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Study on Clinical and Echocardiographic Assessment of Right Ventricular Function in Patients with Mitral Valve Disease in Medical College Kolkata

Satyendra Nath Dutta[1], Basabendra Choudhary[2]

[1]Clinic of Cardiology, Healthworld Hospitals, Durgapur, India
[2]Clinic of Cardiology, Fortis Hospital, Kolkata, India

Abstract

Background and Aim: Mitral valve disease (MVD) is a significant cardiovascular condition requiring comprehensive evaluation of right ventricular (RV) function. The present study aims to assess the RV function using clinical methods and echocardiography in patients with MVD.

Materials and Methods: This cross-sectional, observational study included 100 patients with moderate and severe MVD at a tertiary care center in India. RV function was assessed through clinical examination and comprehensive echocardiography using 2D, M-mode, color Doppler, pulsed wave Doppler, and tissue Doppler imaging (TDI).

Results: Among the total of 100 patients, 43 (43%) patients had mitral stenosis, 31 (31%) had mitral regurgitation, and 26 (26%) had mixed lesions. RV function was assessed using various parameters, 28 (28%) by eye estimation, 43 (40%) by tricuspid annular plane systolic excursion, 38 (38%) by RV fractional area change, 47 (47%) by TDI S'velocity, and 42 (42%) by RV myocardial performance index. RV dysfunction was more prevalent in patients with: atrial fibrillation, those classified as New York Heart Association class III and IV, and severe mitral valve involvement.

Conclusion: RV dysfunction is common in MVD patients, particularly in those with atrial fibrillation, left atrial dilatation, severe symptoms, and severe valvular involvement. Comprehensive echocardiographic assessment of RV function should be an integral part of the evaluation in MVD patients, as it provides valuable information for risk stratification and clinical management.

Keywords: Atrial fibrillation, echocardiography, heart valve diseases, mitral valve stenosis, ventricular dysfunction, right

INTRODUCTION

Valvular heart disease (VHD) represents a significant global health burden, with mitral valve disease (MVD) emerging as one of its most common manifestations. MVD stands as a major contributor to cardiovascular morbidity and mortality worldwide. The demographic landscape of MVD is particularly noteworthy, as its prevalence demonstrates a striking age-dependent pattern, with a marked increase in the elderly population. Indeed, epidemiological studies have revealed that up to 10% of individuals over 75 years of age are affected by this condition.[1] From the current estimate of 1.5 million individuals aged 65 and above, this number is projected to reach double its present value by 2046, ultimately escalating to approximately 3.3 million affected individuals by 2056.[2] Evaluation of MVD by cardiovascular imaging plays a pivotal role in multiple critical functions in patient care. The fundamental aspects of imaging assessment encompass detailed valve morphology for etiological

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Address for Correspondence: Satyendra Nath Dutta, Clinic of Cardiology, Healthworld Hospitals, Durgapur, India
E-mail: reach.satyen2009@gmail.com
ORCID ID: orcid.org/0009-0004-8055-4245

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determination, quantification of valvular dysfunction, its hemodynamic impact, and the evaluation of right and left ventricles. Among the various imaging modalities available, echocardiography remains the cornerstone diagnostic tool for mitral valve visualization and assessment.[3] Right ventricular (RV) performance has emerged as a crucial prognostic indicator across numerous cardiovascular conditions. While multiple validated echocardiographic parameters exist for evaluating RV function, each individual measure carries inherent limitations and constraints. A more comprehensive approach, integrating various complementary parameters, offers enhanced reliability in distinguishing between normal and impaired RV function. The diagnostic measurement includes visual assessment, RV myocardial performance index, tricuspid annular plane systolic excursion (TAPSE), 2D RV fractional area change (RVFAC), 2D RV ejection fraction (RVEF), and 3D RVEF. Additionally, advanced techniques like tissue doppler imaging (TDI) are used to derive tricuspid lateral annular systolic velocity (S').[4]

Hence, the aim of the present study was to assess the RV function using clinical methods and echocardiography in patients with MVD.

METHODS

Study Design and Population

This is a cross-sectional, observational study conducted at a tertiary care center in India from July 2017 to December 2018. Patients diagnosed with MVD, attending outpatient department/inpatient department, department of cardiology, were included in the study. A total of 100 patients with a moderate to severe degree of MVD were present in the study. Patients who were not willing to give consent for the study with less than 18 years, pregnant women, with multi-valvular disease with significant aortic valve lesion or organic tricuspid valve lesion, with a medical history of chronic pulmonary disease, co-morbid conditions like diabetes mellitus, severe anemia, and chronic kidney disease, with significant left- to-right shunt or who were hemodynamically unstable were excluded from the study.

