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REVIEW

Echocardiographic Assessment of the Right Ventricle–State of the Art

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Assessment of right ventricular (RV) structure and function by echocardiography has largely been qualitative in the past. More recent approaches emphasise the quantification of RV structure from multiple echocardiographic views and quantification of multiple parameters of RV function. Current echocardiographic examinations should include at least two quantitative measures of RV function. This paper will highlight commonly used measures along with their strengths and weaknesses. With further technical developments in three-dimensional and myocardial deformation imaging and as more outcome data become available it is likely that further quantitative assessment will become routine and be used to guide diagnosis and treatment choices.

Keywords Echocardiography • Right ventricle • Quantification • Diagnosis • Prognosis

Introduction

Quantitative assessment of cardiac function has largely been focussed on the left ventricle (LV) with the right ventricle (RV) often described as the forgotten ventricle despite the fact that in most individuals it is required to pump the same volume as the LV. Recently, the importance of the RV as a predictor of prognosis across a range of cardiac conditions has become more accepted [1–3]; and, consequently more effort has been applied to improve the routine assessment of the RV. Echocardiography remains the first line modality for the assessment of RV structure and function, but there are limitations in traditional M-mode, two-dimensional imaging and Doppler parameters [4]. Novel measures such as three-dimensional (3D) echocardiography, those derived from Doppler tissue imaging (DTI) and speckle-tracking strain attempt to counter these limitations and, having shown promise in the research arena, are used increasingly for routine clinical use. At present, however, limited data on normal values, as well the technical difficulties in imaging the right ventricle, continue to be problematic.

One of the largest changes has been from visual assessment of the RV to routine quantification of parameters of RV structure and function. In contrast to the LV, the RV has complex structural geometry [5] and unique responses to disease [6]. For these reasons, quantitative RV assessment is more difficult and may require some geometric assumptions. This can lead to inaccuracies, causing physicians to rely on eyeball estimates rather than quantitative assessment. Despite their limitations, current best practice recommends the use of at least two quantitative assessments during the routine transthoracic echocardiogram [7]. These may provide both diagnostic and prognostic information.

Right Ventricular Structure and Function

The RV is the most anterior structure of the heart, lying posterior to the lower sternum. It can be divided into three distinct regions: the smooth muscular inflow, containing the tricuspid valve and its apparatus, the outflow region and the trabeculated apical region. These structures are wrapped around the left ventricle to form a structure, the appearance of which varies significantly based on the chosen echocardiographic image planes (Figure 1).

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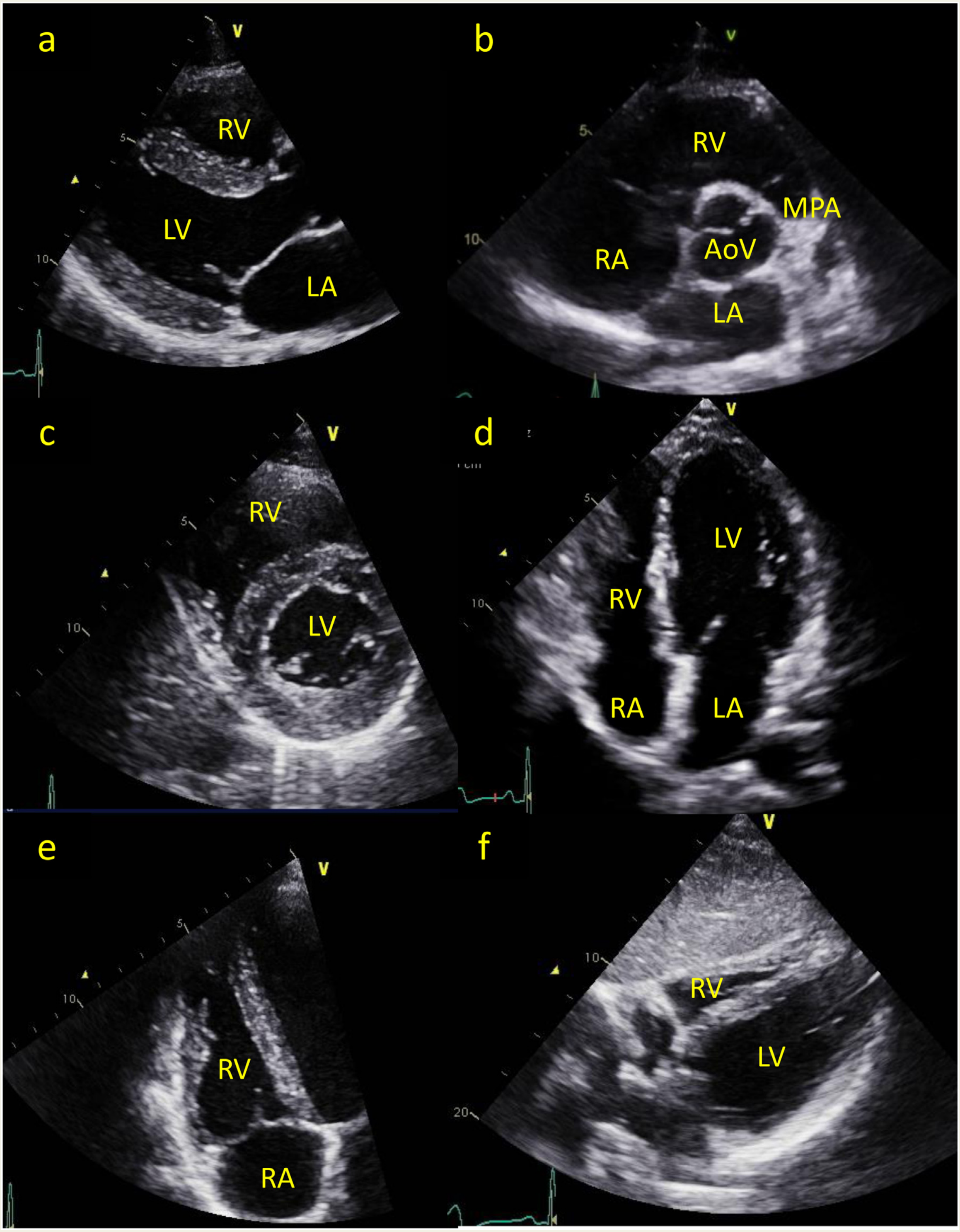

Figure 1 Appearance of the RV from common echocardiographic views.
Panel a: Parasternal long axis view; Panel b: RV inflow-outflow view from a parasternal short axis view at aortic valve level; Panel c: Parasternal short axis view at mid ventricular level; Panel d: Apical 4-chamber view with indistinct RV free wall; Panel e: RV focussed apical view; Panel f: subcostal view.
Abbreviations: RV, right ventricle; LV, left ventricle; LA, left atrium; RA, right atrium; AoV, aortic valve; MPA, main pulmonary artery.

