Guidelines for the Echocardiographic Assessment of the Right Heart in Adults: A Report from the American Society of Echocardiography

Endorsed by the European Association of Echocardiography, a registered branch of the European Society of Cardiology, and the Canadian Society of Echocardiography

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Parameters should be performed and reported for right heart

- Right ventricular (RV) size
- Right atrial (RA) size
- RV systolic function (at least one of the following)
  - Fractional area change(FAC)
  - S’
  - Tricuspid annular plane systolic excursion (TAPSE)
  - With or without RV index of myocardial performance(RIMP)
  - Systolic pulmonary artery pressure(SPAP) with estimate of RA pressure on the basis of IVC size and collapse

Table 1 Summary of reference limits for recommended measures of right heart structure and function

Variable	Unit	Abnormal	Illustration
Chamber dimensions			
RV basal diameter	cm	>4.2	Figure 7
RV subcostal wall thickness	cm	>0.5	Figure 5
RVOT PSAX distal diameter	cm	>2.7	Figure 8
RVOT PLAX proximal diameter	cm	>3.3	Figure 8
RA major dimension	cm	>5.3	Figure 3
RA minor dimension	cm	>4.4	Figure 3
RA end-systolic area	cm^2	>18	Figure 3
Systolic function			
TAPSE	cm	<1.6	Figure 17
Pulsed Doppler peak velocity at the annulus	cm/s	<10	Figure 16
Pulsed Doppler MPI	—	>0.40	Figure 16
Tissue Doppler MPI	—	>0.55	Figures 16 and 18
FAC (%)	%	<35	Figure 9
Diastolic function			
E/A ratio	—	<0.8 or >2.1	
E/E′ ratio	—	>6	
Deceleration time (ms)	ms	<120	

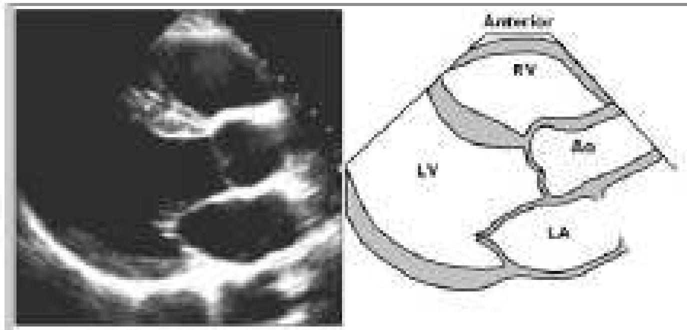
FAC, Fractional area change; *MPI*, myocardial performance index; *PLAX*, parasternal long-axis; *PSAX*, parasternal short-axis; *RA*, right atrium; *RV*, right ventricle; *RVD*, right ventricular diameter; *RVOT*, right ventricular outflow tract; *TAPSE*, tricuspid annular plane systolic excursion.

Essential imaging windows and views

- Apical 4-chamber
- Modified apical 4-chamber
- Left parasternal long-axis(PLAX)
- Parasternal short axis(PSAX)
- Left parasternal RV inflow and subcostal views

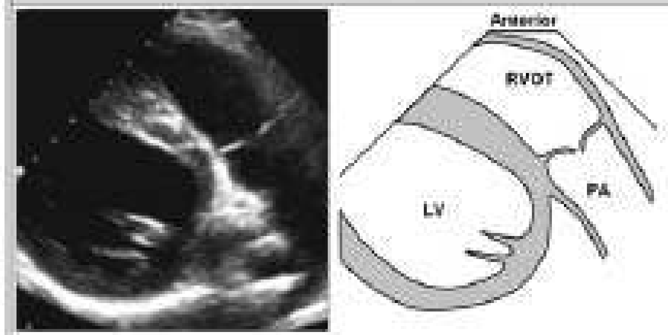
Providing images for the comprehensive assessment of RV systolic and diastolic function and RV systolic pressure(RVSP)

Parasternal long axis views



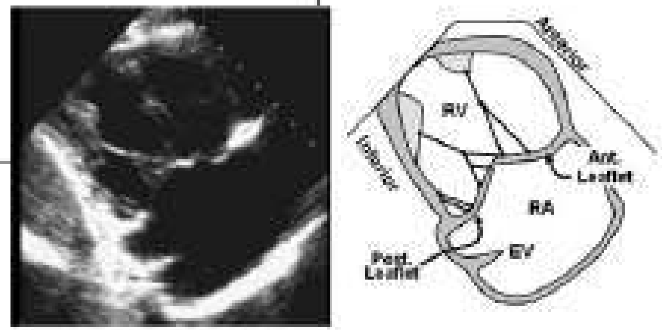
Parasternal long-axis of RV anterior wall

- Used for measurement of RV enlargement, RV wall thickness and the RVOT dimension by 2D.
- View is highly variable depending on transducer angulation and the rib interspace position from which it was obtained. Therefore it should not be the sole view to evaluate RVOT size.