Data Collection

After taking informed consent from the eligible patients, a detailed history along with clinical and laboratory investigation was also performed. RV function of each patient was assessed through clinical examination as well as echocardiography examination using GE Vivid 7 echocardiography machine, which included 2D, M mode, color Doppler, pulsed wave Doppler, and TDI. Patients were examined for any history of symptoms of dyspnea, fatigue, palpitation, chest pain and were classified based on New York Heart Association (NYHA) classification. Clinical examination of the patients included pulse rate, blood pressure, jugular venous pressure, dependent edema, precordial examination with particular emphasis on the RV impulse. Atrial fibrillation/flutter or other types of arrhythmias, RV hypertrophy, RV strain, right axis deviation, right bundle branch block, and right atrium enlargement were detected using 12 lead electrocardiography with long lead II. any symptoms related to congestive cardiac failure (CCF) were also noted.

Definition

Mitral Stenosis and Mitral Regurgitation

Reference ranges for mitral stenosis and mitral regurgitation were taken in this study based on the 2014 American Heart Association/American College of Cardiology[5] and are depicted in Table 1 and Table 2. Mitral valve area was calculated by 2D echocardiography planimetry from the parasternal short axis views. MV mean pressure gradient was calculated using continuous wave Doppler in apical-4 chamber view. Mitral regurgitation was calculated using 2D, colour Doppler, proximal isovelocity area method, jet area, vena contracta, effective regurgitant orifice, regurgitant volume, and regurgitant fraction.

Congestive Cardiac Failure

CCF was assessed based on the Framingham criteria of congestive heart failure.[6] The Framingham Heart Study criteria are 100% sensitive and 78% specific for identifying persons with definite congestive heart failure. Major criteria included: paroxysmal nocturnal dyspnea, neck vein distension, rales, radiographic cardiomegaly, acute pulmonary oedema, S3 gallop, increased central venous pressure (>16 cm H_2O at right atrium), hepatojugular reflux, weight loss >4.5 kg, in 5 days in response to treatment while minor criteria included bilateral ankle oedema, nocturnal cough, dyspnea on ordinary exertion, hepatomegaly, pleural effusion, decrease in vital capacity by one third from maximum recorded, and tachycardia (heart rate > 120 beats/min).

NYHA was used to classify the severity of symptoms like dyspnea, fatigue, palpitation, and chest pain. Classification is as follows:

Class I: Patients with no limitation of activities; they suffer no symptoms from ordinary activities.

Class II: Patients with slight, mild limitation of activity; they are comfortable with rest or with mild exertion.

Class III: Patients with marked limitation of activity; they are comfortable only at rest.

Class IV: Patients who should be at complete rest, confined to bed or chair; any physical activity brings on discomfort and symptoms occur at rest.

Right Ventricular Parameters

RV systolic and diastolic parameters were taken for reference from 2015 guidelines of the American Society of Echocardiography as shown in Figure 1.[7] RV diameter: measured in end-diastole from the RV focused apical 4-chamber view at the mid-level. A value >35 mm was considered abnormal.[7] Pulmonary artery systolic pressure is calculated from the tricuspid regurgitation (TR) jet peak velocity using the Bernoulli equation: pressure =4× (velocity)². The estimated right atrial (RA) pressure was added to the TR peak gradient calculated in this manner.[8]

Mean pulmonary artery pressure (MPAP) is calculated from the pulmonary regurgitation (PR) jet peak velocity using a similar method, after adding the estimated RA pressure to the PR peak gradient. In some patients, it was also calculated from the RV outflow tract acceleration time (RVOT AT) using the standard equation: MPAP = 90 - 0.6×(RVOT AT).[8]

Inferior vena cava (IVC) size and respiratory variation: used as an indicator of RA pressure. Measured from the subcostal view. IVC diameter >2.1 cm that collapses <50% with a sniff suggests high RA pressure of 15 mm Hg (range: 10-20 mm Hg).[7]

Ethical Committee Information

The study was approved by the Institutional Ethics Committee of the Institute and was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants (approval number: MC/Kol/IEC/Non-spon/580/07-2017, date: 26.08.2017).

Outcomes

To assess the RV function using clinical methods and echocardiography in patients with MVD.

Table 1: Mitral valve stenosis-severity assessment criteria

Grade	MVA (cm^2)	MV mean PG (mmHg)
Mild	>1.5	<5
Moderate	1-1.5	5-10
Severe	≤1.0	>10

MVA: Mitral valve area, PG: Pressure gradient

Table 2: Severity assessment criteria for mitral valve regurgitation

Definition	Valve hemodynamics
Mild	Central jet area <20% of LA; eccentric holosystolic jet <0.2 cm^2; regurgitant volume <30 mL
Moderate	Central jet area 20-40 of LA%; ERO =0.20-0.39 cm^2; regurgitant volume = 30-59 mL
Severe	Central jet area >40% of LA or eccentric holosystolic jet; vena contracta ≥0.7 cm, ERO ≥0.40 cm^2, regurgitant volume ≥60 mL, regurgitant fraction ≥50%