The biomechanics of the RV are significantly different from those of the LV and are optimised to deal with changes in volume load but to function at low pressure. The predominant RV muscle fibres are arranged in a longitudinal fashion from the tricuspid annulus to the apex. Under normal physiological conditions these provide predominantly longitudinal contraction of the right ventricle and for the ventricle as a whole to act as a piston pump. Circumferential fibres and intraventricular septal contraction result in the right ventricular free wall and septum acting like a bellows. In contrast, with increased pre-load, the fibre orientation changes to a more lateral arrangement, thereby augmenting the radial component of the right ventricular contraction. It has also been shown that function of the interventricular septum and the LV are crucial parts of the RV contractile complex with coordinated contraction of the septum essential for efficient function of the RV. This complex biomechanical construct and the change in relative components of radial function and longitudinal function with loading adds to the complexity in overall assessment of right ventricular function [8,9]. In addition, the tricuspid valve is an important component of normal function of the RV.

Structural Assessment of the Right Ventricle

Assessment of the RV should be included in all routine transthoracic echocardiograms, and should be performed from multiple windows, including the parasternal long-axis, parasternal right ventricular inflow and outflow views, apical four-chamber, apical view with a right ventricular focus and subcostal views. Given the geometric complexity of the right ventricular, each view provides additional information to help assess right ventricular function [10].

Dimensions of different segments of the RV may be measured in each of the views with published limits for normality in guideline documents (Table 1) [7]. In obtaining these measurements, care should always be taken with correct alignment of the views to ensure the values obtained are representative. This has been emphasised at some length for measurement of dimensions of the RV from the apical four-chamber view where tilting of the transducer can lead to under- or over-estimation of RV size. Likewise, measurements of the outflow portion of the RV are very important in the assessment of suspected or proven arrhythmogenic right ventricular cardiomyopathy (ARVC). Dimensions of the right ventricular outflow tract by echocardiography may be used as part of major or minor criteria towards a diagnosis under the revised taskforce criteria [11].

Other qualitative abnormalities of LV and RV can be useful indicators of RV abnormalities. Abnormal septal motion with end-diastolic or end-systolic septal flattening may indicate RV volume or pressure overload, respectively (Figure 2). This will lead to a change in LV shape in short axis to a D-shape with an abnormal eccentricity index [12], a finding which may have prognostic implications [13]. Localised areas of akinesis or dyskinesis may occur in ARVC [11].

Right ventricular wall thickness is measured at end-diastole in the subcostal four-chamber view or the parasternal views, with the free wall measuring >5 mm considered abnormal. Care must be taken not to include trabeculae as

Table 1 Abnormal values for routine clinical measures of RV structure and function.

Parameter	Abnormal	Notes\Limitations
RV basal dimension	>4.2 cm	From apical 4-chamber view. Rotation of transducer may produce error.
RV outflow tract proximal dimension	>27 mm	From parasternal short axis view, anterior to the aortic valve. Limited normative data. Endocardial definition may be limited.
RV fractional area change	<35%	From apical 4-chamber view, excluding trabeculation. May be difficult to acquire due to poor endocardial definition. Load dependent. Neglects contribution of RVOT.
Tricuspid annular plane systolic excursion	<16 mm	M-mode from apical 4-chamber view. May underestimate RV function due to regionality. Only assesses longitudinal motion of the free wall. Highly angle dependent. Dependent on LV function.
Tricuspid annular systolic excursion velocity	<10 cm/sec	Tissue Doppler from apical 4-chamber view. Highly angle dependent. Only assesses longitudinal motion of the free wall.
3D RV ejection fraction	<44%	Image quality remains problematic.
RV index of Myocardial performance (DTI)	<0.55	Tissue Doppler imaging of lateral tricuspid annulus. May be normal if RA pressure is elevated.
RV index of Myocardial performance (PW)	<0.4	Pulsed wave blood pool Doppler of RVOT and tricuspid inflow. May be pseudo-normal if RA pressure is elevated.

Abbreviations: RV, right ventricular; DTI, Doppler tissue imaging; PW, pulsed wave Doppler imaging; RVOT, right ventricular outflow tract; RA, right atrium; 3D, three dimensional.

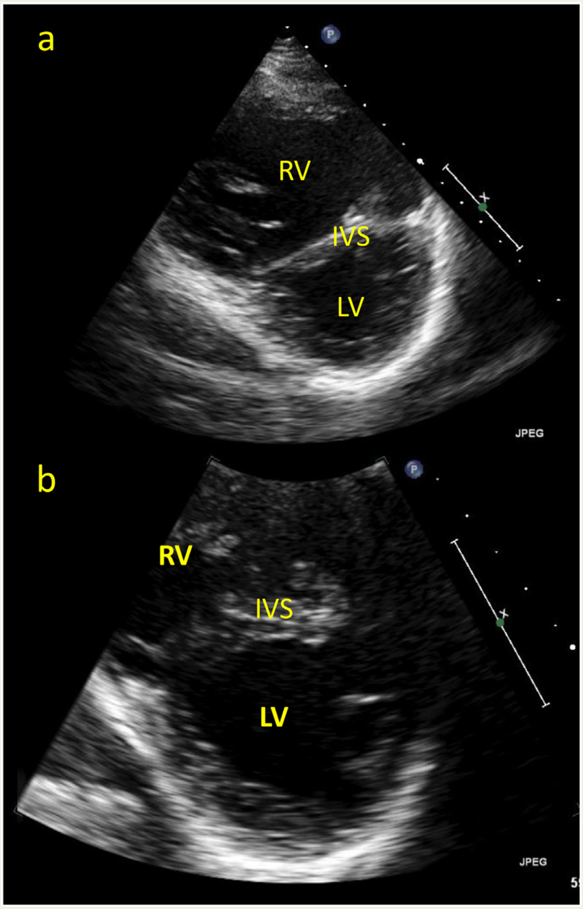

Figure 2 Change in septal and LV shape in the setting of RV pressure loading. Panel a shows flattening of the IVS with a D-shaped LV as a result of RV pressure loading due to PAH. Panel b shows the same person 12 months later after treatment for PAH with a normal shaped LV and IVS.
Abbreviations: LV, left ventricular; IVS, interventricular septum; PAH, pulmonary arterial hypertension.

part of the wall. Hypertrophy is caused by either chronic exposure to an increased afterload (eg. pulmonary hypertension or pulmonary stenosis) or infiltrative diseases (eg. cardiac amyloidosis).

