ASIAN JOURNAL OF PHARMACEUTICAL AND CLINICAL RESEARCH

INNOVARE ACADEMIC SCIENCES
Knowledge to Innovation

Vol 17, Issue 6, 2024

Online - 2455-3891
Print - 0974-2441

Research Article

A STUDY ON ASSESSMENT OF RIGHT VENTRICULAR FUNCTION BY RIGHT VENTRICULAR OUTFLOW TRACT SYSTOLIC EXCURSION IN ADULT POPULATION ATTENDING A TERTIARY CARE HOSPITAL IN EASTERN INDIA

KAPIL KANT TRIPATHI[1], ANURAG JAIN[2], VISHAL SHRIVASTAVA[3], DILEEP DANDOTIYA[4]*

[1]Department of Cardiology, RK Cardio and Gastro Clinic, Bhopal, Madhya Pradesh, India. [2]Department of Medicine, BMC, Sagar, Madhya Pradesh, India. [3]Department of Pediatrics, PCMS and RC, Bhopal, Madhya Pradesh, India. [4]Department of Community Medicine, CIMS, Chhindwara, Madhya Pradesh, India.
***Corresponding author: Dileep Dandotiya; Email: dr.dileep85@gmail.com**

Received: 29 March 2024, Revised and Accepted: 11 May 2024

ABSTRACT

Objectives: The objectives of the study are as follows:

(1) to assess the right ventricular function (RVF) by right ventricle outflow tract systolic excursion through M-mode echocardiography and (2) to correlate the right ventricle outflow tract systolic excursion value with other 2D echocardiographic methods of RVF assessment.

Methods: The present observational prospective study was conducted in the department of cardiology, Apollo Multispeciality Hospital, Kolkata, among patients visiting the cardiology outpatient department and inpatient department from August 2021 to August 2022 to assess the RVF by right ventricle outflow tract systolic excursion through M-mode echocardiography and correlate the results with other methods (tricuspid annulus plane systolic excursion, tissue Doppler imaging, pulmonary artery pressure, fractional area change [FAC]) of RVF assessment.

Results: Majority of the patients in both groups belong to the age group of 51–60 years (45.5%), followed by 61–70 years (29.5%) and 41–50 years (20.5%). Patients with right ventricular (RV) dysfunction were more aged as compared to normal RVF. The mean body mass index (BMI) was significantly higher and mean hemoglobin level was significantly lower in patients with RV dysfunction as compared to the control group ($p<0.05$). Both systolic and diastolic blood pressures were significantly higher among the patient group than in the control group ($p<0.05$). We found that right ventricular outflow tract systolic excursion (RVOT-SE), tricuspid annular plane systolic excursion (TAPSE), tissue Doppler myocardial performance index, left ventricular (LV) ejection fraction (%), and FAC were significantly lower among patient group than control group ($p<0.01$). TAPSE ≤17 mm was the best cutoff value that differentiates patients with RV systolic dysfunction from healthy individuals with normal RV systolic function. There were 67% of patients with ≤17 mm and 33% had >17 mm TAPSE.

Conclusion: Our study concludes that RVOT-SE is a highly sensitive and specific method for diagnosing reduced RV systolic function patients. RVOT SE is not accurate as a sole parameter, but its high values can be used as an indicator for normal RV systolic function. It is simple to get, requiring one easy and reproducible M-Mode measurement from the parasternal short-axis view.

Keywords: Right ventricular outflow tract systolic excursion, Right ventricular function, Systolic function, Tricuspid annular plane systolic excursion.

 DOI: http://dx.doi.org/10.22159/ajpcr.2024v17i6.51373. Journal homepage: https://innovareacademics.in/journals/index.php/ajpcr

INTRODUCTION

Right ventricular function (RVF) plays an integral role in determining the exercise capacity of any individual. In numerous other cardiac and pulmonary disorders, it also plays a predictive function. In individuals with left-sided heart failure (HF), valvular heart disease, congenital heart disease, and coronary artery disease, right ventricular (RV) function may be compromised. Chronic left HF is the most frequent cause of right HF. Earlier, the importance of RV function was underestimated, but now its importance in prognostication of cardiac and pulmonary diseases has been realized [1].

Any cardiovascular or pulmonary condition that reduces the RV's capacity to accommodate or pump blood may cause RV failure. Main clinical signs of RV failure are:

(1) Fluid retention, which can cause tiredness, ascites, and peripheral edema;
(2) Diminished systolic reserve or low cardiac output.

