Echocardiographic Diagnosis of Chronic Rheumatic Valvular Lesions

Anita Saxena

New Delhi, India

ABSTRACT

Rheumatic heart disease continues to be a significant public health problem in many developing countries and in some of the aboriginal populations in developed countries. Echocardiography has become indispensable in the assessment of valve lesions secondary to rheumatic heart disease. It confirms the rheumatic etiology of valvular abnormality as the features are quite typical in most cases. It also helps to exclude nonrheumatic causes of valve lesions. M-mode and cross-sectional echo helps to assess the severity of valve abnormality and its hemodynamic effects on the heart. Further, color flow imaging evaluates the flow across a valve, both qualitatively and quantitatively. Serial echocardiography plays a crucial role in the follow-up of patients with rheumatic heart disease and is very helpful for determining the timing of intervention. Recently, addition of real-time 3-dimensional echocardiography has further improved imaging of cardiac valves, especially the mitral valve.

Rheumatic heart disease (RHD) continues to be a significant cause of cardiovascular morbidity and mortality in developing countries [1,2]. Echocardiography has become indispensable in the assessment of valve lesions secondary to RHD. Although echo is the key noninvasive test for valve assessment, it is essential to combine clinical data with 2-dimensional (2D) echo and Doppler findings in order to make a decision regarding the management of the patient. Real-time 3-dimensional echo (RT3DE) may have an advantage over 2D echo because it provides multiple imaging planes. It must, however, be kept in mind that factors such as loading conditions of the heart, irregular rhythm, and low cardiac output influence flows and gradients across the valves, thereby interfering with the assessment of the valve abnormality. In this review, the echocardiographic features of RHD will be discussed, primarily focusing on the qualitative and quantitative value of echocardiography in diagnosis, management, and follow-up. Each valvular abnormality will be subdivided into regurgitant and stenotic lesions. Pulmonary valve abnormality is not being discussed as it is hardly ever affected by the rheumatic process.

MITRAL REGURGITATION

Mitral regurgitation (MR) is the most common abnormality seen in RHD patients [3,4]. Although MR can occur due to several other etiologies, the echocardiographic picture of rheumatic mitral valve is very characteristic. This helps with diagnosing MR secondary to RHD, even in patients with no previous history of rheumatic fever, especially in populations living in endemic regions. Typically, the valve leaflets are thick and may show some doming and restricted mobility, but the valve area is generally normal except in cases with associated mitral stenosis (MS).

M-mode echo

The left atrium and left ventricle are enlarged in patients with significant MR. The degree of dilation of the left ventricle determines the timing of surgery in these patients. In children, the measurement should be indexed. The left ventricular function is preserved until late in the natural history of the disease. In isolated chronic MR, the pulmonary pressures are not much elevated unless the left ventricular dysfunction has set in. Hence, the right atrium and right ventricle are not enlarged and the interventricular septal motion remains normal.

2D echo

Mitral valve leaflets are thickened and elongation of chordae may result in prolapse of the anterior mitral leaflet (Fig. 1). Chordal rupture leading to flail anterior mitral leaflet may occur in severe cases secondary to infective endocarditis or acute rheumatic carditis [5]. In some cases of pure MR and in those associated with MS, the restricted movement of mitral leaflets results in doming, producing an elbow or dog leg deformity of the anterior mitral leaflet. Mitral valve leaflet calcification is unusual in children and young adults, but it is seen in older patients with long-standing MR. Echocardiography is very useful to assess mitral valve suitability for repair. In those with suboptimal transthoracic images, transesophageal echocardiography, performed pre-operatively or in the operating room, is done to gather this information.

The left atrium and left ventricle are enlarged in those with significant MR. The assessment of left ventricle size by 2D echo is likely to be more accurate than it would be by M-mode echo. End-systolic and end-diastolic volumes and ejection fraction can be calculated using Simpson or area-length

From the Department of Cardiology, All India Institute of Medical Sciences, Ansari Nagar, New Delhi, India. Correspondence: A. Saxena (anitasaxena@hotmail.com).

GLOBAL HEART

VOL. 8, NO. 3, 2013
ISSN 2211-8160
http://dx.doi.org/10.1016/j.gheart.2013.08.007

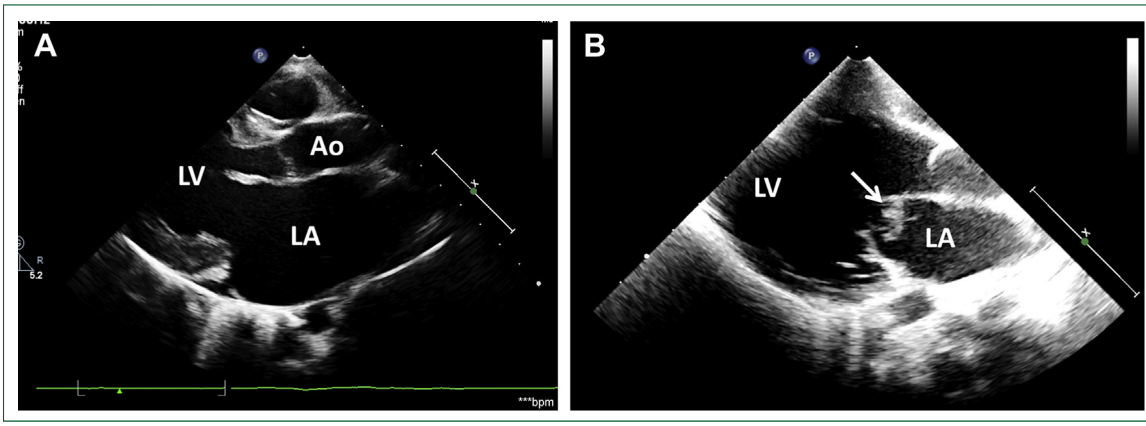

FIGURE 1. Two-dimensional echo from a patient with severe mitral regurgitation showing dilated left atrium (A), left ventricle, thickened mitral leaflets (B), and prolapse of the anterior leaflet (arrow). Ao, aorta; LA, left atrium; LV, left ventricle.

methods. The interatrial septum may be bowed toward the right atrium. A left atrial clot is unusual in isolated MR.