Functional Assessment of the Right Ventricle

Right Ventricular Area and Fractional Area Change

The Fractional Area Change (FAC) is defined as

$$\frac{End\ Diastolic\ Area - End\ Systolic\ Area}{End\ Diastolic\ Area} \times 100$$

Fractional area change is obtained by manually tracing the right ventricular endocardium at both end-diastole and end-systole in a four chamber or RV focussed apical view, without including the trabeculation in the wall (Figure 3). This parameter, FAC, has been found to correlate well with right ventricular ejection fraction on cardiac magnetic resonance imaging (CMR), with a figure of greater than 35% considered normal [7]. Reduced FAC has been shown to be an independent predictor of heart failure, sudden cardiac death, stroke and mortality in patients suffering pulmonary embolism [14]. Meta-analysis suggests it is more accurate as a measure of RV function than tricuspid annular plane systolic excursion (TAPSE), although care needs to be taken to acquire good views [15]. Its primary limitation is the requirement of good endocardial definition, which is often difficult, particularly in the heavily trabeculated free wall [16].

Two-Dimensional (2D) Volume and Ejection Fraction (EF) Estimation

Due to the complexity of the right ventricular geometry, 2D EF estimation is difficult and limited due to the required assumptions. It can be divided into area-length methods or disk summation methods. The area-length method, historically derived from angiographic assessment, requires approximation of the right ventricular geometry, most often based on ellipsoidal models. It has been shown to grossly underestimate MRI-derived right ventricular volumes. The disk summation method, generally performed in the apical view, excludes the right ventricular outflow tract (RVOT) and therefore, again, underestimates EF. Due to the inaccuracy of both methods, they are not recommended during routine assessment of the RV [7].

Three-Dimensional (3D) Volume and Ejection Fraction Estimation

Many newer ultrasound systems have 3D capability which can be used for assessment of RV structure and function (Figure 4). They use a matrix transducer to acquire a 3D volume in one or more heartbeats. The choice of acquisition mode will depend on the capability of the ultrasound system and trade-offs between spatial and temporal resolution. The technical challenge is to include the entire RV volume, from tricuspid valve to pulmonary valve in the ultrasound volume at adequate spatial and temporal resolution without "stitching" artefact if multibeat acquisition is used. Often a modified apical view or RV focussed view is best with the transducer located slightly lateral to the true apex.

Three-dimensional volume measurement is superior to 2D assessment as it accounts for complex RV geometry. Studies have yielded good correlation with MRI and in vitro studies [17]. However, the current recommended reference ranges show a significant range between low and upper values. For example, the end systolic volume 'normal' ranges from 12 to 45 mL/m^2 [7]. Three-dimensional echocardiography has been shown to have less systematic underestimation and an improved test-retest variation when compared to 2D assessment [18]. Due to the challenges of correctly identifying the endocardial border in the heavily trabeculated RV, 3D echo

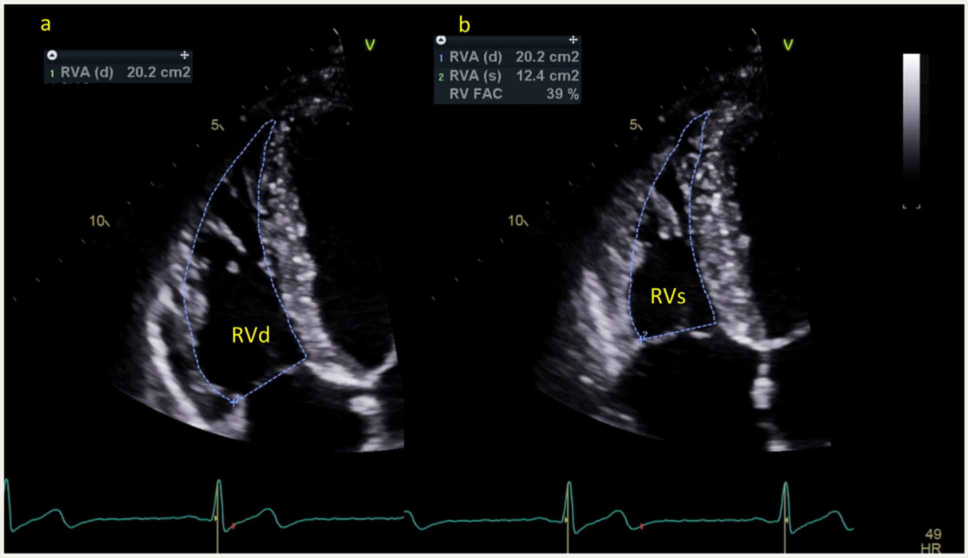

Figure 3 Measurement of right ventricular fractional area change (RV FAC).
Panel a, RV endocardial border traced at end-diastole; Panel b, RV endocardial border traced at end-systole.
Abbreviations: RV, right ventricular; RVd, right ventricle at end-diastole; RVs, right ventricle at end-systole; FAC, fractional area change.