On the other hand, RV dysfunction describes irregularities in filling or contraction, either with or without HF signs or symptoms. Therefore, RVF assessment becomes crucial for patients with these serious illnesses to manage them effectively [2]. Cardiac magnetic resonance imaging (MRI) is considered the gold standard for RVF assessment; however, it is not easily accessible at all centers as well as is cost ineffective. Therefore, it was needed to device numerous methods by 2D echocardiography to assess RVF as it is an easily available and non-invasive modality. The 2D echocardiography methods are tricuspid annular plane systolic excursion (TAPSE), fractional area change (FAC), myocardial performance index (MPI), tissue Doppler systolic velocity of TV lateral annulus, visual estimation of RV free wall, and tricuspid valve annular motion [3] At present, all these methods are currently being used for RVF assessment but each of them has its own limitations. There is interobserver variation as well as decreased reproducibility in all the methods mentioned above. RV outflow tract systolic excursion (RVOT-SE) is one such innovative technique. It is described as a systolic excursion of the front wall of the right ventricle's outflow tract. The RVOT is acquired at the level of the aortic valve using M-mode echocardiography in the parasternal short-axis view, with the ultrasound transducer beam falling perpendicular to the RVOT walls. RVOT-SE typically has a value of >6 mm [4]. There are less studies on the assessment of RVF by RVOT-SE. This study is done to study the assessment of RVF by RVOT-SE in adult population attending a tertiary care hospital in eastern India.

Objectives

The objectives of the study are as follows:
1. To assess the RVF by right ventricle outflow tract systolic excursion through M-mode echocardiography
2. To correlate the right ventricle outflow tract systolic excursion value with other 2D echocardiographic methods of RVF assessment (tricuspid annulus plane systolic excursion, MPI, pulmonary artery pressure, FAC).

METHODS

This study was conducted in the department of cardiology, Apollo Hospital, Kolkata, during the period of August 2021-August 2022 on patients visiting Apollo hospital, Kolkata, for echocardiography who are above 18 years of age with normal sinus rhythm. A total of 200 patients enrolled in this study were divided into normal and reduced groups based on their RVF

Inclusion criteria

All patients coming to Apollo Multispeciality Hospital, Kolkata, for echocardiography who were above 18 years of age with normal sinus rhythm.

Exclusion criteria

The following criteria were excluded from the study:
- Patients with valvular heart disease and congenital heart disease
- Patients with pericardial effusion and cardiac tamponade
- Patients of carcinoma lung or atrial myxoma
- Patients with orthotopic heart transplant
- Patients with atrial fibrillation.

Sample size

Size was calculated by the formula for estimating sensitivity and specificity using statistical software nMaster 2.0. A sample of 73 RV dysfunction cases in 73 normal RV function subjects was required to detect 95% sensitivity and 95% specificity with 5% precision and 95% sample confidence interval.

Ethical issues

This study was conducted after obtaining the necessary approval from the institutional ethics committee. Appropriate informed consent was taken from the participants of study.

Methodology

1. Proper medical history of the patient including present history, history, and family history was noted in a pro forma
2. Physical examination was done and relevant findings were recorded
3. Clinical findings at the time of diagnosis were recorded
4. Transthoracic echocardiography was done by Phillips IE33, with S 1-5 MHZ transducer, and all basic parameters in addition to parameters in question (RVOT-SE, TAPSE, FAC, tissue Doppler MPI, pulmonary artery pressure) in this study were recorded using standard views and techniques according to the guidelines. RVOT-SE was measured in parasternal short-axis view in M-mode at the level of the aortic valve. RVOT-SE was defined as systolic excursion of the endocardial surface of the anterior wall of RVOT relative to transducer
5. FAC was measured in four-chamber view by recording the RV area at the end of systole and diastole. FAC was calculated using the formula: FAC%=(diastolic RV area − systolic RV area)/diastolic RV area × 100. Similarly, TAPSE and tissue Doppler imaging were performed in four-chamber view at the lateral tricuspid annulus. Pulmonary artery pressure was measured using tricuspid regurgitation peak velocity and right atrial pressure
6. Calculation of RV MPI.

Data analysis

All the data analysis was performed by IBM Statistical Package for the Social Sciences version 20 software. Continuous variables were expressed as mean±standard deviation or median (Min – Max) as appropriate and categorical variables were expressed as the number of patients and percentage of patients. Pearson's Chi-square test for independence of attributes/Fisher's exact test was used to find the association between the categorical variables as appropriate. The p-value of and <0.05 was considered statistically significant.