Doppler echo

The degree of MR is best judged by color flow mapping. Often the MR jet is directed posteriorly (Fig. 2). The severity of regurgitation is assessed by grading the regurgitant jet area in comparison to the total left atrial area. It is important to distinguish mild pathologic MR from physiologic MR, sometimes seen in normal individuals. A pathological MR is seen in at least 2 views, with the regurgitant jet length of >2 cm in at least 1 view, peak velocity of the jet ≥3 m/s, and pansystolic Doppler signal in at least 1 beat. The other methods to quantify MR include measuring vena contracta, flow convergence (proximal isovelocity surface area, or PISA), and systolic pulmonary flow reversal in pulmonary veins. All these techniques are more accurate but time-consuming [6].

MR can be classified into mild, moderate, or severe based on various parameters by 2D echo and Doppler echocardiography [7].

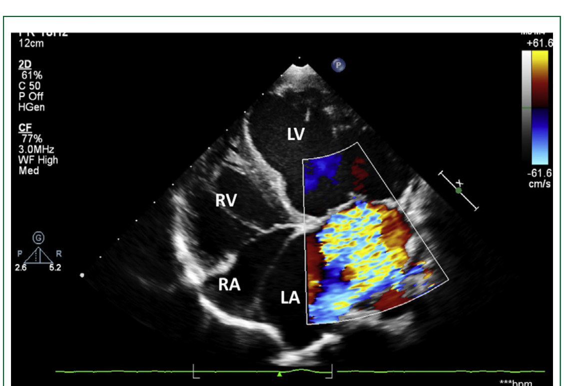

FIGURE 2. Color flow mapping showing severe mitral regurgitation. RA, right atrium; RV, right ventricle; other abbreviations as in Figure 1.

3D echo

RT3DE is increasingly employed in evaluation of mitral valve pathology and is considered as the modality of choice for surgical planning in many centers. The mitral valve has a saddle-shaped, nonplanar annulus and displays variation in size and shape during a cardiac cycle. RT3DE can distinguish the differences in annular shape and function in various types of MR. Most of the published data is on MR secondary to myxomatous mitral valve and ischemia, but RT3DE is likely to be very useful for patients with RHD as it clearly shows the pathomechanism of MR [8]. RT3DE not only guides the surgical repair but also assesses the success of repair in the post-operative period. The quantification of MR is evaluated better by 3D echo. Because RT3DE provides multiple imaging planes, the narrowest portion of the regurgitant color flow jet can be easily assessed [9]. One can accurately measure cross-sectional area of the vena contracta, anatomic regurgitant orifice

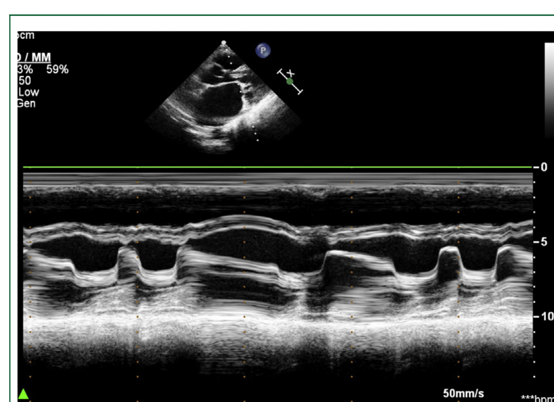

FIGURE 3. M-mode echo of mitral valve in a patient with mitral stenosis and atrial fibrillation, showing thickened mitral valve, reduced EF slope of anterior mitral leaflet and paradoxical motion of posterior mitral leaflet.

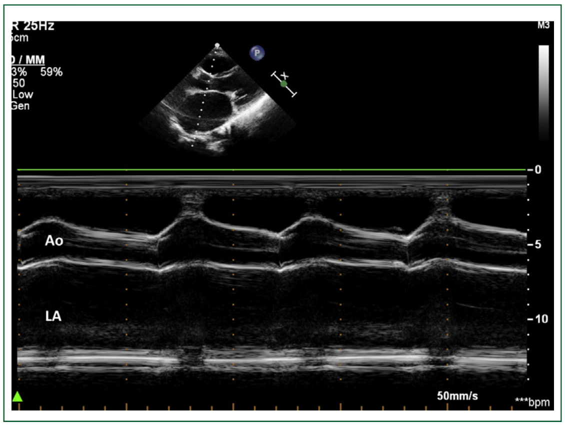

FIGURE 4. M Mode echo of a patient with mitral stenosis showing enlarged left atrium. Abbreviations as in Figure 1.

area, and PISA for the calculation of the effective regurgitant orifice area [10]. Poor echo windows produce poor images similar to the case of 2D echo. In such patients, electrocardiogram-gated reconstructed images develop stitch artefacts, interfering with the interpretation.

MITRAL STENOSIS

MS is secondary to RHD in a vast majority of cases. Chronic rheumatic process results in fibrosis and thickening of the valve and commissural fusion. In some of the developing countries, severe MS develops at a young age [11]. The mitral valve leaflets are thick with restricted openings, and subvalvular apparatuses with chordal shortening and fusion may be involved. Balloon valvuloplasty is the treatment of choice for patients with MS, and echocardiography plays a crucial role in the assessment of severity of MS and suitability for balloon valvuloplasty.

M-mode echo

The findings on M-mode echo are very typical, showing thickened mitral valve leaflets, reduced E-F slope of the anterior mitral leaflet, paradoxical or anterior motion of the posterior mitral valve leaflet reduced valve leaflet excursion (D-E excursion), and absent or reduced A-wave of the mitral leaflet (Fig. 3). The left atrium is enlarged (Fig. 4). The left ventricular size and systolic function are generally preserved; in some cases, the function may be reduced secondary to acute rheumatic carditis or chronic atrial fibrillation. The right atrium and right ventricle may also be enlarged in those with significant pulmonary hypertension. The interventricular septal motion is paradoxical in these cases.