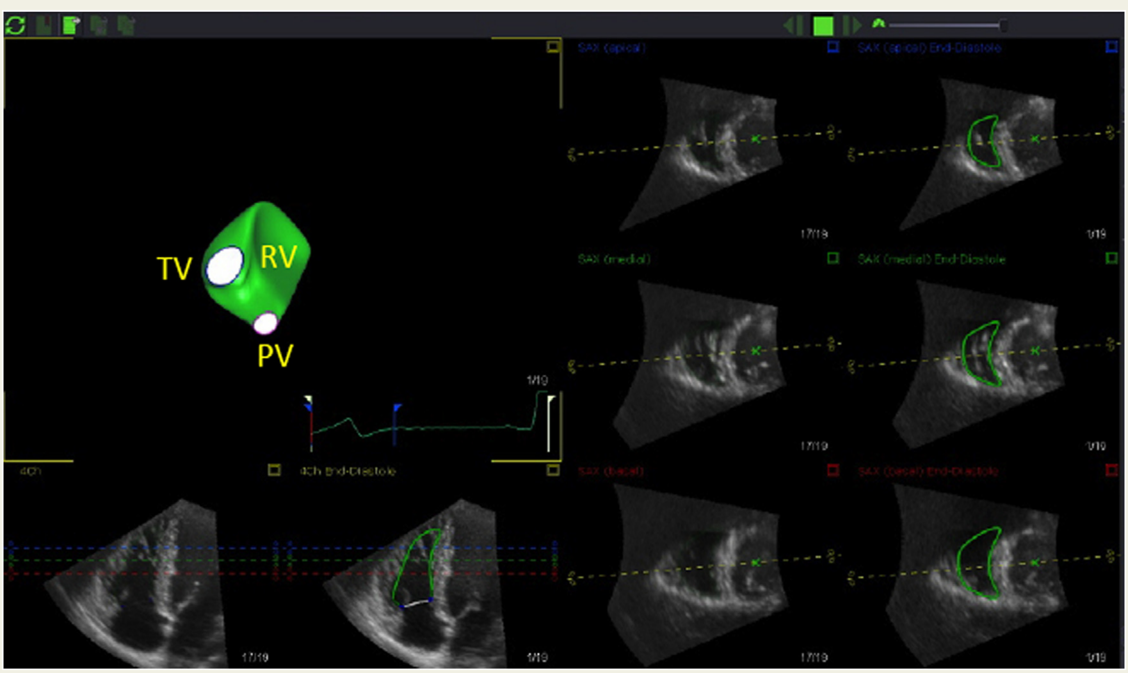

Figure 4 Measurement of RV volumes and ejection fraction using 3D echocardiography. End-diastolic and end-systolic volumes are determined after the endocardial borders are identified from the 3D dataset and used to calculate the right ventricular ejection fraction. The effect of the convex RV surface of the interventricular septum on the shape of the left venticular cavity can be seen on modelled RV cavity shape.
Abbreviations: RV, right ventricle; TV, tricuspid valve; PV, pulmonary valve; 3D, three dimensional.

yields systematically lower volumes than those obtained by CMR, however RVEF correlates well. Due to the technical limitation of 3D imaging as well as limitations in the image quality, the current recommendation is that 3D echocardiography should be used in conjunction with 2D imaging in the assessment of RV ventricular volumes and function.

Global Assessment of the Right Ventricle

Right Ventricular Rate of Change of Pressure (RV dP/dt)

The use of the rate of change of pressure (dP/dt) in the ventricles has historically been validated predominantly in the left ventricle. As early as the 1960s, the rate of change of pressure has been described for the right ventricle. The value is usually calculated from the slope of the line between 1 and 2 m/sec (4 to 16 mmHg) of the TR spectral display. Although the lack of normative values and the fact it is highly load dependent [16], limits its use in routine echocardiography, it may still be useful in serial monitoring of patients with right ventricular dysfunction. Its principal benefit is its ease of acquisition as well as its sound physiological basis [7].

A RV dP/dt of <400 is likely to be abnormal.

Right Ventricular Index of Myocardial Performance (RIMP)

RIMP (Tei Index) is an index of global right ventricular performance analogous to that measured for the LV and is derived from

$$\frac{\textit{Tricuspid valve closure time} - \textit{Ejection Time}}{\textit{Ejection Time}}$$

This is most often acquired using pulsed wave Doppler tissue imaging (DTI) at the lateral tricuspid annulus (Figure 5). The timings can also be calculated using pulsed wave blood pool Doppler of the RVOT and the tricuspid inflow. The latter method requires measurements of two different cardiac cycles, therefore, in order to ensure accuracy, a consistent R-R interval is required. For that reason, use of the DTI method is preferred. The index is a parameter which reflects both RV systolic and diastolic function.

Right ventricular index of myocardial performance has been found to be a prognostic marker in patients with pulmonary hypertension, both as a single measurement, as well as when evaluated serially [19]. It has been studied in right ventricular infarction, hypertrophic cardiomyopathy and congenital heart disease.

A RIMP of less than 0.4 via pulsed Doppler method and 0.55 via tissue Doppler method are considered abnormal.