Parasternal long-axis of RVOT and PA

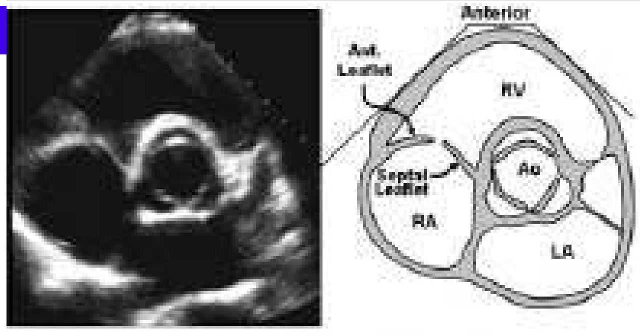
- Shows anterior RVOT in its long-axis view with infundibular segment. The pulmonary valve and main PA are also visible.
- Used to measure pulmonary annular dimension and to assess pulmonary valve.



Parasternal long-axis view of RV inflow

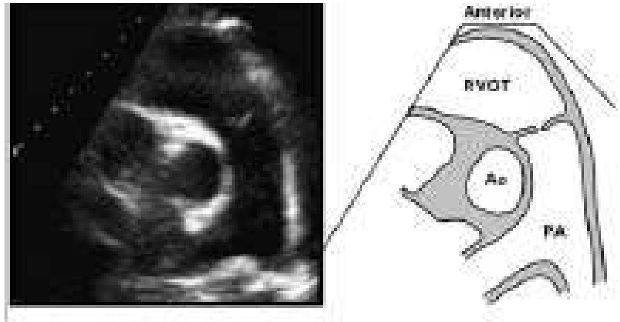
- Important view to assess anterior/inferior RV wall and anterior/posterior tricuspid valve leaflets.
- Anterior and posterior papillary muscles, chordal attachment, and ostium of inferior vena cava including the Eustachian valve are visible. The coronary sinus (not shown) may also be seen in this view.
- TR jet parameters can be measured in this view provided the TR jet is parallel to the U/S beam.

Parasternal short axis views



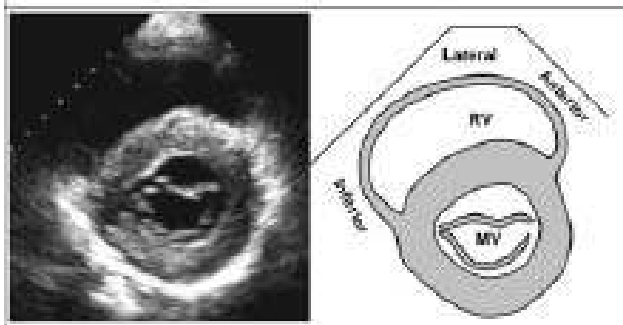
Parasternal short-axis of basal RV

- Shows the basal anterior RV wall, RVOT, tricuspid valve, pulmonary valve and RA.
- Normally used to measure RVOT dimension in diastole.
- TR jet parameters can be measured in this view provided the TR jet is parallel to the U/S beam.
- Used to assess the interatrial septum for shunts (particularly patent foramen ovale flow just posterior to the aortic root



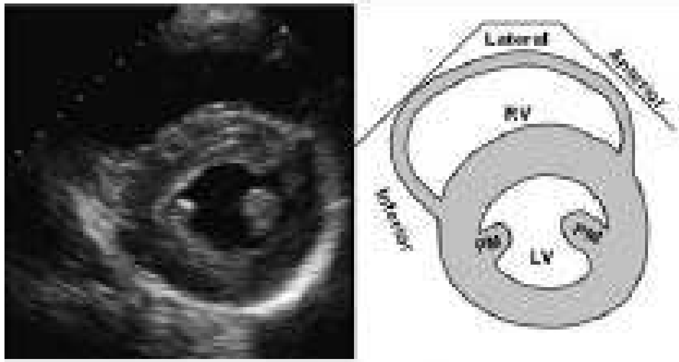
Parasternal short-axis of bifurcation of the PA

- Used to assess the pulmonary valve, pulmonary artery and its branches.
- Used for measuring pulmonary annulus dimension, pulmonary artery size and for Doppler measurement of the infundibulum, pulmonary valve and pulmonary artery.
- Proximal and distal RVOT segments are also visible.