ERO: Effective regurgitant orifice, LA: Left atrium

Statistical Analysis

Data were analysed using GraphPad InStat (version 3.0). Continuous variables were expressed as mean ± standard deviation. Chi-square and Fisher's exact tests were used to compare data between the two groups. Pearson's correlation coefficient was used to assess relationships between pairs of parameters. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 100 patients with MVD were included in this study. The demographic and clinical characteristics of the patient population are presented in Table 3. The study cohort was predominantly female, with the majority of patients falling within the 20- to 50-year old age group, representing the most prevalent demographic in this population. Rheumatic heart disease was the most common aetiology for MVD in our study. According to the severity of symptoms, most of the patients belong to NHYA class II and III. Figure 2 shows the types of mitral valve involvement.

RV dysfunction, estimated through eye examination, was identified in 28 patients (28%), with the highest prevalence in mitral stenosis (34.8%) compared to regurgitation (19.35%) and mixed lesions (26.9%). Severe mitral stenosis showed higher rates than moderate stenosis (44% vs 22.22%, *P* =0.19), while regurgitation severity showed no significant relationship (*P* =1.0). Despite its subjective nature, eye estimation effectively identifies clinically significant RV dysfunction, particularly in symptomatic patients with stenotic lesions.

Various parameters showing RV systolic and diastolic dysfunction are illustrated in Table 4. The RV dysfunction was observed in 40 (43%) patients by TAPSE, 38 (38%) patients by RVFAC, 47 (47%) patients by TDI S' velocity, and 42 (42%) by RV myocardial performance index/Tei.

Pulsed wave doppler was used to identify the ratio of early diastole to atrial systole, wave velocity right ventricle in flow (A) wave velocity right ventricle inflow (E) at the tricuspid valve in 66 patients without atrial fibrillation, with a mean E/A ratio of 0.79±0.2032 and a mean E wave deceleration time (EDT) of 220.33±32.779 msec. Among these 66 patients, an abnormal E/A ratio <0.8 was found in 44 (66.7%) patients, early diastolic velocity at the tricuspid lateral annulus by TDI early diastolic velocity at tricuspid lateral annulus by TDI (e') in 37 (56%) patients, abnormal E/e' >6 in 47 (71%) patients, e'/ late diastolic velocity at tricuspid lateral annulus by tissue doppler image (a') ratio in 38 (58%) patients, abnormal EDT in 38 (57%) patients, dilated IVC in 34 (52%) patients, and decreased IVC collapse in 26 (40%) patients, suggesting RV diastolic dysfunction.

Parameter	Mean ± SD	Abnormality threshold
TAPSE (mm)	24 ± 3.5	<17
Pulsed Doppler S wave (cm/sec)	14.1 ± 2.3	<9.5
Color Doppler S wave (cm/sec)	9.7 ± 1.85	<6.0
RV fractional area change (%)	49 ± 7	<35
RV free wall 2D strain* (%)	−29 ± 4.5	>−20 (<20 in magnitude with the negative sign)
RV 3D EF (%)	58 ± 6.5	<45
Pulsed Doppler MPI	0.26 ± 0.085	>0.43
Tissue Doppler MPI	0.38 ± 0.08	>0.54
E wave deceleration time (msec)	180 ± 31	<119 or >242
E/A	1.4 ± 0.3	<0.8 or >2.0
e′/a′	1.18 ± 0.33	<0.52
e′	14.0 ± 3.1	<7.8
E/e′	4.0 ± 1.0	>6.0

Figure 1: Normal RV parameters as per American Society of Echocardiography

RV: Right ventricle, MPI:Myocardial performance index, EF: Eection fraction, TAPSE: Tricuspid annular plane systolic excursion, SD: Standard deviation

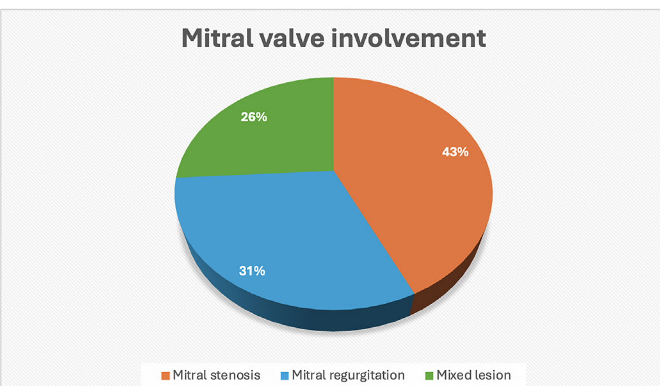

Figure 2: Types of mitral valve involvement

Figure 3 shows correlations of RVFAC with LA size (diameter), left ventricular EF (LVEF), and MPAP. Figure 3A shows a significant linear correlation between RVFAC values and the corresponding LA diameter of patients, suggesting that a larger left atrial diameter was associated with poorer RV systolic function. The linear correlation coefficient (r) was -0.6237 with a 95% confidence interval (CI) of -0.7106 to -0.4869, and significance of p <0.0001. Figure 3B shows that lower LVEF, suggestive of poor LV systolic function, was associated with lower RVFAC (r=0.6387, 95% CI: 0.5057 to 0.7420, P <0.0001). Figure 3C shows that higher MPAP, indicating greater mean pulmonary pressure RV afterload, was associated with lower RVFAC, indicating worse RV systolic function (r=-0.5941, 95% CI: -0.7080 to -0.4502, P <0.0001).