2D echo

The mitral valve is thickened, and often the anterior mitral leaflet measures >5 mm in thickness. The motion of the mitral valve is restricted, producing doming and the characteristic dog leg deformity (Fig. 5). Commissural fusion, the hallmark of rheumatic etiology is best seen in the parasternal short-axis view (Fig. 6). The mitral valve area can be calculated by planimetry performed in the parasternal short-axis view at the tips of the leaflet. Two-dimensional echo also allows detailed evaluation of the subvalvular deformity. The subvalvular apparatus is often abnormal with thickening and shortening of chordae (Fig. 7). The valve may be calcified in some cases, especially in those over 30 to 40 years of age. Several scoring systems have been described for the morphology of the mitral valve leaflets and subvalvular apparatus, the most commonly used is the Wilkins score. In this scoring system, leaflet mobility, leaflet thickening, subvalvular thickening, and calcification are scored on a scale of 1 to 4, and a total score is estimated. A score of >8 may be associated with a lower rate of success of balloon valvuloplasty [12]. The left atrium is enlarged as a consequence of chronic pressure overload. Left atrial thrombus is not uncommon in MS, especially in those with atrial fibrillation and/or very large left atrium (>50 mm). The clot is commonly located in the left atrial appendage and may escape detection unless the appendage is visualized specifically in short-axis view (Fig. 8). This is of utmost importance in patients undergoing balloon dilation of mitral valve. In patients with a suboptimal transthoracic window, a transesophageal echocardiography is mandatory to rule out a left atrial clot. Presence of left atrial spontaneous contrast is a predictor of thromboembolic risk.

Increased left atrial pressure leads to pulmonary venous and thereby pulmonary arterial hypertension. The right-sided chambers may be enlarged in those with significant pulmonary hypertension, leading to functional tricuspid regurgitation (TR). In these cases, the interventricular septum may exhibit flat or paradoxical movement.

Echocardiography is commonly performed in the catheterization lab to assess a valve immediately after

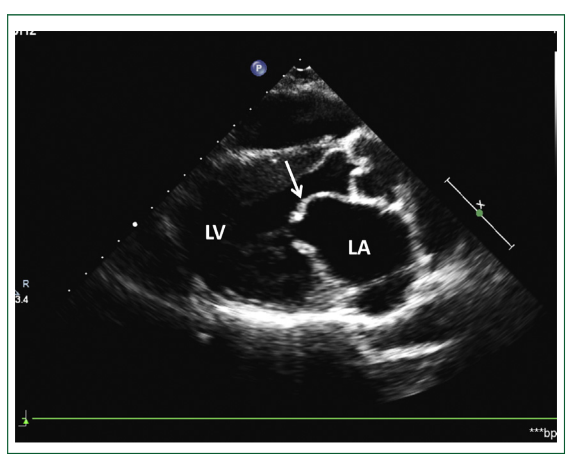

FIGURE 5. Parasternal long-axis view in a patient with mitral stenosis showing thickened mitral valve with dog leg deformity of the anterior mitral leaflet (arrow). Abbreviations as in Figure 1.

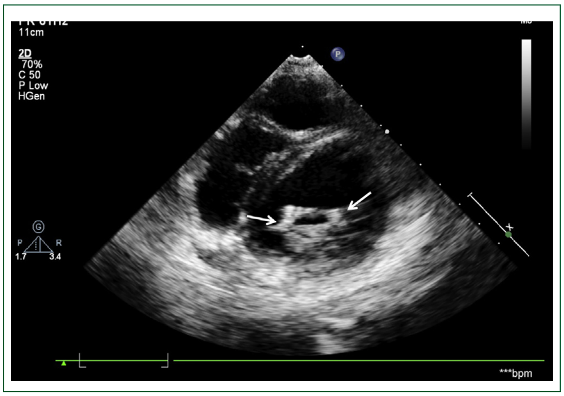

FIGURE 6. Parasternal short-axis view showing severe mitral stenosis with commissural fusion (arrows).

balloon dilation. The split of commissures can be seen in cases with successful dilation.

Doppler echo

The flow across the mitral orifice is turbulent with decreased E-F slope of the mitral inflow Doppler trace. Mitral valve area can be estimated by pressure half-time method (PHT) or continuity method and will be described in detail later. Echocardiography has replaced cardiac catheterization as the gold standard for determining the severity of MS, and the main reason now for catheterization of these patients is for performing balloon mitral valvotomy. The Doppler trace across the mitral valve is used to derive mean and end-diastolic gradients (Fig. 9). Color flow imaging in apical 4-chamber view is very useful to identify the diastolic jet because it may be eccentric due to subvalvular involvement (Fig. 10). The gradients derived using color jets are more reliable. The gradients can vary depending on the heart rate. In atrial fibrillation, an average of 5 or more cardiac cycles should be used to calculate the mean gradient. The mean gradient may not correlate with severity of MS as it is affected by heart rate, cardiac output, and concomitant MR.

The severity of pulmonary hypertension is estimated by measuring the TR jet velocity using Bernoulli equation (gradient $= 4 \times \text{velocity}^2$). Concomitant presence of MR should be looked for. In all patients with MS, other valves must be carefully examined for any involvement by RHD.

Following balloon dilation, the transmitral gradients decrease and the severity of pulmonary hypertension reduces, indicating the procedure was successful. In case the patient develops MR, its mechanism can be easily identified, and the patient can be managed accordingly. In those with MR due to valve tear or chordal avulsion, urgent surgery for repair or replacement of the mitral valve is often required, whereas commissural MR, which is not severe, can be closely followed conservatively.

3D echo

RT3DE provides an en face view of the complete mitral apparatus, defining the valve morphology much better.

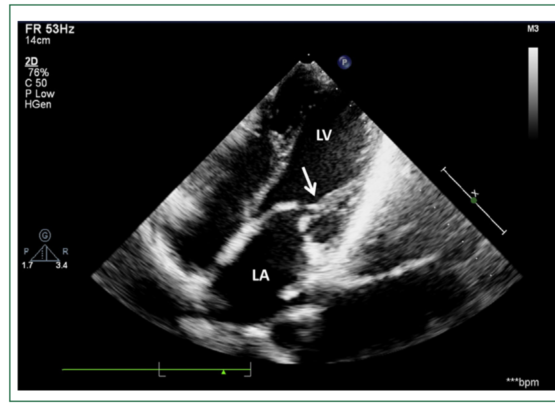

FIGURE 7. Apical 4-chamber view showing thickened mitral leaflets with restricted opening and severe subvalvular deformity (arrow). Abbreviations as in Figure 1.