Table 1: Comparing age distribution between groups

Variables	Group		Total	p
	Normal	RV dysfunction		
Age of patients				
≤40				
Count	5	4	9	0.001
Percentage	5.0	4.0	4.5	
41–50				
Count	30	11	41	
Percentage	30.0	11.0	20.5	
51–60				
Count	46	45	91	
Percentage	46.0	45.0	45.5	
61–70				
Count	19	40	59	
Percentage	19.0	40.0	29.5	

RV: Right ventricular

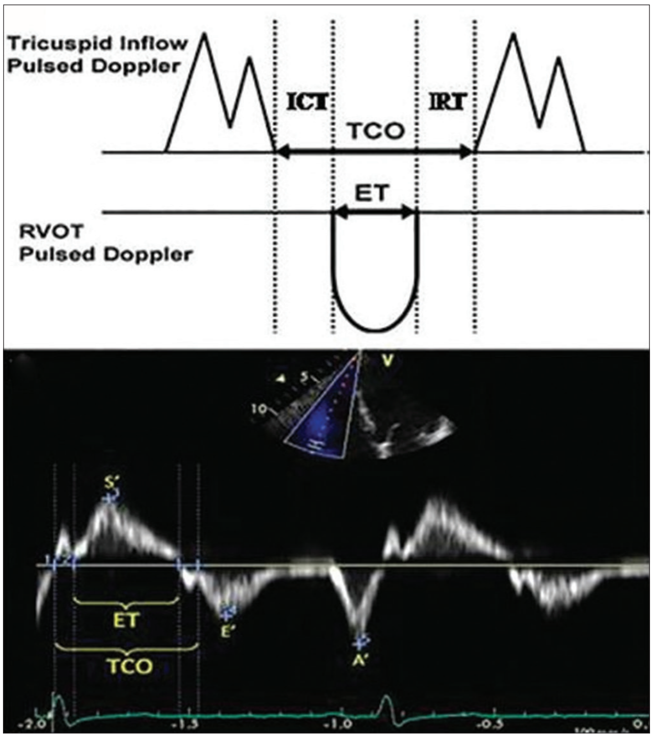

Fig. 1: Calculation of right ventricular myocardial performance index (Tei Index). Time intervals measured from pulsed tissue Doppler were obtained from the lateral tricuspid annulus (Abtahi 2016)

OBSERVATIONS AND RESULTS

A total of 200 patients enrolled in this study were divided into normal and reduced groups based on their RVF. Majority of the patients in both groups belong to the age group of 51–60 years (45.5%), followed by 61–70 years (29.5%), 41–50 years (20.5%), and <40 years (4.5%). Patients with reduced RV function were more aged as compared to normal RV function (Fig. 1) and (Tables 1,2,4 and 5).

The mean age within the control group was 53.81±6.9 years while it was 57.98±7.7 years in the patient group, with a significant difference

Table 2: Comparing different patient characteristics

Patient characteristics	Group						p-value
	Normal		RV dysfunction		Total		
	Mean	SD	Mean	SD	Mean	SD	
Age	53.81	6.926	57.98	7.754	55.90	7.625	<0.001
BMI	24.41	2.511	27.10	2.773	25.76	2.963	<0.001
SBP	129.78	29.017	136.50	15.000	133.14	23.285	0.041
DBP	80.00	8.989	83.90	9.629	81.95	9.495	0.001
Hb	13.472	1.1503	11.451	1.0128	12.461	1.4815	<0.001

BMI: Body mass index, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, Hb: Hemoglobin, SD: Standard deviation, RV: Right ventricular

between them (p>0.05). The mean BMI was significantly higher and the mean hemoglobin level was significantly lower in patients with reduced RV function as compared to the control group (p<0.05). Both systolic and diastolic blood pressures were significantly higher among the patient group than in the control group (p<0.05).

The number of patients with past and family history of the disease and clinical symptoms pedal edema, shortness of breath, abdominal distension, and chest pain were significantly higher in the reduced RV function group as compared to the control group (p<0.05).

All measured left ventricular (LV) echocardiographic parameters were significantly different between both groups as shown in Table 3. As expected, echocardiographic parameters of RV function left atrial diameter, aortic root diameter, RV area systolic, pulmonary artery pressure, IV septal thickness, LV diameter diastole and systole, and posterior wall thickness were significantly higher in patients with reduced RV function as compared to control group (p<0.01). We found that RVOT-SE, TAPSE, tissue Doppler MPI, LV ejection fraction (%), FAC, RV area diastolic, and mid-cavity internal diameter were significantly lower among the patient group than the control group (p<0.01).

Right ventricular outflow tract fractional shortening (RVOT FS) ≤17 mm was the best cutoff value that differentiates patients with RV systolic dysfunction from healthy individuals with normal RV systolic function. There were 67% of patients with ≤17 mm and 33% had >17 mm TAPSE.