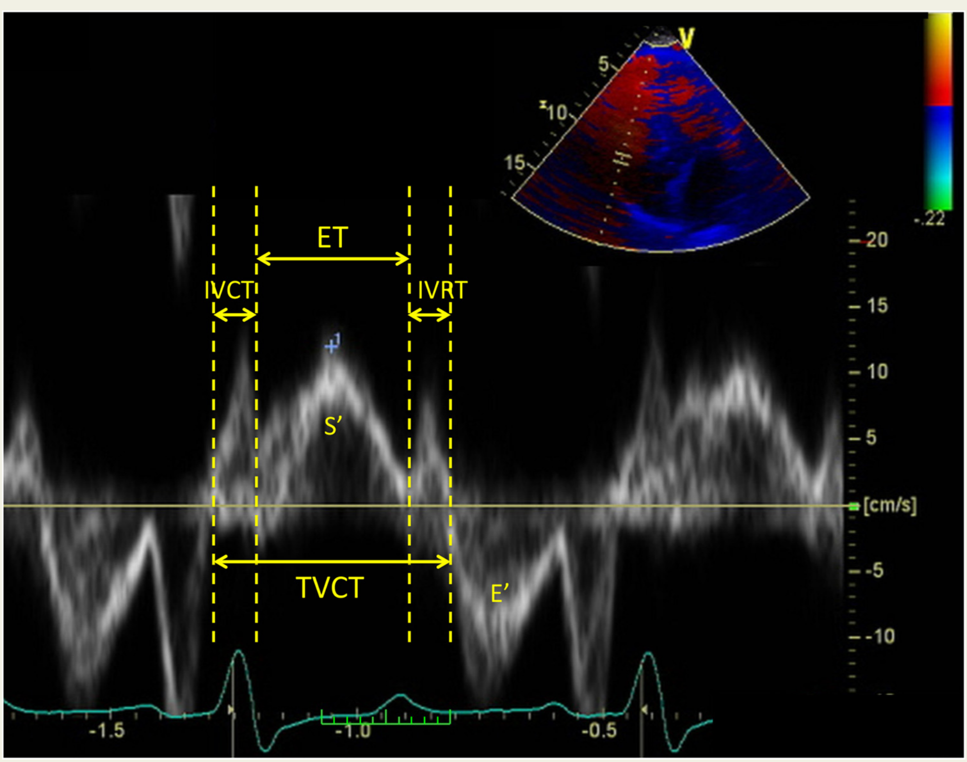

Figure 5 Measurement of intervals used for calculation of RIMP from DTI of the tricuspid annulus.
Abbreviations: RIMP, Right Ventricular Index of Myocardial Performance; DTI, Doppler tissue Imaging; S′ systolic motion, E′, early diastolic motion; IVCT, isovolumic contraction time; ET, ejection time; IVRT, isovolumic relaxation time; TVCT, tricuspid valve closure time.

Regional Assessment of the Right Ventricle

Tricuspid Annular Plane Systolic Excursion (TAPSE)

TAPSE is a measure of longitudinal contraction of the RV. It is assessed using an M-mode cursor from an apical view placed through the lateral tricuspid annulus, and measures the longitudinal excursion of the annulus from end-diastole to peak systole (Figure 6). The key strength of TAPSE is its simplicity as it can be measured on all ultrasound machines. It has been shown to have prognostic value in a variety of conditions which may affect the RV such as heart failure with preserved or reduced ejection fraction [20] and pulmonary hypertension [21]. As with all regional assessments of function, the obvious assumption made is that the longitudinal function of the RV free wall is indicative of function of the RV as a whole. This assumption is clearly not applicable in some situations such as myocardial infarction.

As discussed previously, RV contraction has a predominantly longitudinal component in the healthy individual, however, as the right ventricle dilates the radial component becomes important. This introduces an element of error in assessment of RV function as TAPSE only measures the longitudinal component of contraction. TAPSE can also be falsely reassuring in the setting of significant right ventricular impairment if the left ventricular apex has a significant rotational component. This causes the right ventricle free wall to be pulled, without significant contraction. This dragging motion can give a falsely normal TAPSE measurement despite significant dysfunction. Use of multiple measures of RV function can overcome this limitation. TAPSE has, however, been demonstrated to be highly reproducible with minimal inter-observer variability. A TAPSE <16 mm is considered to be abnormal with good specificity, but poor sensitivity.

Doppler Tissue Imaging (DTI)

The measurement of tissue Doppler-derived right ventricular systolic excursion velocity (RV S′) is similar in many ways to TAPSE, being unidimensional and evaluating longitudinal function, thus making the same assumptions with many of the same limitations. It is, however, highly reproducible. It uses a pulsed wave (PW) sample volume at the lateral tricuspid annulus from an apical transducer position (Figure 7). While it is acknowledged that there is a fall in RV S′ with age, a value <10 cm/s is considered abnormal, particularly in young patients.

While the annular velocity has been shown to correlate well with overall right ventricular function, the measurement of systolic excursion velocities at other points of the right ventricular free wall should be discouraged due to difficulty with standardisation and interpretation. It is also challenging to adequately align the ultrasound probe with the area of interest, as an oblique angle of insonation can add significant error to the measurement. So whilst tricuspid annular TDI is recommended for routine use, myocardial DTI is currently not [7].

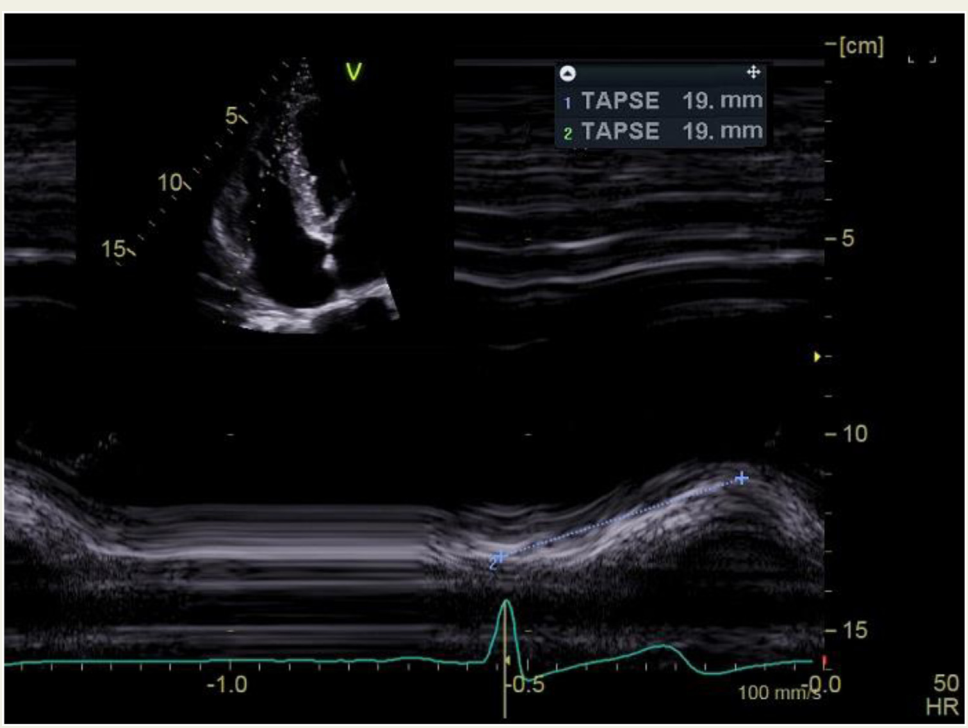

Figure 6 Measurement of triscupid annular plane systolic excursion (TAPSE) from M-mode of the tricuspid annulus.