Table 5 demonstrates the relationship between RV function and atrial fibrillation/flutter. All parameters of RV function were significantly affected in patients with atrial fibrillation. The evaluation of RV function using TAPSE, RVFAC, TDI S' vel, TDI Tei, and decreased IVC collapsibility showed significant changes in patients with atrial fibrillation (P <0.05), while e', E/e', and e'/a' also showed significant changes with P <0.0001. When comparing the occurrence of RV systolic dysfunction (RVFAC <35%) between patient groups with and without atrial fibrillation/flutter using Fisher's exact test, a significant association was found (P =0.0318, relative risk=1.747, 95% CI: 1.077 to 2.835).

The correlation between RV function and NYHA class of symptoms is shown in Table 6. All parameters of RV function were significantly affected in the NYHA class III and IV. The RV function, measured by mean E and mean A, showed significant changes in the more symptomatic group (P <0.05), while TAPSE, RVFAC, TDI S' vel, RV Tei index, decreased IVC collapse, e', E/e', and e'/a' were significant with P <0.0001. Table 7 and Table 8 demonstrate the correlation between RV function and mitral stenosis and regurgitation. Patients with severe MVD showed significantly more RV dysfunction compared to those with moderate MVD.

Figure 4 shows a relationship between e'/a' and LA diameter. The graph demonstrates that increased left atrial diameter was associated with a lower e'/a' ratio, suggesting more significant RV diastolic dysfunction. The coefficient of correlation (r) was -0.6053 (95% CI: -0.7166 to -0.4640, P <0.0001).

Table 3: Demographic and clinical characteristics of the patient population

Variables	n=100 patients
Age, years	
<20	0 (0)
20-30	35 (35)
30-40	35 (35)
40-50	21 (21)
50-60	5 (5)
>60	4 (4)
Female	70 (70)
Male	30 (30)
Etiology of mitral valve lesion	
RHD	82 (82)
IHD	4 (4)
ICMP	4 (4)
MVP	4 (4)
SLE	2 (2)
DCM	2 (2)
MAC	2 (2)
NYHA classification	
NYHA class I	12 (12)
NYHA class II	32 (32)
NYHA class III	46 (46)
NYHA class IV	10 (10)
Atrial fibrillation/flutter	
Mitral stenosis	13 (38.2)
Mitral regurgitation	7 (20.6)
Mixed lesions	14 (41.2)
Mean pulse rate (pulse/min)	87.04±9.812
Mean SBP (mmHg)	102.96±11.272
Mean DBP (mmHg)	71.08±6.627
Mean PASP (mmHg)	46.65±10.167
MPAP (mmHg)	31.5±6.984
Right ventricular impulse (%)	
Yes	74 (74)
No	26 (26)
Jugular venous pressure	
Mitral stenosis	25 (58.14)
Mitral regurgitation	13 (41.9)
Mixed lesions	23 (79.31)
Congestive cardiac failure	
Mitral stenosis	21 (48.84)
Mitral regurgitation	13 (41.9)
Mixed lesions	19 (73.1)

Data are presented as n (%) and mean ± standard deviation.

DBP: Diastolic blood pressure, DCM: Dilated cardiomyopathy, ICMP: Ischemic cardiomyopathy, IHD: Ischemic heart disease, MAC: Mitral annular calcification, MPAP: Mean pulmonary artery pressure, NYHA: New York Heart Association, PASP: Pulmonary artery systolic pressure, RHD: Rheumatic heart disease, SLE: Systemic lupus erythematosus, SBP: Systolic blood pressure

Among the 47 patients who did not have clinical heart failure at the time of examination, echocardiographic assessment revealed varying degrees of cardiac dysfunction, which identified RV systolic dysfunction in 4 (8.5%) patients by RVFAC, and 5 (10.6%) patients, by RV Tei method. The RV diastolic dysfunction was found in 23 (62.16%) out of 37 patients by E/A ratio (without atrial fibrillation), 16 (34.04%) out of 47 patients by E/e' ratio, and 10 (21.27) out of 47 patients by both e' and e'/a' ratios.

