2D FAC , E/A ratio & deceleration time in follow up (Table 3).

Table (2): Comparison between baseline and follow up according to ECHO parameters.

	Baseline	**Follow up**	**P**
LA max	94.45 ± 28.27	97.65 ± 30.09	0.186
LA min	56.28 ± 19.79	57.84 ± 21.78	0.321
LA pre A	72.68 ± 22.93	71.41 ± 23.46	0.504
LA Total EF (%)	40.73 ± 8.13	41.46 ± 8.42	0.588
LA active EF (%)	22.58 ± 8.90	25.91 ± 13.36	0.128
LA passive EF (%)	23.13 ± 8.77	26.98 ± 7.83	0.013*
TAPSE (cm)	2.25 ± 0.26	2.32 ± 0.27	0.061
2D FAC	47.11 ± 5.67	46.97 ± 5.25	0.895
RIMP	0.73 ± 0.26	0.56 ± 0.14	<0.001*
S' wave	14.32 ± 2.36	13.09 ± 1.48	<0.001*
E/A ratio	1.07 ± 0.30	1.14 ± 0.37	0.203
Deceleration time	253.52 ± 84.11	270.10 ± 47.86	0.233
E/e' ratio	3.61 ± 1.36	3.33 ± 1.28	0.003*
IVC size (cm)	1.48 ± 0.20	1.62 ± 0.14	<0.001*
RA Major diameter (mm)	51.0 ± 7.16	52.63 ± 6.77	0.032*
RA Minor diameter (mm)	34.91 ± 5.87	38.43 ± 5.47	<0.001*

p: p value for **Paired t-test** for comparing between **Baseline** and **Follow up.** *: Statistically significant at $p \leq 0.05$

Table (3): Relation between mitral stenosis with LV and RV ECHO parameters in each period (n = 41)

	Baseline			Follow up			p_0
	Mild (n = 29)	Moderate (n = 12)	p	Mild (n = 29)	Moderate (n = 12)	P	
TAPSE (cm)	2.24 ± 0.20	2.07 ± 0.12	0.002	2.34 ± 0.30	2.20 ± 0.18	0.071	0.017*
2D FAC	48.26 ± 5.54	45.46 ± 6.02	0.159	47.66 ± 5.16	44.38 ± 5.67	0.080	0.541
RIMP	0.71 ± 0.27	0.74 ± 0.28	0.769	0.56 ± 0.11	0.61 ± 0.15	0.249	0.001*
S' wave	14.53 ± 2.32	14.53 ± 2.82	0.995	13.17 ± 1.01	13.0 ± 2.45	0.825	<0.001*
E/A ratio	1.03 ± 0.34	1.06 ± 0.14	0.753	1.05 ± 0.33	1.34 ± 0.45	0.028*	0.077
Deceleration time	275.8 ± 70.47	198.7 ± 77.59	0.004*	267.69±40.08	273.42±60.68	0.723	0.268
E/e' ratio	3.54 ± 1.43	3.67 ± 1.23	0.798	3.41 ± 1.34	3.21 ± 1.30	0.656	0.028*
IVC size	1.48 ± 0.17	1.48 ± 0.17	0.931	1.61 ± 0.12	1.61 ± 0.09	0.959	<0.001*
LA max	99.31 ± 28.13	87.13 ± 21.96	0.189	101.15 ± 31.65	99.26 ± 29.12	0.860	0.067
LA min	59.72 ± 22.27	55.78 ± 14.92	0.578	59.16 ± 22.40	61.73 ± 24.07	0.746	0.463
LA pre A	75.77 ± 22.81	73.18 ± 19.32	0.731	73.68 ± 23.69	75.15 ± 26.02	0.861	0.649
LA Total EF (%)	41.01 ± 7.21	35.62 ± 8.60	0.046*	42.30 ± 9.41	38.69 ± 7.27	0.242	0.241
LA active EF (%)	22.14 ± 9.04	23.39 ± 8.51	0.684	27.88 ± 16.23	23.24 ± 8.64	0.357	0.117
LA passive EF (%)	23.87 ± 7.45	15.97 ± 7.83	0.004*	27.10 ± 9.02	24.93 ± 5.30	0.442	0.004*
RA Major	52.70 ± 8.42	50.99 ± 1.91	0.309	54.41 ± 7.44	51.47 ± 4.42	0.126	0.114
RA Minor	35.36 ± 6.85	33.53 ± 3.17	0.385	39.47 ± 5.89	36.33 ± 4.06	0.101	<0.001*
PAP	25.55 ± 9.03	26.92 ± 7.39	0.646	26.03 ± 8.17	24.58 ± 6.56	0.588	0.645
RV mid	28.07 ± 2.14	28.08 ± 1.98	0.984	28.12 ± 2.19	28.21 ± 2.23	0.906	0.877

p: p value for **Student t-test** for comparing between **Mild** and **Moderate** p0: p value for **Paired t-test** for comparing between **Baseline** and **Follow up,** *: Statistically significant at $p \leq 0.05$