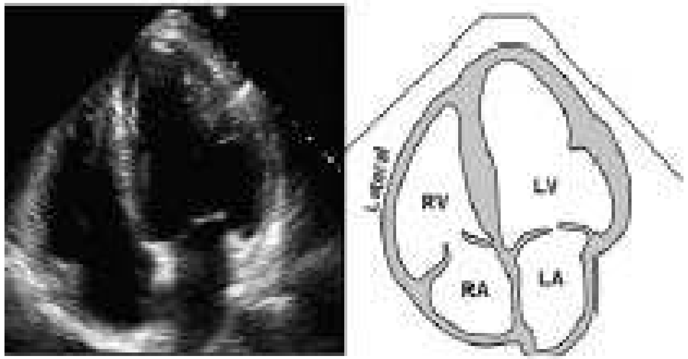
Parasternal RV short-axis at MV level

- Basal level of anterior, inferior and lateral RV walls.
- A crescent shape of RV is well appreciated in this view.
- Septal flattening in systole or diastole from RV volume or pressure overload is often best appreciated in this view.
- Valuable for initial assessment of RV size, but cannot be used for assessment of RV systolic function due to the asymmetric nature of RV contraction.



Parasternal RV short-axis at papillary muscle (PM) level

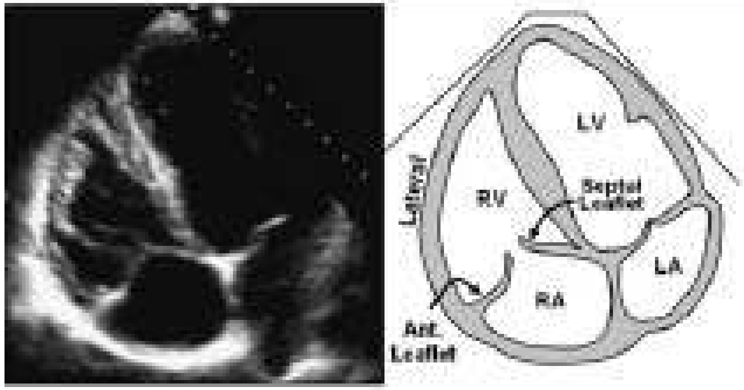
- Mid-level of anterior, inferior and lateral RV walls are shown in this view.
- A crescent shape of RV is well appreciated in this view.
- Septal flattening in systole or diastole from RV volume or pressure overload is also clearly seen in this view.
- Valuable for initial assessment of RV size, but cannot be used for assessment of RV systolic function due to the asymmetric nature of RV contraction.



Apical 4-chamber

- Useful view for demonstrating RV/RA size, shape and function.
- Used to measure RV maximal long-axis distance, minor distances at base and mid-level, RV area and RV fractional area change. RA major and minor axis dimensions; RA area and volume are commonly measured here.
- RV inflow, TR jet by Doppler, tricuspid annulus excursion by M-mode and RV strain by tissue Doppler are also commonly assessed in this view.
- TR jet parameters can be measured in this view provided the TR jet is parallel to the U/S beam.

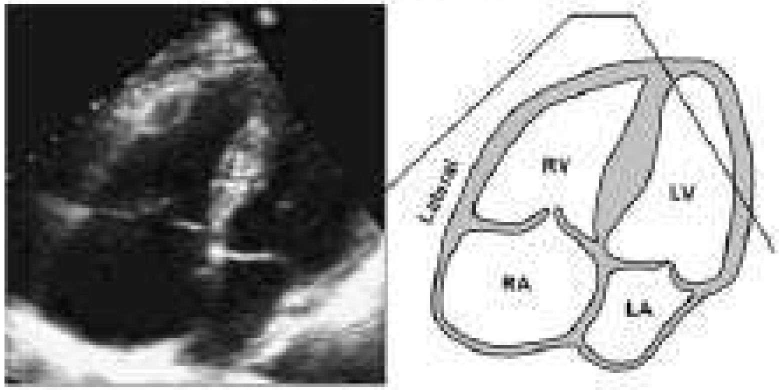
RV focused and RV modified apical 4 chamber views



RV focused apical 4-chamber

Recommended alternative to Apical 4-chamber to measure RV minor dimension in basal segment of the RV.