Three-dimensional echo is better than 2D echo because it identifies the ideal plane where the planimetry should be done for mitral valve area calculation. The likelihood of obtaining good images is greater with 3D than with 2D echo. It has been seen that the mitral valve area by 3D echo is less than that by 2D echo, but 3D is more likely to be correct for estimating mitral orifice area for the reasons previously mentioned [13]. RT3DE also allows excellent assessment of commissures, both before and after balloon valvuloplasty [14]. It also identifies any complication that may occur following balloon dilation more accurately.

Evaluation of severity of mitral stenosis

Accurate assessment of MS severity is important for decisions regarding patient management. Echo-derived mitral valve area is used as the main criteria for defining severity. MS is considered severe, moderate, or mild depending on whether the mitral valve area is <1.0 cm^2, 1.0 to 1.5 cm^2, or >1.5 cm^2, respectively [15]. Severity based on

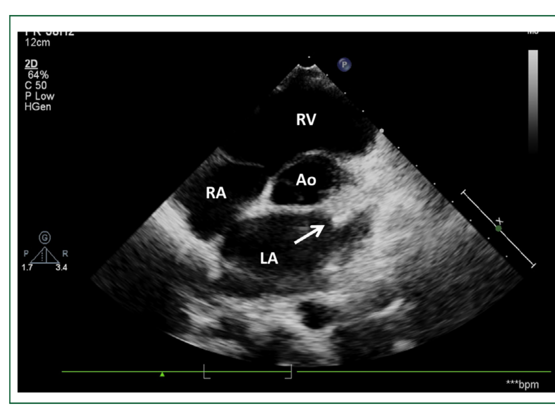

FIGURE 8. Parasternal short-axis view showing thrombus in left atrial appendage (arrow) in a patient with mitral stenosis. Abbreviations as in Figures 1 and 2.

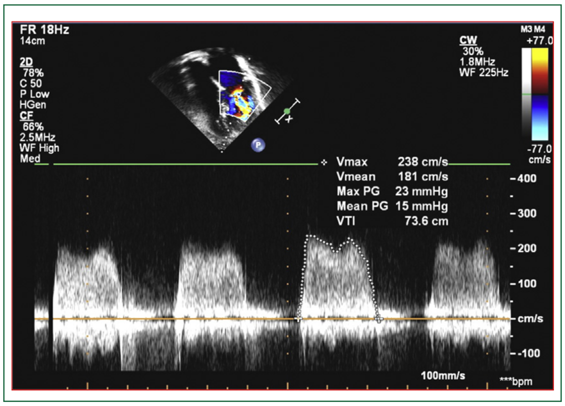

FIGURE 9. Maximum and mean gradients across mitral valve as seen on Doppler signal across mitral valve in a patient with mitral stenosis.

transmitral gradients is less useful as it depends upon heart rate, rhythm, and cardiac output. The severity assessment of MS should rely more on mitral valve area, as mean gradient and pulmonary artery pressure are influenced by several factors. Normal resting values of pulmonary artery pressure may be seen in some cases of severe MS. Four methods are described for defining the mitral valve area by echocardiography.

Planimetry Planimetry measures the anatomic orifice of the mitral valve. Planimetry should be performed in parasternal short-axis at the tips of the mitral valve leaflets (Fig. 11). The scan should slowly start from the apex moving toward the base of the heart, and the mitral valve area should be calculated at the narrowest orifice. The correct timing for measuring planimetry is mid-diastole and several measurements should be made to minimize error. It is a very accurate method in experienced hands, but it can be very fallacious if not done properly or when the acoustic window is poor. This method may not be feasible when the valve anatomy is severely distorted. Addition of RT3DE has greatly helped in determining the exact place where planimetry should be done, and the accuracy is likely to be maintained even when performed by less-experienced personnel.

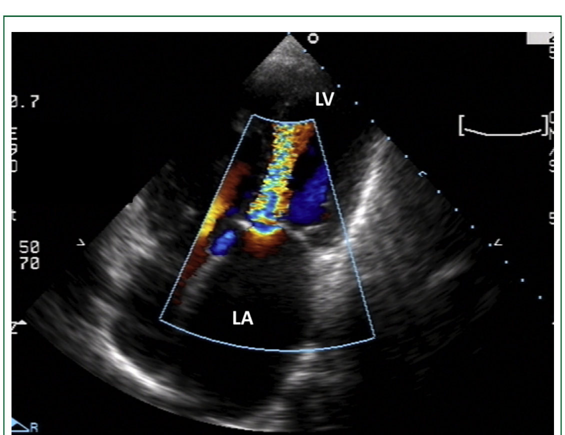

FIGURE 10. Color Doppler across mitral valve in a patient with mitral stenosis. Abbreviations as in Figure 1.

Pressure half-time method Originally described by Hatle et al. [16], PHT is the interval in milliseconds between the maximum early diastolic gradient and the time point at which this gradient is halved.

Normal PHT is 30 to 60 ms; in severe MS, it is >220 ms. A good quality contour of the Doppler flow must be obtained for accurate PHT.

The main advantage of the PHT method is the ease of calculating mitral valve area through the simple calculation of mitral valve area equaling 220 divided by PHT (Fig. 12). However, this method is likely to be inaccurate in determining mitral valve area in presence of tachycardia, atrial fibrillation, severe aortic regurgitation (AR), and immediate post-balloon dilation.

Continuity equation In this method, mitral valve area is calculated by dividing aortic stroke volume by mitral time velocity integral. Aortic stroke volume is derived by multiplying diameter of left ventricular outflow with aortic time velocity integral. Again, this method cannot be used in the presence of MR or AR. In patients with atrial fibrillation, an average of >5 beats should be taken. Because this method involves a number of measurements, its accuracy and reproducibility is questionable.

Proximal isovelocity surface area method This method is often used for assessing the severity of regurgitant lesions, but it is sometimes used for MS cases also. It is based on the hemispherical shape of the convergence of color mitral flow in diastole, which is seen on the atrial aspect of the mitral valve. This method can be used in the presence of MR also. It is time-consuming and requires good images of the hemisphere crossing the mitral orifice. The flow convergence region must be magnified to minimize error. Because it is technically demanding, its use in routine practice is limited.