DISCUSSION

This study demonstrated that RV dysfunction (RVD) is prevalent in patients with MVD, manifesting across various combinations of valvular lesions. The analysis revealed significant correlations between RV systolic dysfunction and multiple hemodynamic parameters, including left atrial size, LV systolic function, and MPAP. Additionally, the correlation between e'/a' ratio and left atrial diameter provided evidence of associated diastolic dysfunction.

A study by Kammoun et al.[9] which characterized RVD in patients with moderate to severe rheumatic mitral stenosis using TAPSE, FSA, and S' measurements, found that RV systolic function was impaired in 35% of patients. This dysfunction was notably more prevalent among patients who had atrial fibrillation and left atrial dilation, which aligns with our observations of higher RVD rates in patients with atrial fibrillation.

A comparative study utilizing TDI and velocity vector imaging demonstrated progressive deterioration of RV systolic performance correlating with stenosis severity, establishing a proportional relationship between mitral stenosis severity and RVD magnitude.[10] These concordant findings validate our observations and reinforce that RV impairment represents a predictable hemodynamic consequence of progressive mitral valve obstruction.

Furthermore, TDI studies have revealed that RV diastolic function can be impaired in symptomatic patients with isolated mitral stenosis, even when RV systolic function remains normal.[11] This supports our finding of abnormal diastolic dysfunction parameters in a significant proportion of patients.

In the present study, several significant correlations were identified that elucidate the complex hemodynamic relationships in MVD. A strong negative correlation was observed between RVFAC and left atrial diameter (r=-0.6237, *P* <0.0001), indicating that progressive left atrial enlargement is associated with deteriorating RV function. Conversely, a moderate to strong positive correlation between RVFAC and LV ejection fraction (r=0.6387, *P* <0.0001) demonstrated that improvements in LV systolic performance are accompanied by corresponding enhancements in RV function, reflecting

Table 4: Right ventricular systolic and diastolic dysfunction of the patient population based on different parameters

Variables	Total (n=100)	Mitral stenosis (n=43)	Mitral regurgitation (n=31)	Mixed lesions (n=26)
Mean LA size (mm)	50.22±8.764	47.53±6.642	50.0±10.096	54.84±8.545
Mean LVEF (%)	55.03±8.290	57.56±5.607	52.58±11.587	53.77±6.173
RV diameter (mm)	27.9 ± 4.58	27.26	25.71	30.00
Mean IVC diameter (mm)	16.95±3.29	16.72	16.16	18.27
Dilated IVC (≥18 mm)	52 (52)	20 (46.5)	15 (48.4)	17 (65.4)
Less than adequate IVC collapse	40 (40)	18 (41.86)	10 (32.23)	12 (46.15)
Mean TAPSE (mm)	15.67±2.94	15.56±3.25	16.71±2.53	14.62±2.52
Abnormal TAPSE	43 (40)	18 (41.86)	10 (32.25)	15 (57.7)
Mean RV FAC (%)	40.44±9.733	41.58±10.012	42.39±8.48	36.23±9.750
Abnormal RV FAC <35%	38 (38)	16 (37.2)	8 (25.8)	14 (53.8)
Mean TDI-S' vel (cm/sec)	9.41±2.638	9.37±2.966	10.03±2.313	8.73±2.320
Abnormal TDI-S' vel (<9.5 cm/sec)	47 (47)	22 (51.2)	10 (32.2)	15 (57.7)
RV MPI/Tei index	0.53±0.117	0.526±0.127	0.48±0.933	0.58±0.106
Abnormal MPI/Tei index (>0.54)	42 (42)	18 (41.9)	9 (29)	15 (57.7)
Mean e'	7.52±2.819	7.88±2.803	8.45±3.161	5.81±1.393
e' (<7.8)	56 (56)	23 (53.5)	13 (41.9)	20 (76.9)
E/e' ratio	7.782±2.72	7.69±2.670	6.97±2.088	8.91±1.031
Abnormal E/e' (>6)	71 (71)	29 (67.4)	19 (61.3)	23 (88.5)
e'/a'	0.54±0.190	0.59±0.176	0.55±0.223	0.42±0.110
Abnormal e'/a' (<0.52)	58 (58)	23 (53.5)	15 (48.4)	20 (76.9)
Abnormal EDT (msec) (>220)	57 (57)	19 (44.2)	18 (58.1)	20 (76.9)

Data are presented as n (%) and mean ± standard deviation.

a': Late diastolic velocity at tricuspid lateral annulus by tissue doppler image, E: E wave velocity right ventricle inflow, EDT: E wave deceleration time, e': Early diastolic velocity at tricuspid lateral annulus by tissue doppler imaging, FAC: Fractional area change, IVC: Inferior vena cava, LA: Left atrium, LVEF: Left ventricular ejection fraction, MPI: Myocardial performance index, RV: Right ventricle, TAPSE: Tricuspid annular plane systolic excursion, TDI S' vel: Tissue doppler image S' wave velocity

ventricular interdependence. Additionally, a strong negative correlation between RVFAC and MPAP ($r=-0.5941$, $P<0.0001$) was identified, confirming that elevated pulmonary pressures directly compromise RV systolic performance.