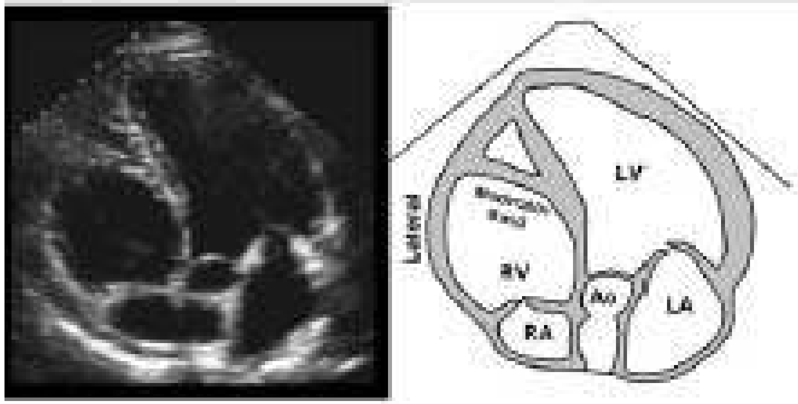
- Useful view for demonstrating RV/RA size, shape and function, with enhanced visualization of the RV free wall.
- TR jet parameters can be measured in this view provided the TR jet is parallel to the U/S beam.



RV modified apical 4-chamber

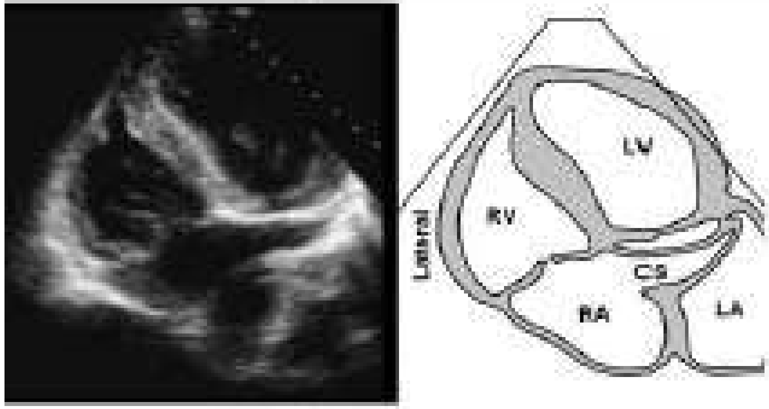
- This modified 4-chamber view provides information about a portion of the lateral RV wall and oblique plane of the RA.
- It should **not** be used quantitatively to assess RA due to its foreshortened and oblique image angle and should **not** be used for measurement of RV dimensions
- It can be used to measure RV inflow parameters and TR parameters provided the TR jet is parallel to the ultrasound beam.
- ASD and PFO flow can be assessed with 2D and color Doppler