AORTIC REGURGITATION

The involvement of aortic valve in RHD is less common and is often associated with mitral valve abnormalities. AR is far more common than aortic stenosis (AS) is, especially in a younger population. Some degree of AS may be associated with AR. Generally, these patients have long asymptomatic periods, and cardiac symptoms suggest severe disease.

M-mode echo

The aortic valve is usually thick and a trileaflet. The left ventricle is dilated; degree of dilation depends on severity

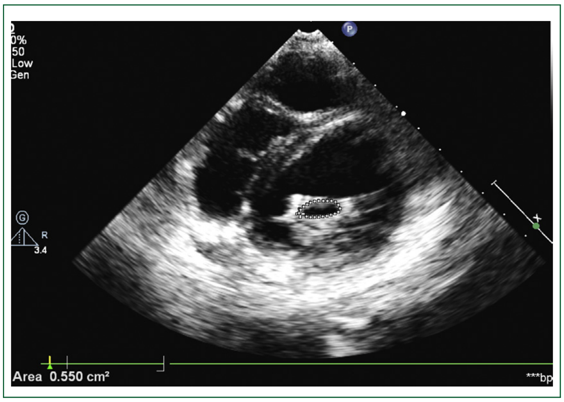

FIGURE 11. Planimetry for calculating mitral valve area in parasternal short-axis view in a case with severe mitral stenosis, area being 0.55 cm^2.

of AR. Echocardiography is very important in follow-up of patients with chronic AR, as the timing of surgery is conventionally based on these M-mode parameters. In general, the degree of left ventricular dilation is more than it is in MR cases. A mitral valve may show diastolic flutter of anterior mitral leaflet. The left atrium tends to remain normal sized unless there is associated mitral valve disease. The aortic root and ascending aorta dilate in severe cases of AR. The mitral valve may show premature closure in severe or acute AR.

2D echo

The valve leaflets have variable degrees of thickening, especially at the level of their edges (Fig. 13). Commissural fusion is the hallmark of rheumatic etiology of AR. Sometimes it may be difficult to discern 3 different cusps of the aortic valve due to fusion and/or calcification. Incomplete coaptation of the aortic valve is often seen in the short-axis view. Dilated aortic root is better appreciated by

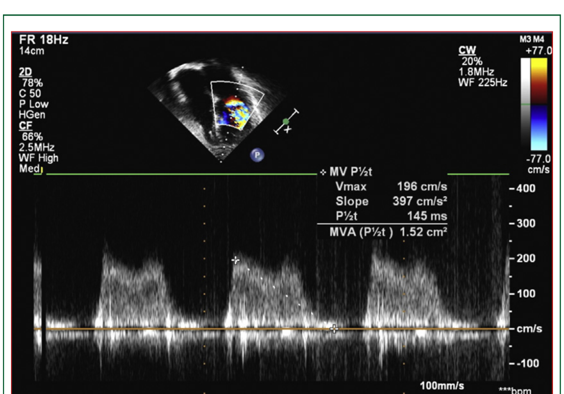

FIGURE 12. Mitral valve area calculated by pressure-half time method in a case with mild mitral stenosis.

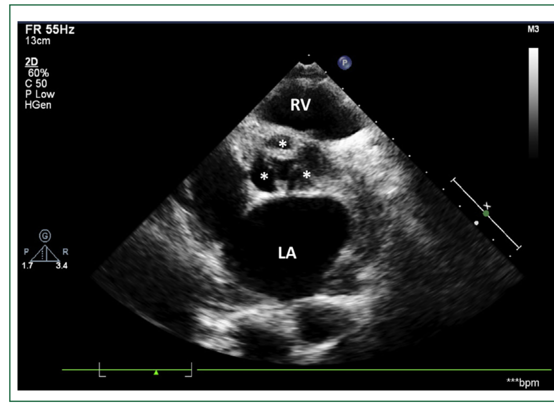

FIGURE 13. Parasternal short-axis view showing thick aortic valve with 3 cusps (*) in a patient with rheumatic aortic stenosis. Abbreviations as in Figures 1 and 2.

2D echo. Left ventricular volumes and ejection fraction are calculated using Simpson or area-length methods.

Doppler echo

The jet of rheumatic AR is mostly central (Fig. 14). Doppler with color flow imaging is very useful for quantifying the severity of AR [17]. The width of the color flow jet in relation to left ventricular outflow width as measured in the parasternal long-axis view is a good indicator of AR severity (Fig. 15). Severe AR results in two-thirds or more of color jet width when compared with the left ventricular outflow width. Similarly, if the area of the color jet of AR is 66% or more of the left ventricular outflow tract area, the AR is severe [17]. Measuring PHT of the aortic regurgitant jet is also useful (Fig. 16); a value of $<$200 ms indicates severe AR, and a value of $>$500 ms suggests mild AR. Heart rate and left ventricular end-diastolic pressure can influence PHT of the AR Doppler jet. A very strong parameter for severity of AR assessment is the degree of diastolic reversal in descending thoracic aorta, as imaged from the suprasternal notch. Pan-diastolic reversal of flow in descending thoracic aorta indicates moderate or severe AR (Fig. 17). In more severe cases, the reversed diastolic flow is seen in the abdominal aorta also. Use of vena contracta and PISA are good methods, but they are time-consuming and, hence, are not performed routinely.

Assessing the severity of AR

Table 1 shows the Doppler-derived parameters that can be used to describe the severity of AR.

Transesophageal echo and RT3DE may provide better quality images for assessing valve morphology and aortic root dimensions. They should be considered in adult patients being planned for aortic valve surgery.

AORTIC STENOSIS

Isolated AS secondary to RHD is unusual. It is generally associated with AR, and the mitral valve is often involved. RHD patients with significant AS tend to have MS also.