Table 3: Comparing history and symptoms

Parameters	Group		p
	Normal	RV dysfunction	
History			
Count	17	37	0.001
Percentage	17.0	37.0	
Family history			
Count	4	39	<0.001
Percentage	4.0	39.0	
Pedal edema			
Count	0	53	<0.001
Percentage	0.0	53.0	
Shortness of breath			
Count	0	81	<0.001
Percentage	0.0	81.0	
Abdominal distension			
Count	5	61	<0.001
Percentage	5.0	61.0	
Chest pain			
Count	22	67	<0.001
Percentage	22.0	67.0	

RV: Right ventricular

DISCUSSION

Echocardiographic assessment of the right side of the heart is gaining importance in the current clinical practice and research with guidelines recently published specifically to address this purpose [2]. This is because of growing evidence of its effects on clinical outcome, morbidity, and mortality of several cardiac conditions [3]. RVOT represents up to 20% of RV volume and contributes to up to 15% of total RV stroke volume [5]. RVOT has also an important role in some patients with congenital heart diseases or arrhythmias [6]. Surgeons frequently estimate RV function during surgery by looking at the RVOT contraction [4]. This study aims to assess the usefulness of RVOT function for the assessment of the whole RV function using RVOT SE parameters.

The main findings of this study are that patients with impaired RV systolic function have significant impairment of RVOT systolic function manifested by a reduction in RVOT SE in comparison to healthy controls with normal RV systolic function. To the best of our knowledge, very few studies previously assessed RVOT SE and simultaneously compared between them among patients with impaired RV systolic function and correlating both with other RV echocardiographic parameters. In this study, out of 200 patients, majority of the patients belong to the age group of 51–60 years (45.5%) followed by 61–70 years (29.5%) and 41–50 years (20.5%). Patients with RV dysfunction are more aged as compared to normal RV function. The mean age within the control group is 53.81±6.9 years while it is 57.98±7.7 years in the patient group, with a significant difference between them (p>0.05). The mean age of the patients was higher as compared to the study done by Allam *et al*. [7] who found that the age within the control group was 37.5±10.6 years while it was 45.7±14.34 years in the patient group, with an insignificant difference between them (p>0.05). Similar results were obtained in other study by Asmer *et al*. [4] In the current study, we found that systolic and diastolic blood pressure were significantly higher in the patient group with RV dysfunction in comparison to the control group. These differences may be due to the presence of hypertension, chronic kidney disease as comorbidities, or the presence of LV dysfunction (due to coronary artery disease, ischemic cardiomyopathy), higher BMI, and noncompliance to medical treatment. Hypertensive patients could also have increased myocardial wall thickness along with reduced cardiac functions [8].

In the current study, echocardiographic parameters of LV function were significantly different between both groups and this was attributed to the same pathology affecting RV simultaneously affecting LV and also due to interventricular dependence. As expected, echocardiographic parameters of RV function RV systolic area and RV diastolic area, mid cavity internal diameter, pulmonary artery pressure along with left atrial diameter, aortic root diameter IV septal thickness, LV diameter diastole, and systole are significantly higher in patients with RV dysfunction as compared to the control group (p<0.01). We found that RVOT-SE, TAPSE, tissue Doppler MPI, LV ejection fraction (%), and FAC are significantly lower among the patient group than the control group (p<0.01). RVOT-SE is found to be a parameter of global RV function, although RVOT-SE directly measures contraction of the RVOT region, which results from superficial circular muscle fibers shortening [9]. Lindqvist *et al*. [10] reported their findings with RVOT fractional shortening using M-mode echocardiography. In their study, RVOT fractional shortening moderately correlated with TAPSE, and moderately and inversely correlated with RV-right atrial pressure gradient. In Lindqvist's study, however, RV function was defined only

Table 4: Echocardiographic characteristics

Characteristics	Normal, mean±SD	RV dysfunction, mean±SD	p
Left atrial diameter (mm)	33.19±2.102	36.43±3.520	<0.001
Aortic root diameter (mm)	33.36±1.50	35.44±2.73	<0.001
Mid RV internal diameter (mm)	35.84±1.183	38.21±2.407	0.014
RV area systolic (cm^2)	14.17±4.48	18.89±4.46	<0.001
RV area diastolic (cm^2)	24.38±4.47	27.88±3.81	<0.001
FAC (%)	42.01±9.9	27.29±4.68	<0.001
Pulmonary artery pressure (mmHg)	15.27±4.102	33.80±4.791	<0.001
IV septal thickness (mm)	10.730±1.314	10.129±3.624	0.011
LV diameter diastole	52.89±1.663	58.50±4.437	<0.001
LV diameter systole	33.47±6.923	43.49±6.680	<0.001
Posterior wall thickness (mm)	11.60±1.39	10.23±2.84	0.003
LV ejection fraction (%)	60.05±2.17	48.0±5.39	<0.001
Tissue Doppler MPI	0.287±0.011	0.488±0.031	<0.001
TAPSE (mm)	18.30±1.235	10.54±1.487	<0.001
RVOT-SE (mm)	8.16±0.961	4.17±0.753	<0.001