Apical 5 chamber and apical coronary sinus views



RV apical 5-chamber view

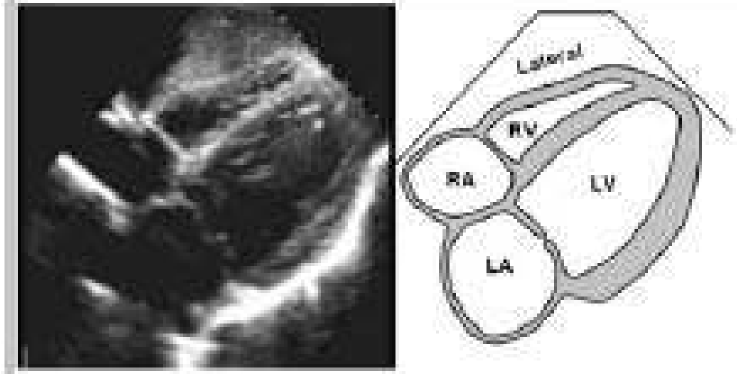
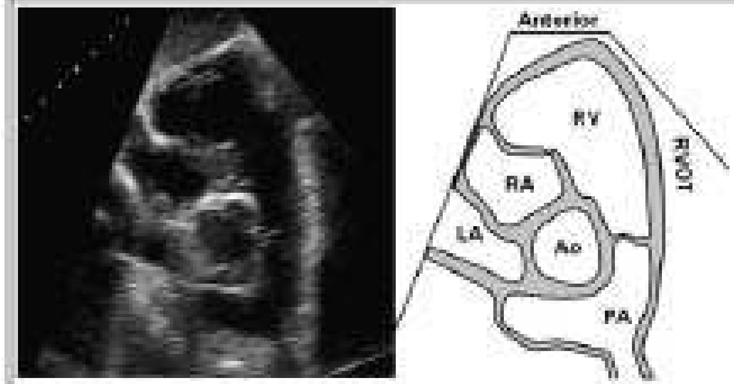
- Modified view to visualize the anterolateral RV wall.
- The moderator band is best visualized in this view.
- TR jet parameters can be measured in this view provided the TR jet is parallel to the U/S beam.