Our findings have important clinical implications for the management of patients with MVD. RVD was detected even in patients without clinical evidence of CCF, suggesting subclinical impairment that precedes overt heart failure symptoms. The prevalence of RVD was markedly higher among patients with advanced functional limitations (NYHA class III and IV) and in patients with severe forms of both mitral stenosis and mitral regurgitation, underscoring the progressive nature of right heart involvement as valvular disease severity increases. Giannini et al.[12] in their study of survival outcomes in patients with severe functional mitral regurgitation and advanced heart failure who underwent percutaneous mitral valve repair, concluded that the assessment of RV systolic function plays a crucial role in risk stratification for these patients.

In a multi-centre large cohort study of patients diagnosed with degenerative mitral regurgitation, it was observed that RVD assessed by transthoracic echocardiography was a major and independent determinant of long-term survival in response to conservative or surgical management, and RV systolic function should be included in routine DMR evaluation and in the clinical decision-making process.[13]

The strong association between functional class and RV impairment emphasizes the importance of comprehensive RV evaluation in symptomatic patients. The severity-dependent nature of RVD across different types of MVD suggests that RV function parameters could serve as important markers for surgical timing and prognostic assessment, particularly in patients with severe disease who may benefit from earlier intervention to preserve RV function and improve long-term outcomes.

Study Limitation

The present study has several limitations, which should be considered during interpretation of the results. It was a single centre study with a relatively small sample size, which may limit the generalizability of the study findings. A significant

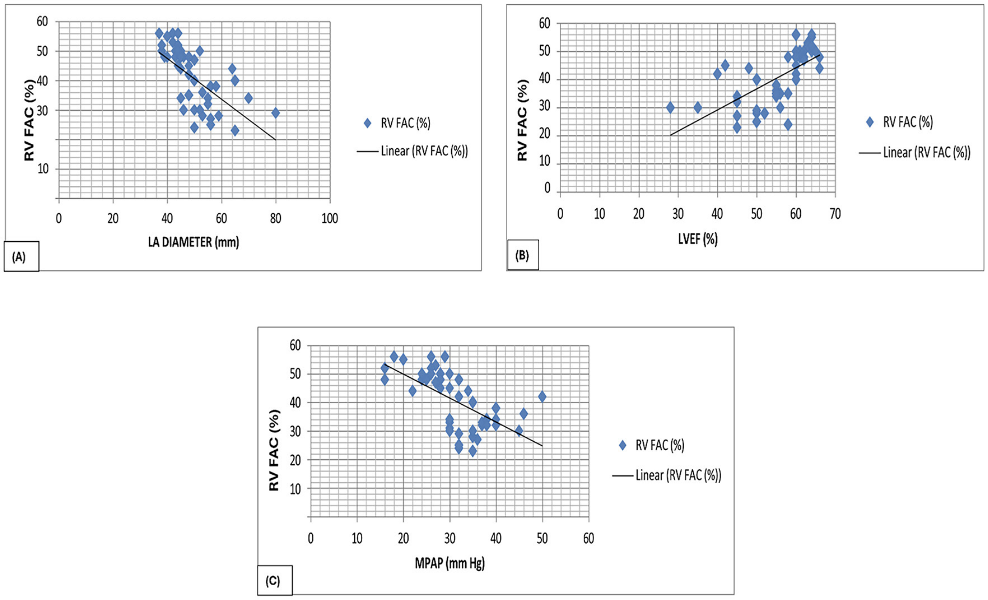

Figure 3: Correlation of RV FAC with LA size (diameter), LVEF and MPAP

(A) Shows a significant linear correlation between RVFAC values and the corresponding LA diameter of patients, suggesting that a larger left atrial diameter was associated with poorer RV systolic function. The linear correlation coefficient (r) was -0.6237 with a 95% confidence interval (CI) of -0.7106 to -0.4869, and significance of *P* <0.0001. (B) Shows that lower LVEF, suggestive of poor LV systolic function, was associated with lower RVFAC (r=0.6387, 95% CI: 0.5057 to 0.7420, *P* <0.0001). (C) Shows that higher MPAP, indicating greater mean pulmonary pressure RV afterload, was associated with lower RVFAC, indicating worse RV systolic function (r=-0.5941, 95% CI: -0.7080 to -0.4502, *P* <0.0001).