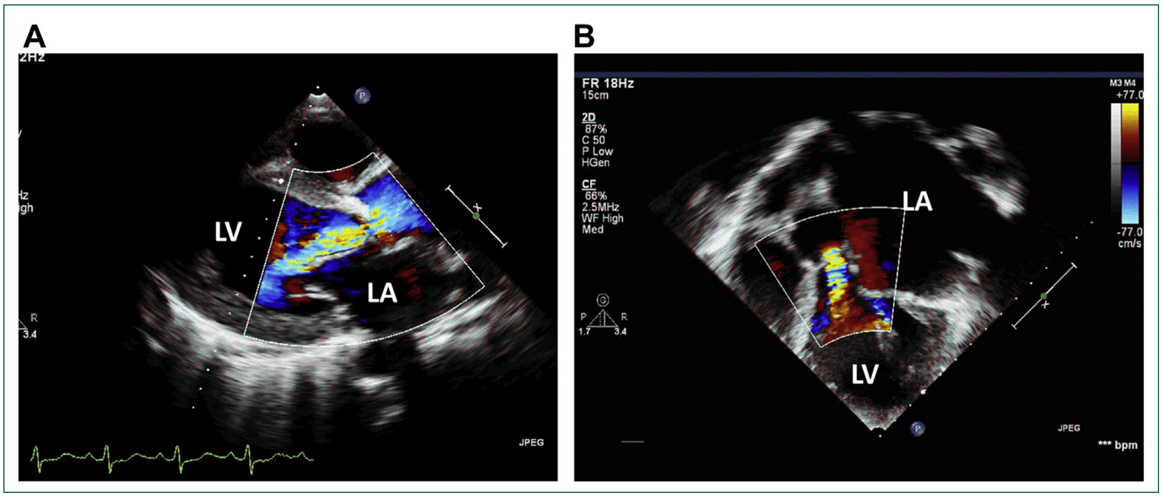

FIGURE 14. Parasternal long-axis (A) and apical 3-chamber (B) views showing color jet of aortic regurgitation. Abbreviations as in Figure 1.

Echocardiographic findings

The aortic valve is thickened, especially at the cusp edges and has a restricted opening. Typically there is commissural fusion resulting in a triangular systolic orifice. In older patients, the edges of the cusp may be calcified. Left ventricle size may be normal, but it is hypertrophied, the degree of hypertrophy depends upon the severity of AS. Left ventricular function remains normal until the very late stage of the disease. The left atrium tends to be normal or minimally enlarged unless there is concomitant mitral valve disease.

Doppler echo is very useful for obtaining peak and mean gradients across the aortic valve. It is important to interrogate the aortic valve from multiple echo windows, including apical, suprasternal, high right parasternal, and subcostal. This will ensure that the Doppler line is well aligned to the jet giving the appropriate gradient across the aortic valve. The peak instantaneous and mean gradients across the aortic valve are best estimated using a dedicated small dual crystal continuous wave transducer. This small transducer allows optimal position and angulation especially in suprasternal and right parasternal regions. Peak instantaneous gradient across aortic valve tends to be higher than the peak-to-peak gradient obtained at cardiac catheterization, and the correlation of the catheter gradient with the echo-derived mean gradient is better. Patients who have isolated severe AR may show flow gradients across the aortic valve by Doppler; care must be taken in interpreting these as being due to AS (Fig. 18). One can also derive the aortic valve area by Doppler echocardiography using the continuity equation; this is especially useful in patients with left ventricular dysfunction wherein the gradients may be reduced, even though the stenosis is severe. A valve area of <1.0 cm^2 indicates severe AS. The grading of severity of AS derived by AS jet velocity is given in Table 2.

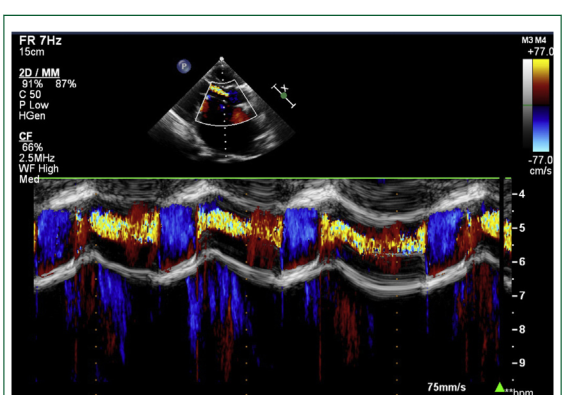

FIGURE 15. Color M-mode echo for measuring the width of aortic regurgitant jet in relation to left ventricular outflow width.

TABLE 1. Doppler-derived parameters used to describe the severity of AR

Parameter	Mild	Moderate	Severe
Jet width, % of LVOT	<25	25–64	>65
Vena contracta, cm	<0.3	0.3–0.6	>0.6
Regurgitation volume, ml/beat	<30	30–59	>60
Regurgitation fraction, %	<30	30–49	>50
Effective regurgitant orifice area, cm^2	<0.1	01–0.29	>0.3
AR pressure half-time	>400	250–400	<250
Diastolic flow reversal in DTA			Holo

AR, aortic regurgitation; DTA, descending thoracic aorta; Holo, holodiastolic; LVOT, left ventricular outflow tract.

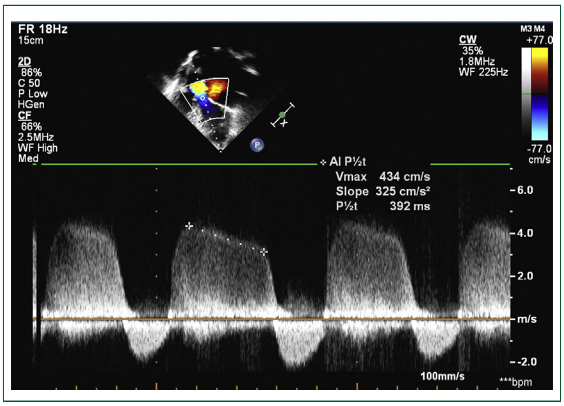

FIGURE 16. Pressure half-time of aortic regurgitant Doppler jet suggestive of moderate aortic regurgitation.

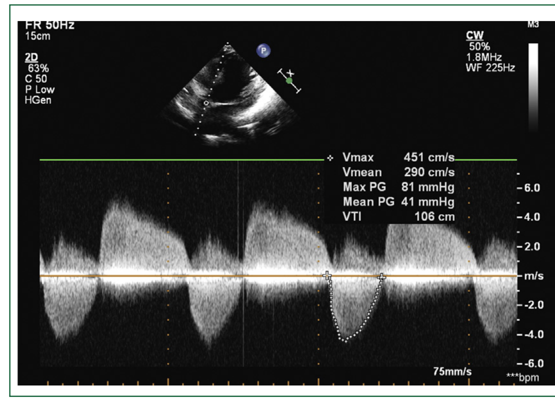

FIGURE 18. Doppler signal across aortic valve showing maximum and mean gradients of aortic stenosis in a patient with both aortic stenosis and aortic regurgitation.