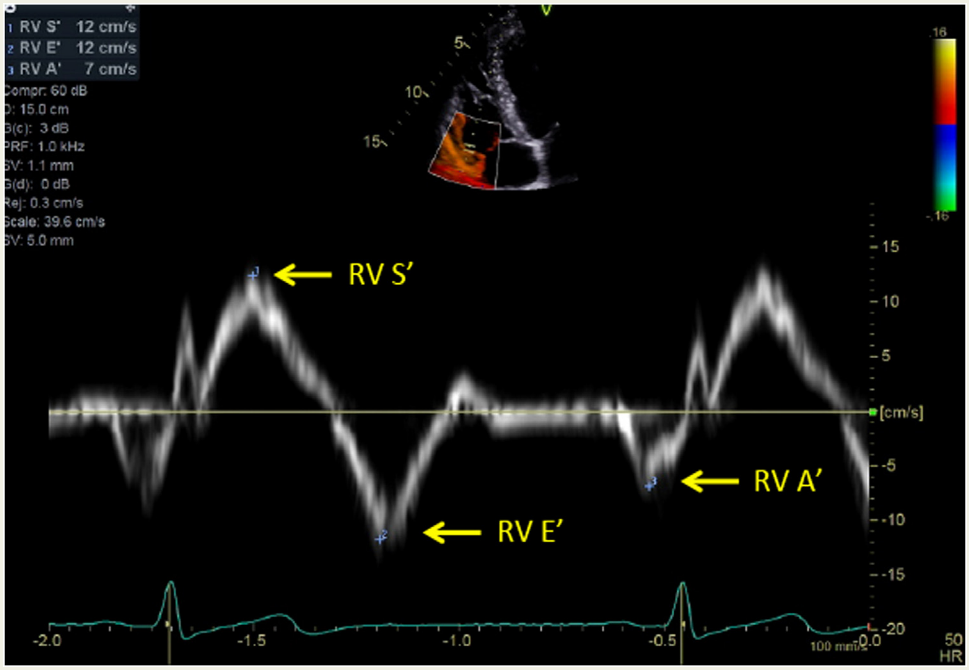

Figure 7 Measurement of tricuspid annular motion using Doppler tissue imaging. The key parameter of systolic function measured is peak systolic velocity (RV S′).

Myocardial Acceleration During Isovolumic Contraction

Myocardial acceleration during isovolumic contraction is defined as the peak isovolumic myocardial velocity divided by the time to reach peak velocity. It is usually measured from colour TDI images. This measure, in contrast to those mentioned above, is relatively load-independent as it occurs during the isovolumic period and decreases with RV dysfunction. It has been shown to correlate with disease severity in a variety of conditions including: obstructive sleep apnoea, congenital heart disease, and mitral stenosis. It does, however, lack sensitivity and has a large confidence interval for the normal values. It is therefore not recommended for routine use, but may be useful in patients with conditions known to affect right ventricular function [7].

An isovolumic acceleration (IVA) $>2.2\,m/s^2$ is considered normal, however the 95% confidence interval is $1.4–3.0\,m/s^2$

Tissue Deformation Imaging: Right Ventricular Strain and Strain Rate

Strain is a measure of myocardial deformation defined as the percentage change in the length of a segment of myocardium, while strain rate is the derivative of the strain, and therefore, represents the strain change over time. It now well accepted that strain and strain rate closely correlate with myocardial contractility [4].

One-Dimensional Strain

Doppler tissue imaging velocities can be used to derive strain rate (from the difference in velocity between two known locations within the myocardium) and from this, measures of one-dimensional strain can be calculated. Right ventricular free wall longitudinal strain, is measured from the apical four-chamber view. DTI-derived strain can be measured in the basal and mid free wall and sometimes at the apex. However, it is highly operator-dependent and, more importantly, angle dependent [7].

While it has been validated in a number of conditions [16], there is currently a lack of normative studies. Published studies had limitations due to varying algorithms between vendors and difficulties in reproducibility leading to large confidence intervals [7]. The major advantage of this method is the rapid sampling rate which currently makes it the only viable method for measuring RV strain during exercise [22].

Two-Dimensional Strain

Two-dimensional, or ‘‘speckle tracking’’ strain is a newer method that allows tissue tracking to occur in two dimensions. It allows global and regional strain to be measured using frame by frame tracking of unique ‘‘speckles’’ within the myocardium produced by interference between scattered ultrasound waves (Figure 8). The biggest advantage over one dimensional strain is angle independence, although temporal resolution is lower. This technique is well validated in the left ventricle and has been studied in patients with systemic right ventricle as well as in patients with pulmonary hypertension [7]. There is still some conjecture about whether strain analysis of the RV should look at the RV free wall alone or whether the strain in the interventricular septum should be included as a measure of global longitudinal RV strain. From a technical point of view, it is important to ensure that the region of interest is not too wide so it is confined to the RV free wall avoiding the RV cavity and pericardium.

This parameter shows great promise, however there are challenges due to differences in algorithms between vendors, variation in normal ranges between imaging platforms, limiting serial tracking of strain values across platforms [7]. Normal ranges are still being established, however a value for free wall strain <20% is likely to be abnormal.

Three-Dimensional Strain

Some vendors have developed the ability to track speckles in three dimensions and therefore assess the complex motion patterns of the ventricles in three dimensions. It also allows newer parameters such as ‘‘area strain’’, a measure combining deformation in two directions, to be measured. Three-dimensional/4D strain has been studied in a preliminary fashion within the right ventricle in both animals and humans, but at present requires more research and is not ready for ‘‘prime-time’’ [23].

Assessment of RV Function During Exercise Stress

Most evaluation of RV structure and function is performed at rest, however, it is possible that some abnormalities may only be unmasked by stress testing of the right ventricle. It has been demonstrated that reduced RV contractile reserve during exercise testing detected by either echocardiography or CMR may differentiate athletes with occult RV dysfunction from normal athletes [24]. Although the study primarily used CMR, similar findings were achieved using FAC by echocardiography, a more widely available technique. Whether this approach finds routine clinical use with further study in a wider variety of conditions is unclear, but it has appeal as a technique for identification of early disease in those with normal resting RV function.