LA: Left atrium, LVEF: Left ventricular ejection fraction, MPAP: Mean pulmonary artery pressure, RVFAC: Right ventricular fractional area change

Table 5: Correlation of right ventricular function and atrial fibrillation/flutter

Variables	Atrial fibrillation/ flutter (n=34)	No atrial fibrillation/ flutter (n=66)	*P* -value
Mean TAPSE (mm)	14.65±2.460	16.97±3.049	0.0075
Mean RV FAC (%)	37.41±8.482	42±10.025	0.0186
Mean TDI S' (cm/s)	8.32±2.215	9.97±2.677	0.0016
Mean TDI Tei	0.56±0.107	0.51±0.122	0.0395
Mean E (cm/sec)	51.53±7.195	53.26±8.642	0.292
Mean e'	5.97±1.255	8.32±3.067	<0.0001
Mean E/e'	9.29±1.082	7.004±2.337	<0.0001
Mean e'/a'	0.42±0.084	0.59±0.205	<0.0001
Mean EDT (msec)	225.32±26.047	219.27±32.863	0.318
Patients with less than adequate IVC collapse	19 (55.9)	21 (31.8)	0.031

Data are presented as n (%) and mean ± standard deviation.

a': Late diastolic velocity at tricuspid lateral annulus by tissue doppler image, E: E wave velocity right ventricle inflow, EDT: E wave deceleration time, e': Early diastolic velocity at tricuspid lateral annulus by tissue doppler imaging, FAC: Fractional area change, IVC: Inferior vena cava, RV: Right ventricle, TAPSE: Tricuspid annular plane systolic excursion, TDI S' vel: Tissue doppler image S' wave velocity

Table 6: Correlation of right ventricular function and NYHA class of symptoms

Variables	NYHA class I-II (n=44)	NYHA class III-IV (n=56)	*P* -value
Mean TAPSE (mm)	17.95±1.589	13.87±2.494	<0.0001
Mean RV FAC (%)	48.57±5.884	34.054±7.005	<0.0001
Mean TDI S' (cm/s)	11.52±1.422	7.75±2.136	<0.0001
Mean TDI Tei	0.44±0.72	0.597±0.968	<0.0001
Mean E (cm/sec)	56.023±7.663	50.036±7.654	0.0002
Mean A (cm/sec)	72.57±10.241	64.69±9.064	0.0017
Mean E/A	0.8±0.199	0.77±0.211	0.4933
Mean e'	9.36±2.727	6.07±1.908	<0.0001
Mean E/e'	6.36±2.070	8.89±1.751	<0.0001
Mean e'/a'	0.65±0.178	0.44±0.147	<0.0001
Mean EDT (msec)	221.18±20.871	219.66±39.906	0.8065
Patients with less than adequate IVC collapse	6 (13.6)	34 (60.7)	<0.0001

Data are presented as n (%) and mean ± standard deviation.

A: A wave velocity right ventricle in flow, a': Late diastolic velocity at tricuspid lateral annulus by tissue doppler image, E: E wave velocity right ventricle inflow, EDT: E wave deceleration time, e': Early diastolic velocity at tricuspid lateral annulus by tissue doppler imaging, FAC: Fractional area change, IVC: Inferior vena cava, RV: Right ventricle, TAPSE: Tricuspid annular plane systolic excursion, TDI S' vel: Tissue doppler image S' wave velocity

Table 7: Correlation of right ventricular function and severity of mitral stenosis

Variables	Severe mitral stenosis (n=25)	Moderate mitral stenosis (n=18)	*P* -value
Mean TAPSE (mm)	14.32±3.185	17.28±2.54	0.0022
Mean RV FAC (%)	37.28±9.204	47.56±7.943	0.001
Mean TDI S' (cm/s)	8.24±2.7	10.94±2.62	0.0026
Mean TDI Tei	0.57±0.117	0.47±0.123	0.015
Mean E (cm/sec)	50.4±8.155	60.56±7.579	0.0005
Mean A (cm/sec)	65.67±11.159	71.33±11.568	0.15
Mean E/A	0.776±0.25	0.896±0.25	0.13
Mean e'	6.56±2.038	9.72±2.718	0.0002
Mean E/e'	8.34±2.759	6.766±2.307	0.0225
Mean e'/a'	0.53±0.16	0.704±0.136	0.0012
Mean EDT (msec)	203.12±49.17	218.11±28.004	0.62
Patients with less than adequate IVC collapse	14 (56)	4 (22.22)	0.034

Data are presented as n (%) and mean ± standard deviation.