TABLE 2. Grading the severity of AS derived by AS jet velocity

Echo Parameter	Mild	Moderate	Severe
Jet velocity, m/s	<3	3–4	>4
Mean gradient, mm Hg	<25	25–40	40
Valve area, cm^2	>1.5	1.0–1.5	<1.0

AS, aortic stenosis.

TRICUSPID VALVE DISEASE

Tricuspid regurgitation (TR) is almost always functional, secondary to pulmonary hypertension, and most commonly seen in severe MS. The pulmonary artery pressure can be estimated using TR jet velocity (Fig. 19). Organic tricuspid valve disease secondary to RHD is always associated with mitral valve disease and often with aortic valve abnormalities. Most of these patients are in atrial fibrillation.

Tricuspid stenosis

The valve is thickened with reduced E-F slope, the posterior leaflet shows anterior motion. Tricuspid valve shows doming of its leaflets due to restricted motion (Fig. 20). Three-dimensional echo may have an advantage over 2D echo as it shows the en face view of the tricuspid valve, allowing the visualization of commissural fusion. The right atrium is enlarged and the inferior vena cava is dilated. Doppler echo shows turbulent flow across the tricuspid valve. Although the valve area can be calculated using the PHT method for mitral valve area, it has not been validated for tricuspid stenosis (TS). It is preferable to measure mean gradient across the valve to grade the severity of the stenosis (Fig. 21). As a general rule, the pressure gradients are lower in TS than in MS. A mean pressure gradient of 5 mm Hg or more suggests significant TS. A variable degree of TR is almost always associated with TS and may increase the mean gradient (Fig. 22).

Tricuspid regurgitation

Organic TR secondary to RHD is rare. In these cases, some degree of TS may be present. The echo shows a thick

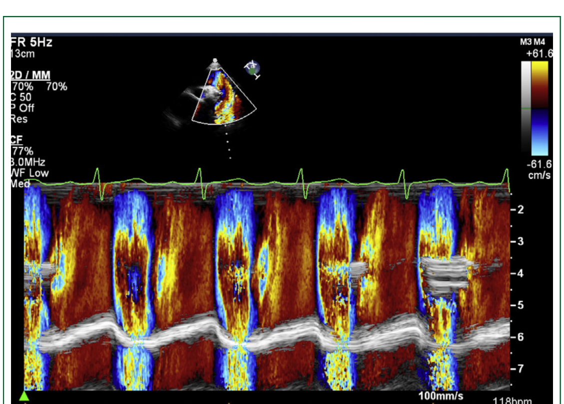

FIGURE 17. Color M-mode echo showing pan-diastolic reversal of flow in descending thoracic aorta suggestive of severe aortic regurgitation.

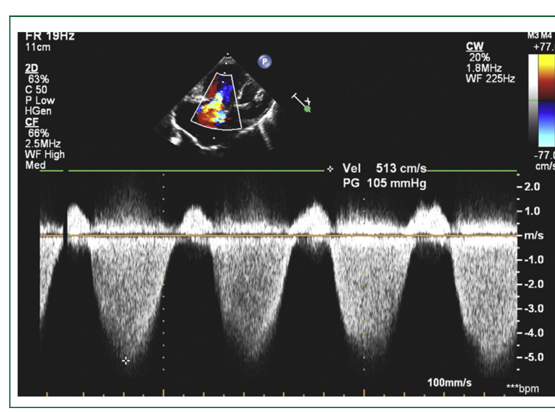

FIGURE 19. Doppler signal of hypertensive tricuspid regurgitation in a patient with severe mitral stenosis. The estimated pulmonary artery systolic pressure is 105 mm Hg.

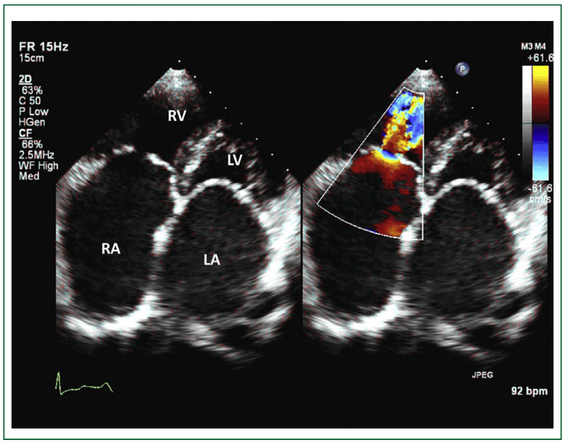

FIGURE 20. Apical 4-chamber view from a patient with tricuspid stenosis showing doming of the tricuspid valve and turbulent color flow across it. Note that this patient also has mitral stenosis. Abbreviations as in Figures 1 and 2.

tricuspid valve with restricted motion of leaflets. It is important to note that some degree of tricuspid valve thickening is seen in functional TR also. The tricuspid annulus, right ventricle, and right atrium are dilated, and, in severe cases, inferior vena cava and hepatic veins are also enlarged. Color flow mapping is used to assess the severity of TR. Systolic flow reversal in hepatic veins is also suggestive of severe TR. In cases with elevated right atrial pressure secondary to severe TR, normal inspiratory collapse of inferior vena cava may be absent. The TR jet velocity is indicative of right ventricular systolic pressure. In organic tricuspid valve disease, the calculated right ventricular pressure is unlikely to be high.