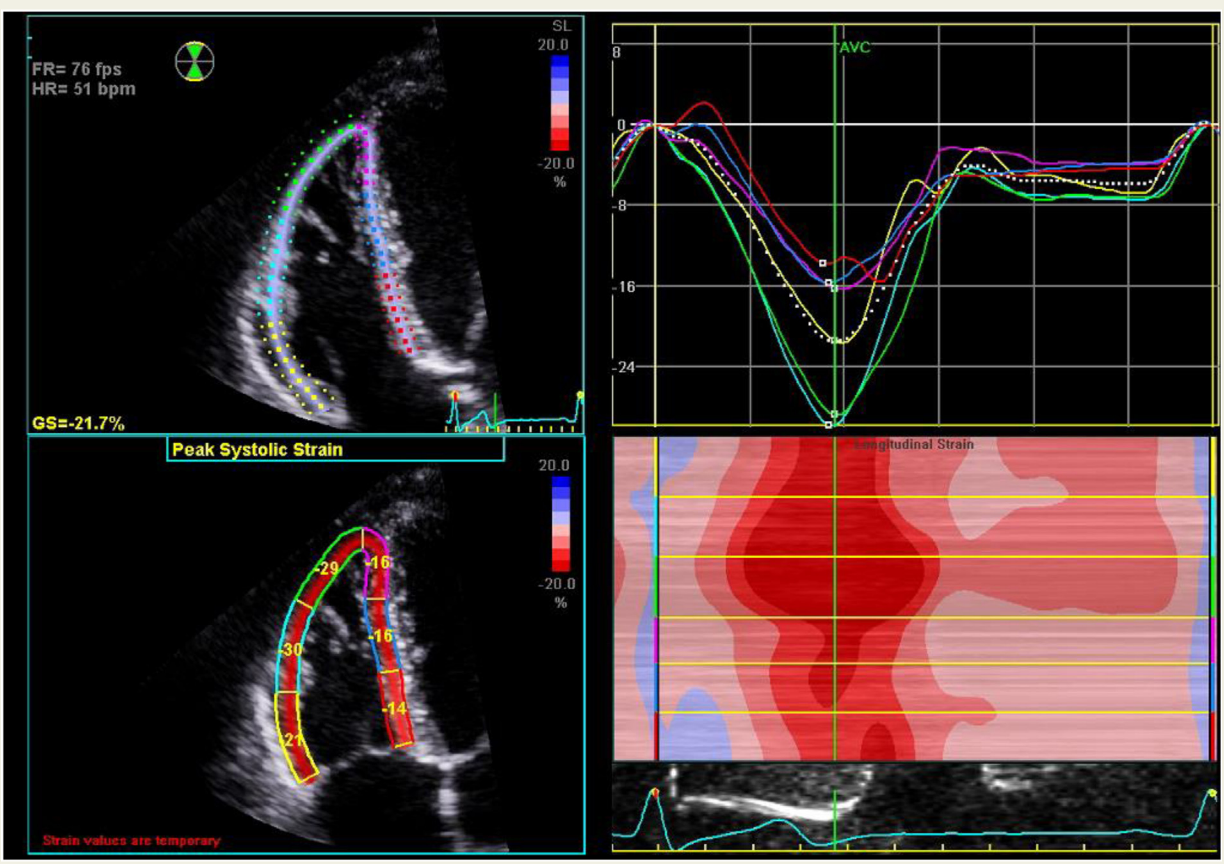

Figure 8 Measurement of right ventricular (RV) strain using both the free wall and interventricular septum from an RV focussed apical view. It is important to include the entire RV free wall, including the apical segment and to ensure correct placement of the region of interest within the RV free wall.

Current Guideline Recommendations

Although now somewhat old, current guidelines from both the American Society of Echocardiography [7] and the European Society of Cardiology [16] place emphasis on the importance of assessing RV function as part of routine transthoracic echocardiogram. To do this both organisations recommend using multiple quantitative methods for assessment.

Important Clinical Applications

Pulmonary Hypertension

Pulmonary hypertension (PH) is defined as a mean Pulmonary Artery Pressure (mPAP) greater than 25 mmHg. Echocardiographic estimation of the RV systolic pressure from the tricuspid regurgitation velocity is well validated, but requires accurate alignment with the TR jet, is operator dependent, particularly where there is a weak TR signal and is not able to be accurately measured in up to 40% of patients. This can be decreased to just 5% through the use of agitated saline study or echocardiographic contrast agents. Agitated saline or contrast, injected intravenously, can be used to highlight the regurgitant jet and enable accurate assessment of pulmonary pressures (Figure 9). Right ventricular systolic pressure may be under or over-estimated due to incorrect measurement of the spectral Doppler TR display. Measurement of an incomplete TR envelope will lead to underestimation. On the other hand, measuring the ‘‘chin’’ rather than the ‘‘beard’’ of the spectral Doppler display improves correlation with invasive measures (Figure 10) as measurement of the ‘‘beard’’ leads to over-estimation [25].

Right ventricular systolic pressure and pulmonary artery (PA) systolic pressure are equal in the absence of right ventricular outflow obstruction and pulmonary stenosis [26]. The mean PA pressure can be derived from echocardiographic measurement of the systolic pulmonary artery pressure [27] and the diastolic pulmonary artery pressure [7] or from PA acceleration time [28], however there is substantial potential for error. Echocardiography can also be used to calculate pulmonary vascular resistance, using the TR-jet and RVOT time-velocity integral (TVI) [29], but lacks accuracy, particularly for serial assessment [30]. While there is clinical utility in these echocardiographic estimates of pulmonary haemodynamics, right heart catheterisation remains the gold standard for diagnosis of pulmonary hypertension.

Two-dimensional imaging, DTI, 2D and 3D strain and 3D echocardiography, have been shown to be effective in the assessment of RV function in the setting of PH. Right ventricular measurements (particularly right ventricular diameter) TAPSE, Tei (RIMP) index and reduction in GLS have been shown to be associated with mortality and morbidity in patients with PH [26].

Three-dimensional echocardiography may also provide insight into the underlying class of pulmonary hypertension, particularly the remodelling which occurs. Studies have found more adverse right ventricular remodelling, particularly restriction of tricuspid valve motion, in patients suffering pulmonary arterial hypertension rather than chronic thromboembolic pulmonary hypertension (CTEPH) or secondary pulmonary hypertension [31,32].