Concerning LA volumes & functions, RA volume, PAP & RV Mid in mitral stenosis at baseline & follow up, there was statistically insignificant difference regarding LA volume, LA total EF, LA active EF, RA major, PAP & RV Mid. There was statistical significant increase regarding LA passive EF at follow up & statistically significant increase regarding RA minor at follow up (Table 4). Regarding baseline & follow up with systolic & diastolic RV functions in mitral regurge, there was statistical significant increase regarding TAPSE & IVC size in follow up, statistical significant decrease of RIMP , S' wave and E/e' ratio in follow up & statistical insignificant difference regarding 2D FAC, E/A ratio & deceleration time in follow up. Univariate regression analysis regarding independent variables affecting TAPSE showed that there was statistical significant decrease in TAPSE with mitral valve disease. Regarding independent variables affecting 2D FAC, there was statistical significant decrease in FAC with TR. RIMP showed that there was statistical significant increase in RIMP with age. S' wave showed that there was statistical significant increase of S' wave with age. E/A ratio showed that there was no statistical significant difference in E/A ratio regarding all independent variables. E/e' ratio showed that there was statistical significant increase in E/e' ratio with hypertension (Table 4).

Table (4): Relation between mitral regurge with RV systolic function and RV diastolic function ECHO parameters in each period (n = 43)

	Mitral regurge						
	Baseline			Follow up			p_0
	Mild (n = 22)	Moderate (n = 21)	p	Mild (n = 22)	Moderate (n = 21)	p	
TAPSE (cm)	2.13 ± 0.20	2.28 ± 0.20	0.025*	2.30 ± 0.30	2.28 ± 0.19	0.809	0.038*
2D FAC	49.16 ± 4.21	46.81 ± 6.42	0.167	47.10 ± 4.66	45.98 ± 5.81	0.487	0.160
RIMP	0.66 ± 0.24	0.69 ± 0.21	0.701	0.54 ± 0.10	0.56 ± 0.16	0.604	0.001*
S' wave	13.91 ± 2.79	14.60 ± 1.83	0.348	12.85 ± 1.21	13.14 ± 1.28	0.452	0.001*
E/A ratio	1.09 ± 0.34	1.06 ± 0.27	0.755	1.13 ± 0.47	1.12 ± 0.28	0.947	0.343
Deceleration time	268.0 ± 63.61	260.7 ± 105.8	0.787	272.0 ± 39.10	261.95±54.48	0.490	0.856
E/e' ratio	3.81 ± 1.56	3.55 ± 1.23	0.547	3.70 ± 1.57	3.03 ± 0.89	0.094	0.002*
IVC size	1.47 ± 0.16	1.50 ± 0.27	0.634	1.63 ± 0.10	1.63 ± 0.18	0.977	<0.001*

p: p value for **Student t-test** for comparing between **Mild** and **Moderate** p0: p value for **Paired t-test** for comparing between **Baseline** and **Follow up,** *: Statistically significant at $p \leq 0.05$

DISCUSSION

Received: 22/03/2023
Accepted: 21/05/2023

This study aimed to assess RV systolic and diastolic functions, also to assess LA volumes & functions and RA volume in rheumatic heart disease patients with mild to moderate valvular lesions. Females represented 84% of the study participants and males represented 16%. This comes in agreement with recent study which found that RHD is more prevalent among females with a relative risk of 1.6 to 2.0 compared to males [10].

In the present study, most of patients presented with mitral regurge (86%), mitral stenosis (82%). While, 54% had aortic regurge and 28% had tricuspid regurge. Regarding valve affected, 12 % were single, 40% were double valve & 48% were triple valve. Regarding RHD severity, 30% of cases were mild and 70% were moderate cases.