MULTIVALVULAR INVOLVEMENT IN RHD

In regions with a high prevalence of RHD, it is common to see patients in whom more than 1 valve is affected. The

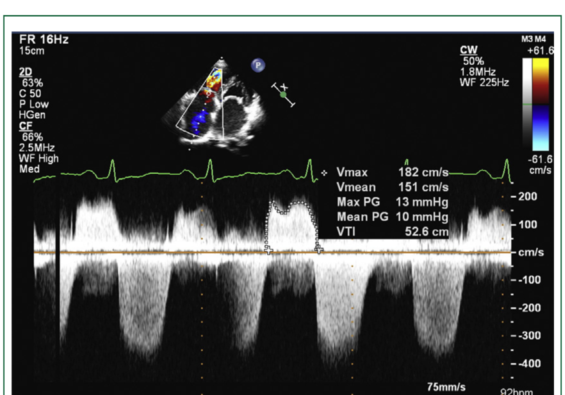

FIGURE 21. Doppler flow across tricuspid valve showing elevated mean gradient across tricuspid valve due to tricuspid stenosis.

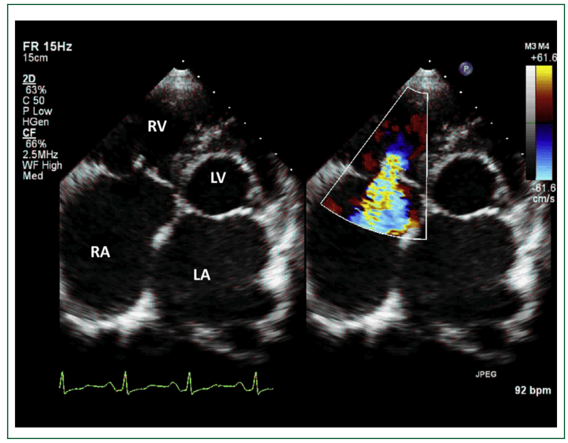

FIGURE 22. Apical 4-chamber view showing tricuspid regurgitation in a patient with rheumatic tricuspid stenosis. Abbreviations as in Figures 1 and 2.

common combinations are MR with AR and MS with AR. Tricuspid involvement is often secondary to pulmonary hypertension. Echocardiography is very useful for assessment of severity of individual lesions. However, it is important to remember that proximal lesions may mask the severity of distal lesions. For example, a patient with severe AR may not show a dilated left ventricle if severe MS is associated. Similarly, a patient with significant TS may not show features of severe MS or AR. The severity of AS may be underestimated in the presence of severe MS. This is especially applicable where load-dependent methods are used to assess severity by echo Doppler.

SUMMARY

Echocardiography is a very important tool in the diagnosis of valve lesions in chronic RHD. It not only provides the anatomic information, but it also accurately quantifies the severity of the valve stenosis or regurgitation. Echocardiography with Doppler and color flow imaging may be able to give more information as compared to that obtained at cardiac catheterization. Further, the assessment of valvular regurgitation by angiography may be affected by ectopic beats, a common occurrence during cardiac catheterization. In patients with chronic RHD, the timing of intervention and the type of intervention is generally decided by echocardiographic findings in conjunction with clinical picture. RT3DE is increasingly being used for evaluating valves for suitability for balloon valvuloplasty as well as for surgical valve repair.

REFERENCES

1. Rheumatic fever and rheumatic heart disease. World Health Organ Tech Rep Ser 2004;923:1–122.
2. Carapetis JR. Rheumatic heart disease in developing countries. N Engl J Med 2007;357:439–41.

3. Chockalingam A, Gnanavelu G, Elangovan S, Chockalingam V. Clinical spectrum of chronic rheumatic heart disease in India. J Heart Valve Dis 2003;12:577–81.
4. Enriquez-Sarano M, Akins CW, Vahanian A. Mitral regurgitation. Lancet 2009;373:1382–94.
5. Marcus RH, Sareli P, Pocock WA, et al. Functional anatomy of severe mitral regurgitation in active rheumatic carditis. Am J Cardiol 1989; 63:577–84.
6. Enriquez-Sarano M, Avierinos JF, Messika-Zeitoun D, et al. Quantitative determinants of the outcome of asymptomatic mitral regurgitation. N Engl J Med 2005;352:875–83.
7. Lancellotti P, Moura L, Pierard LA, et al. European Association of Echocardiography recommendations for the assessment of valvular regurgitation. Part 2: mitral and tricuspid regurgitation (native valve disease). Eur J Echocardiogr 2010;11:307–32.
8. Apor A, Nagy A, Nagi A, Merkely B. The role and potential of 3D echocardiography in the assessment of mitral regurgitation. Eur Cardiol 2012;8:165–70.
9. Yosefy C, Hung J, Chua S, et al. Direct measurement of the vena contracta area by real-time 3-dimensional echocardiography for assessing severity of mitral regurgitation. Am J Cardiol 2009;104: 978–83.
10. Marasan NA, Westenberg JJ, Ypenburg C, et al. Quantification of functional mitral regurgitation by real-time 3D echocardiography: comparison with 3D velocity-encoded cardiac magnetic resonance. JACC Cardiovasc Imaging 2009;2:1245–52.
11. Roy SB, Bhatia ML, Lazaro EJ, Ramalingaswami V. Juvenile mitral stenosis in India. Lancet 1963;2:1193–5.
12. Wilkins GT, Weyman AE, Abascal VM, Block PC, Palacios IF. Percutaneous balloon dilatation of the mitral valve: an analysis of echocardiographic variables related to outcome and the mechanism of dilatation. Br Heart J 1988;60:299–308.
13. Min SY, Song JM, Kim YJ, et al. Discrepancy between mitral valve areas measured by two-dimensional planimetry and three-dimensional transoesophageal echocardiography in patients with mitral stenosis. Heart 2013;99:253–8.
14. Schlosshan D, Aggarwal G, Mathur G, Allan R, Cranney G. Real-time 3D transoesophageal echocardiography for the evaluation of rheumatic mitral stenosis. JACC Imaging 2011;4:580–8.
15. Baumgartner H, Hung J, Bermejo J, et al. Echocardiographic assessment of valve stenosis: EAE/ASE recommendations for clinical practice. Eur J Echocardiogr 2009;10:1–25.
16. Hatle L, Angelsen B, Tromsdal A. Noninvasive assessment of atrioventricular pressure half-time by Doppler ultrasound. Circulation 1979;60:1096–104.
17. Perry G, Helmcke F, Nanda NC, Byard C, Soto B. Evaluation of aortic insufficiency by Doppler color flow mapping. J Am Coll Cardiol 1987; 9:952–9.