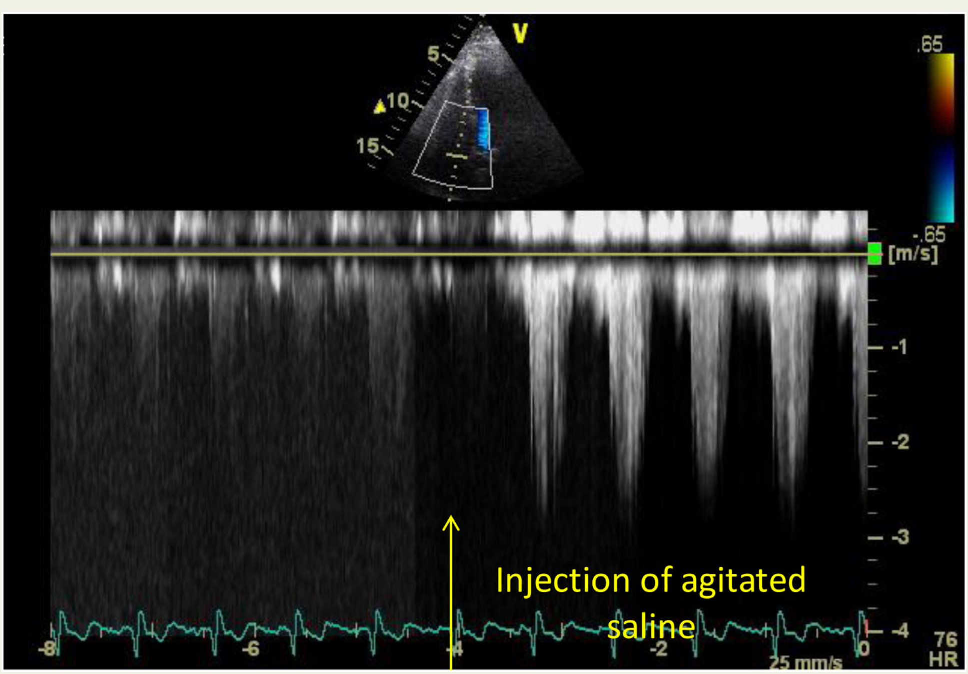

Figure 9 Effect of intravenous agitated saline contrast to enhance a weak tricuspid regurgitation signal.

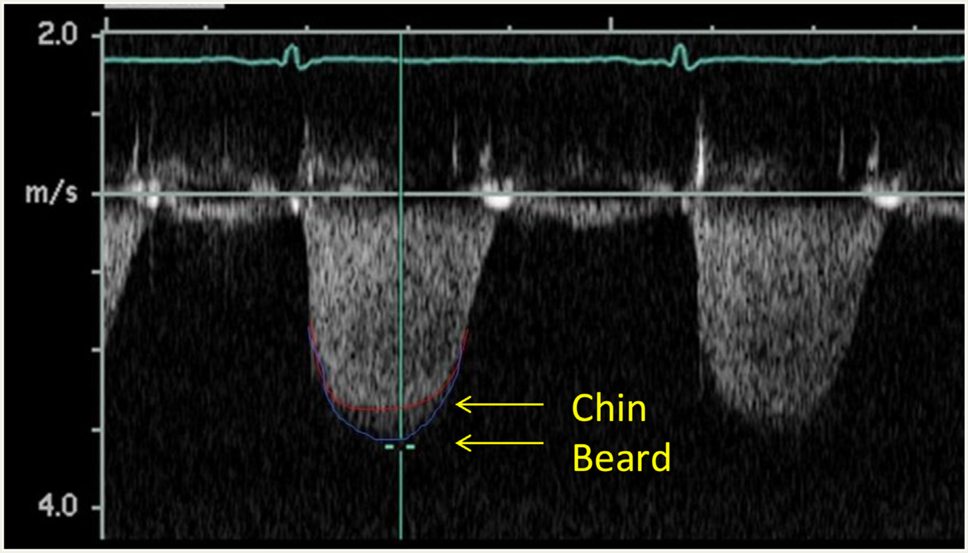

Figure 10 Use of the ''chin'' rather than the ''beard'' to correctly measure peak velocity from tricuspid regurgitation spectral display in estimation of RV systolic pressure.

Pulmonary Embolism

Pulmonary embolism (PE) is a major source of mortality and morbidity with death due to acute failure of the right ventricle In haemodynamically significant PEs (''massive PE'') thrombolytic therapy has been shown to be beneficial [33]. However, in patients presenting without haemodynamically significant PEs (''sub-massive PE'') the presence of right ventricular dysfunction may guide selection of patients for thrombolysis with some studies showing improvements in mortality and morbidity. Therefore, the accurate assessment of the right ventricle in the acute setting is critical in identifying this intermediate-risk group. The Pulmonary Embolism Thrombolysis—PLEITHO trial used at least one of: right ventricular end-diastolic diameter >30 mm, right ventricular end-diastolic ratio >0.9, right ventricular free wall hypokinesis or peak tricuspid regurgitation velocity >2.5 m/s as markers for right ventricular dysfunction [34]. Other echocardiographic features, historically associated with PE, such as McConnell's sign (right ventricular free wall impairment with apical sparing) [35], the ''60/60'' sign (the presence of shortened pulmonary ejection acceleration time [PAAcT] [<60 msec] with midsystolic velocity deceleration [''notch''], tricuspid regurgitation peak systolic gradient [TRPG] <60 mmHg) [36] and the presence of isolated right ventricular thrombosis, have been shown to lack specificity and sensitivity and are not recommended for use in the clinical setting.

RV Function in Left Heart Disease

Right ventricular function has been shown to provide additional prognostic information in the setting of left heart disease. More specifically, RV impairment confers adverse prognosis when associated with heart failure with reduced [1] and preserved [3] ejection fraction and in valvular diseases such as aortic stenosis [37]. For this reason quantitation of RV function is encouraged in these clinical settings.

Conclusion

The echocardiographic assessment of the right ventricle remains challenging due to technical difficulties in its imaging, in addition to its complex geometry and function. While qualitative methods for assessment are commonly used, current guidelines recommend a move to more quantitative measures as part of routine echocardiography. We recommend the routine measurement of RV basal and RVOT proximal dimensions, RV wall thickness, FAC, TAPSE, RVS' and estimation of RV systolic pressure in all patients. When available, novel approaches to right ventricular assessment such as 3D echocardiography and right ventricular strain should be used in conjunction with more established quantitative measures to ensure an accurate assessment of the right ventricle is part of routine care.

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