Regarding left ventricular assessment, we found that patients had mean LVEDD of 4.82 ± 0.69 cm, LVESD of 3.03 ± 0.47 cm, EF of 66.60% ± 6.21% and FS of 36.46% ± 6.15%, which indicated normal left ventricular dimensions. This is expected since we assessed subjects with mild and moderate valvular affection and excluding severe affection. While, in another study the majority of cases of mitral stenosis (1119/1535, 72.9%), mitral regurgitation (1479/2464, 60.4%), pulmonary stenosis (19/32, 59.4%), tricuspid stenosis (58/107, 54.2%), and aortic stenosis (187/302, 61.9%) had moderate-to-severe disease, whereas the majority of cases of aortic regurgitation (922/1671, 55.2%) were mild. The LV was dilated in 23% (n = 581) of adults and 16.4% (n = 413) of children with native valve disease, while the ejection fraction was lowered in 18.3% (n = 460) of adults and 5.6% (n = 140) of children. There was a gradient as patients got older for dilated LV (P<0.0001) and declining LVEF (P<0.0001), indicating disease progression [11].

As regards left atrium, this study found that LA volume & functions parameters follow-up results showed insignificant differences at baseline and after follow-up except for LA passive EF, which increased at follow up with statistical significant differences.

Another study was done on autopsy samples from the National Cerebral and Cardiovascular Centre Autopsy Archives were obtained from successive RHD victims from 2002 to 2014 (RHD group, n = 5) and from AF subjects without RHD (non-RHD group, n = 5) who were matched for age, sex, and LA diameter. The results of the investigation demonstrated significantly greater numbers of immunocompetent cells, including various phenotypic subgroups of DCs, in RHD patients compared to non-RHD patients. This was true for both LA tissues acquired from RHD patients and those obtained from LA size matched non-RHD patients. This data shows that LA remodeling in RHD might be connected with RHD-derived remodeling rather than hemodynamic-related stress [12].

Regarding RV systolic function assessment, our study found that TAPSE was normal at baseline & follow up with increase at follow up, but with statistical insignificant difference. 2D FAC was normal at baseline & follow up with decrease at follow up but with statistically insignificant difference. RIMP showed impaired RV systolic function at baseline with mean of 0.73 ± 0.26. This high result of RIMP at baseline study although indicating RV systolic dysfunction, may be due to lack of experience measuring RIMP at baseline study & abnormal RV systolic function at follow up with mean of 0.56 ± 0.14 with statistical significant decrease at follow up. In another research, the majority of patients showed normal RV systolic function (RVEF 3D 44%), although there were a considerable number of patients with RV dysfunction (n = 14; 27.4%). Despite an increase in the median values of PASP (40 mmHg (30-54)), related to the advanced stage of the illness in these individuals, the mean values of conventional RV function parameters (TAPSE, PSV, FAC) and 2DS parameters (RVFWS, RVGS) remained normal considering the whole study group [13]. As was previously demonstrated by another author **Kong *et al.*** [14] (97%), in the whole group of people with RHD, the mean values of TAPSE, FAC, and EF were normal. While, in **Shiba *et al.*** [12] study where patients are divided into two groups according to their RVEF by 3DE, with patients with RVEF ≥ 44% being considered to have maintained function (A) and patients with RVEF < 44% being considered to have RV systolic dysfunction (B). 14 patients (27.4%) were determined to have RV dysfunction overall in the research. There were significant differences between the groups for all measures, including PSV (p = 0.005), TAPSE (p < 0.001), FAC (p< 0.001), PASP (p< 0.001), RVFWS (p< 0.001), and RFGS (p< 0.001). This might be related to the variation in sample size and follow-up period.

As regards RV diastolic function assessment, this study found that E/A ratio increased at follow up but with statistical insignificant differences. Declaration time increased, which indicated deterioration in diastolic function but with statistical insignificant differences. E/e' ratio showed decrease at follow up with statistically significant difference. At the follow-up, IVC size increased with a statistically significant difference. 8 cases showed E/A ratio less than 0.8 at baseline, while 9 cases showed E/A ratio less than 0.8 at follow up, showing DD grade I. There is lack of studies evaluating RV diastolic function in RHD.

As regards RA volume assessment, this study found that RA major & RA Minor showed significant increase at follow-up. And group with RV diastolic dysfunction assessed by E/A ratio had lower RA major and minor measurements than normal group at baseline & follow up with statistical insignificant differences regarding RA major & with statistical significant decrease in RA minor.

CONCLUSION

- In RHD patients with mild to moderate valvular lesion TAPSE, RIMP, FAC and S' wave showed

significant differences in detecting RV systolic dysfunction.

- TAPSE was normal at baseline & follow up with increase at follow up but with statistical insignificant difference.
- 2D FAC was normal at baseline & follow up with decrease at follow up but with statistically insignificant difference.
- RIMP showed impaired RV systolic function at baseline & at follow up with statistically significant decrease at follow up.
- S' wave showed normal RV systolic function at baseline & follow up with statistical significant decrease at follow up.