A: A wave velocity right ventricle in flow, a': Late diastolic velocity at tricuspid lateral annulus by tissue doppler image, E: E wave velocity right ventricle inflow, EDT: E wave deceleration time, e': Early diastolic velocity at tricuspid lateral annulus by tissue doppler imaging, FAC: Fractional area change, IVC: Inferior vena cava, RV: Right ventricle, TAPSE: Tricuspid annular plane systolic excursion, TDI S' vel: Tissue doppler image S' wave velocity

Table 8: Correlation of right ventricular function and severity of mitral regurgitation

Variables	Severe mitral regurgitation (n=19)	Moderate mitral regurgitation (n=12)	*P* -value
Mean TAPSE (mm)	15.79±2.123	18.167±2.517	0.0017
Mean RV FAC (%)	39.26±6.94	47.33±8.585	0.0016
Mean TDI S' (cm/s)	9.316±2.129	11.167±2.209	0.0273
Mean TDI Tei	0.51±0.088	0.44±0.089	0.0184
Mean E (cm/sec)	49.05±4.743	56±4.671	0.0010
Mean A (cm/sec)	69.167±6.337	68.333±10.731	0.93
Mean E/A	0.702±0.068	0.817±0.189	0.07
Mean e'	7.58±3.372	9.83±2.290	0.0371
Mean E/e'	7.677±2.171	5.843±1.389	0.0237
Mean e'/a'	0.482±0.222	0.668±0.180	0.0234
Mean EDT (msec)	233.11±16.22	216.33±21.35	0.0285
Patients with less than adequate IVC collapse	8 (42.10)	2 (66.66)	0.24

Data are presented as n (%) and mean ± standard deviation.

A: A wave velocity right ventricle in flow, a': Late diastolic velocity at tricuspid lateral annulus by tissue doppler image, E: E wave velocity right ventricle inflow, EDT: E wave deceleration time, e': Early diastolic velocity at tricuspid lateral annulus by tissue doppler imaging, FAC: Fractional area change, IVC: Inferior vena cava, RV: Right ventricle, TAPSE: Tricuspid annular plane systolic excursion, TDI S' vel: Tissue doppler image S' wave velocity

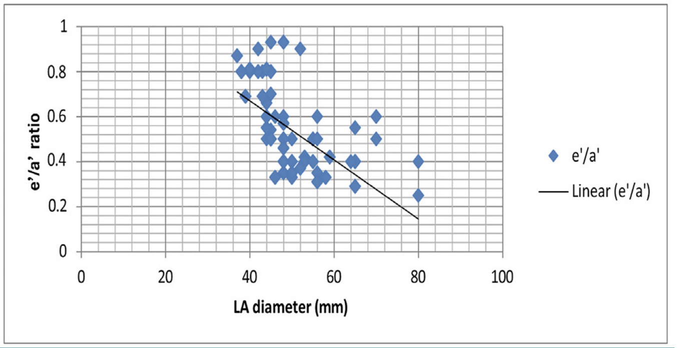

Figure 4: Relation between e'/a' ratio and LA diameter

a': Late diastolic velocity at tricuspid lateral annulus by tissue doppler image, e': Early diastolic velocity at tricuspid lateral annulus by tissue doppler index

limitation is the absence of longitudinal follow-up evaluation, which prevents assessment of the prognostic implications and long-term outcomes of RVD identified in this study. This is particularly important given that RV function is an established prognostic indicator in MVD; however, our cross-sectional design cannot provide insights into survival outcomes, disease progression, or optimal timing for interventions. While our exclusion criteria attempted to minimize confounding factors, the potential influence of different etiological entities on RV function remains a consideration. Future studies incorporating advanced imaging techniques such as 3D echocardiography, strain imaging, and cardiac magnetic resonance imaging could provide a more comprehensive assessment of RV function, though attention to image quality and operator experience would be essential. Prospective multi-centre studies with long-term follow-up are needed to establish the prognostic significance of these findings and enhance generalizability.

CONCLUSION

Despite its critical prognostic value, RV function assessment often receives insufficient attention in the context of VHD. Careful assessment of RV function should be prioritized in patients presenting with MVD in various forms. Simple echocardiography techniques using 2D, M mode, pulsed wave Doppler, TDI, and others can reveal the status of RV function, systolic as well as diastolic, in great detail. Our study demonstrates significant associations between impaired RV function and several clinical parameters, including atrial fibrillation, left atrial dilatation, and more severe symptoms and valvular involvement in patients with MVD. However, the cross-sectional design of this study limits our ability to establish causal relationships or determine the temporal sequence of these associations. These findings carry substantial clinical implications, serving as valuable predictors of symptom progression, risk stratification for adverse events, timing of intervention, and post-procedural outcomes. Such comprehensive evaluation of RV function therefore emerges as an indispensable component in the optimal management of patients with MVD. Future longitudinal studies are warranted to establish the causal relationships and temporal progression of RVD in this patient population.

Ethics

Ethics Committee Approval: The study was approved by the Institutional Ethics Committee of the Institute and was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants (approval number: MC/Kol/IEC/Non-spon/580/07-2017, date: 26.08.2017).

Informed Consent: Written informed consent was obtained from all participants.

Footnotes

Authorship Contributions

Surgical and Medical Practices: S.N.D., B.C., Concept: S.N.D., Design: S.N.D., Data Collection or Processing: B.C., Analysis or Interpretation: S.N.D., B.C., Literature Search: S.N.D., B.C., Writing: S.N.D., B.C.

Conflict of Interest: No conflict of interest was declared by the authors.

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