RV: Right ventricular, LV: Left ventricular, TAPSE: Tricuspid annular plane systolic excursion, RVOT-SE: Right ventricular outflow tract systolic excursion, FAC: Fractional area change, MPI: Myocardial performance index, SD: Standard deviation

Table 5: Distribution as per TAPSE taking cut off of 17 mm

TAPSE (mm)	Interpretation	Frequency	Percent
≤17	Diseased	134	67.0
>17	Normal	66	33.0
Total		200	100.0

TAPSE: Tricuspid annular plane systolic excursion

by TAPSE, and pulmonary hypertension was used as a surrogate parameter of RV function. In our study, RVOT fractional shortening distinguishes well between patients with reduced and preserved RV function, but the distinction of RVOT-SE values was better, due to the fact that RVOT fractional shortening is affected by LV function as well. Anavekar *et al*. [11] found that FAC is best correlated with MRI-derived RV EF. In Alsoos *et al*. [12] study, it was revealed that RVOT-FS and FAC were the best independent variables correlated with RVOT_SE, so there is a high probability to find a strong correlation between RVOT_SE and MRI-derived RV EF. In the current study, we found that RVOT diastolic dimensions in healthy controls were 39.54±2.2 mm while RVOT systolic dimensions were 9.43±1.2 mm. A study by Allam *et al*. [7] found that RVOT diastolic dimensions in healthy controls were 31±4.4 mm while RVOT systolic dimensions were 16.04±4.65 mm. Similar findings were reported in a study by Yamaguchi *et al*. [13] to assess RVOT FS in 81 patients with reduced LV EF. In their study, RVOT diameter was 3.1 cm at end-diastole (range, 1.9–5.3 cm) and 2.1 cm at end systole (range, 0.4–4.5 cm) in normal healthy controls.

In the current study, RVOT SE was significantly lower in patients than in healthy controls (3.47±1.4 mm vs. 5.82±2.43 mm with p<0.001). Similar findings were also recorded in a study by Allam *et al*. [14] This was somewhat different from that reported by Asmer *et al*. [4] They reported that RVOT SE was significantly lower in patients with impaired RV systolic function than in individuals with normal RV function (1.7±1.1 mm vs. 9.6±1.5 mm with p<0.001). RVOT SE in their study was different within each group from that found in our study as reported above. They also reported that the best cutoff value of RVOT SE was <6 mm with 100% sensitivity and 100% specificity to diagnose impaired RV systolic function, which completely separated patients with impaired RV function from patients with preserved RV function, and this fact was not proven in the current study. In our study, we used the TAPSE ≤17 mm as the best cutoff value to differentiate patients with RV systolic dysfunction from healthy individuals with normal RV systolic function. There were 67% of patients with ≤17 mm and 33% had >17 mm TAPSE in our study. Asmer *et al*. [4] reported RVOT-SE as the novel echocardiographic parameter of RV systolic function. Their study included 90 patients and RVOT-SE sensitivity and specificity to diagnose reduced RV function patients were both 100% at RVOT-SE value <0.6 cm; however, RV reduced function was defined by FAC <35% and TAPSE <1.6 cm. In our study, RVOT-SE sensitivity and specificity to diagnose reduced RV function patients were 98 and 96 %, respectively, at RVOT-SE value <0.6 cm, while RV reduced function was defined by FAC <35% (Fig. 1) and (Tables 1,2,4 and 5).

CONCLUSION

RVOT-SE is a highly sensitive and specific method for diagnosing reduced RV systolic function patients. RVOT SE is not accurate as a sole parameter, but its high values can be used as an indicator for normal RV systolic function. It is simple to get, requiring one easy and reproducible M-Mode measurement from the parasternal short-axis view. It can accurately separate patients with normal and RV dysfunction. Larger studies are needed to further establish the value of RVOT-SE when compared with the currently used echocardiographic methods and to other imaging techniques in patients with various disease states affecting the right heart. However, CARDIAC MRI and 3-D ECHO are considered superior to 2-D ECHO.

CONFLICTS OF INTEREST

None declared.

FUNDING

Nil

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