- In RHD patients with mild to moderate valvular lesion, E/A ratio, deceleration time, E/e' ratio & IVC size showed significant differences in detecting RV diastolic dysfunction.
- In RHD patients with mild to moderate valvular lesion, RV diastolic function assessed by E/A ratio, 8 cases out of 50 cases showed diastolic dysfunction grade I with E/A ratio less than 0.8 at baseline study while 9 cases showed RV diastolic dysfunction grade I at follow up.
- Declaration time increased at follow up, which indicated deterioration in RV diastolic function.
- In RHD patients with mild to moderate valvular lesion, LA volumes & functions, there was no difference between baseline & follow up except for La passive EF, which increased at follow up.
- In RHD patients with mild to moderate valvular lesion, RA volume showed significant increase at follow up.
- In RHD patients with mild to moderate valvular lesion who had RV diastolic dysfunction, RA minor showed a statistical significant decrease in comparison with those who had normal diastolic function in both baseline and follow up studies.

- **Sponsoring financially:** Nil.
- **Competing interests:** Nil.

REFERENCES

1. **WHO (2001):** Rheumatic Fever and Rheumatic Heart Disease: Report of a WHO expert Consultation, Geneva, 29 October-1 November, 2001. World Health Organization, Pp: 122. https://apps.who.int/iris/handle/10665/42898
2. **Watkins D, Johnson C, Colquhoun S *et al.* (2017):** Global, Regional, and National Burden of Rheumatic Heart Disease, 1990–2015. N Engl J Med., 377 (8): 713–22.
3. **Pande S, Agarwal S, Dhir U *et al.* (2009):** Pulmonary arterial hypertension in rheumatic mitral stenosis: does it affect right ventricular function and outcome after mitral valve replacement?☆. Interact Cardiovasc Thorac Surg., 9 (3): 421–5.
4. **Zuhlke L, Engel M, Karthikeyan G *et al.* (2015):** Characteristics, complications, and gaps in evidence based interventions in Rheumatic heart disease : the Global Rheumatic Heart Disease Registry (the REMEDY study). Eur Heart J., 36: 1115–22**.**
5. **Engelman D, Mataika R, Kee M *et al.* (2017):** Clinical outcomes for young people with screening-detected and clinically-diagnosed rheumatic heart disease in Fiji. Int J Cardiol., 240: 422–7.
6. **Jurcut R, Giusca S, LaGerche A *et al.* (2010):** The echocardiographic assessment of the right ventricle: what to do in 2010?. Eur J Echocardiogr., 11: 81-96.
7. **Hoit B (2014):** Left Atrial Size and Function. J Am Coll Cardiol., 63 (6): 493–505.
8. **Lang R, Badano L, Mor-Avi V *et al.* (2015):** Recommendations for cardiac chamber quantification by echocardiography in adults: An update from the American society of echocardiography and the European association of cardiovascular imaging. Eur Heart J Cardiovasc Imaging, 16 (3): 233–71.
9. **Ilieșiu A, Hodorogea A, Balahura A *et al.* (2022):** Non-Invasive Assessment of Congestion by Cardiovascular and Pulmonary Ultrasound and Biomarkers in Heart Failure. Diagnostics, 12 (4): 962-66.
10. **Negi P, Kandoria A, Asotra S *et al.* (2020):** Gender differences in the epidemiology of Rheumatic Fever/Rheumatic heart disease (RF/RHD) patient population of hill state of northern India; 9 years prospective hospital based, HP-RHD registry. Indian Heart J., 72 (6): 552–56.
11. **Zühlke L, Karthikeyan G, Engel M *et al.* (2016):** Clinical outcomes in 3343 children and adults with rheumatic heart disease from 14 low-and middle-income countries: two-year follow-up of the Global Rheumatic Heart Disease Registry (the REMEDY Study). Circulation, 134 (19): 1456–66.
12. **Shiba M, Sugano Y, Ikeda Y *et al.* (2018):** Presence of increased inflammatory infiltrates accompanied by activated dendritic cells in the left atrium in rheumatic heart disease. PloS One, 13 (9): e0203756. doi: 10.1371/journal.pone.0203756.
13. **Felix A, Siciliano A, Belém L *et al.* (2018):** Echocardiographic Assessment of Right Ventricular Function by Two-Dimensional Strain In Patients with Left-Sided Valvular Heart Disease: Comparison with Three-Dimensional Echocardiography. International Journal of Cardiovascular Sciences, 31: 630-642.
14. **Kong D, Shu X, Dong L *et al.* (2013):** Right ventricular regional systolic function and dyssynchrony in patients with pulmonary hypertension evaluated by three-dimensional echocardiography. J Am Soc Echocardiogr., 26 (6): 649–56.