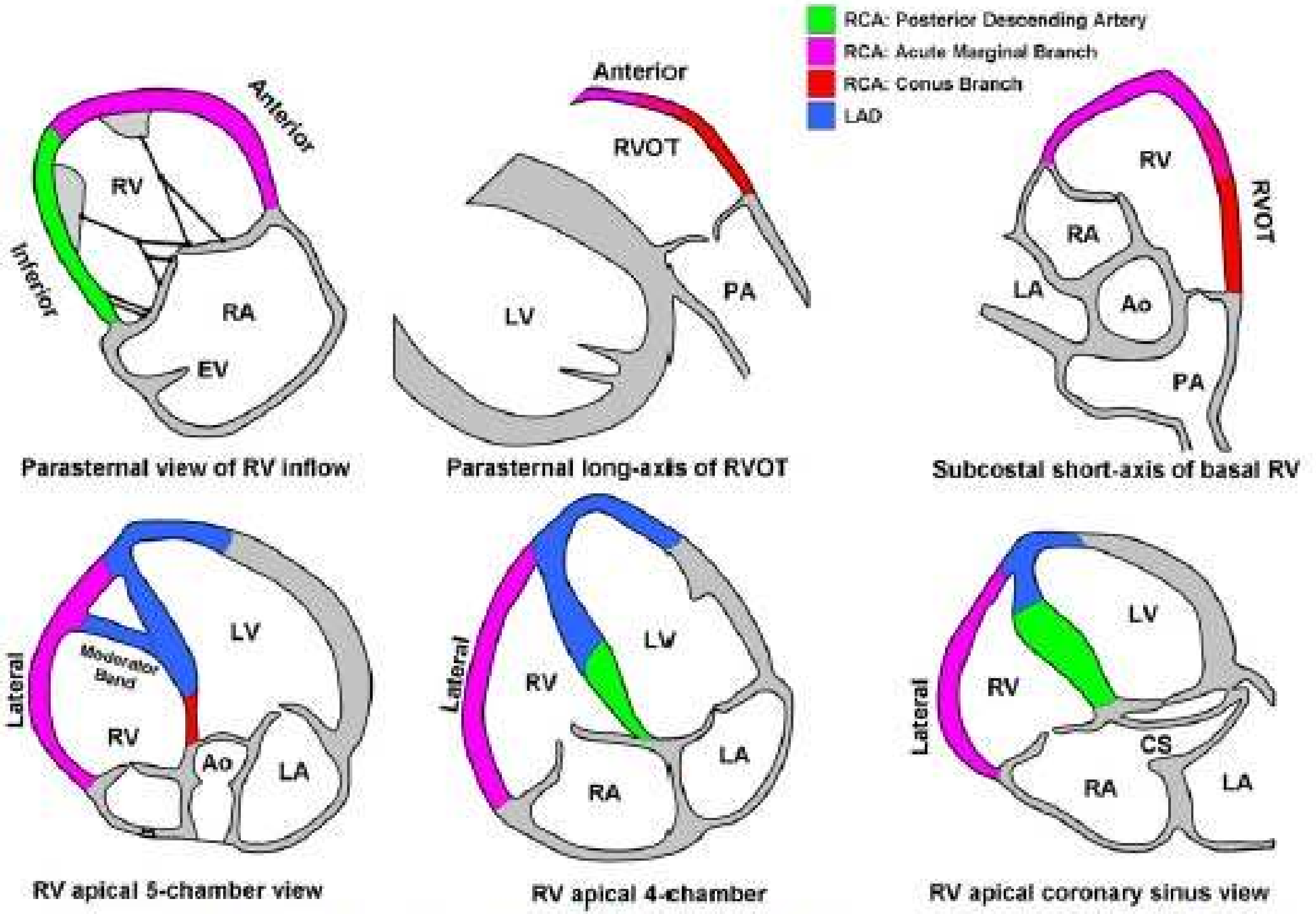
Apical coronary sinus view

- Modified view to visualize posterolateral RV wall.
- The coronary sinus is best visualized in this view.
- TR jet parameters can be measured in this view provided the TR jet is parallel to the U/S beam.

Subcostal views

 RV subcostal 4-chamber	▪ The RV wall thickness is best measured in this view. ▪ It is useful for evaluation of the RV/RA wall inversion/collapse in diagnosing patients with cardiac tamponade. ▪ ASD and PFO are often best shown in this view with 2D and color Doppler. ▪ Used to visualize but not quantify RV/RA sizes due to its foreshortened and oblique angle. ▪ TR jet parameters can be measured in this view provided the TR jet is parallel to the U/S beam.
 Subcostal short-axis of basal RV	▪ Base of the RV wall including RV inflow, RV outflow, pulmonary valve, pulmonary artery and its branches are well visualized. ▪ RVOT dimension can also be measured in this view. ▪ Used for Doppler measurement of the infundibulum, pulmonary valve and pulmonary artery

Segmental nomenclature of the RV walls



Right heart dimensions

- RV dimension
- RA dimension
- RVOT dimension
- RV wall thickness
- IVC dimension

Conventional 2D assessment of RA

- Right atrium acts as
  1. a reservoir for systemic venous return when the tricuspid valve is closed.
  2. a passive conduit in early diastole when the tricuspid valve is open
  3. An active conduit in late diastole during atrial contraction

Assessments of RA

1. RA size
2. RA pressure

Right atrial dimension

- Apical 4-chamber view
- RA enlargement
  - RA area > 18cm2
  - RA length >53mm (major dimension)
  - RA diameter > 44mm (minor dimension)

RA dimensions can be distorted and falsely enlarged in patients with chest and thoracic spine deformities.

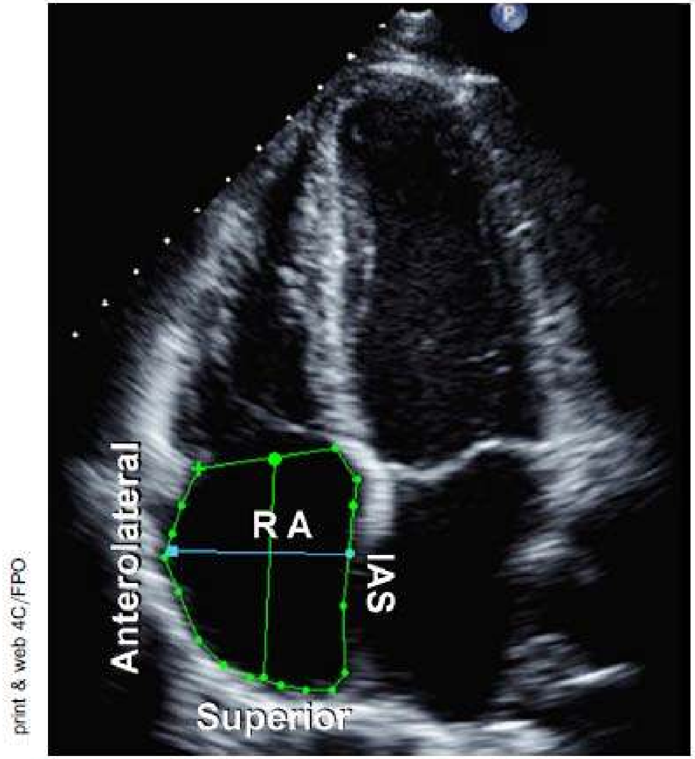
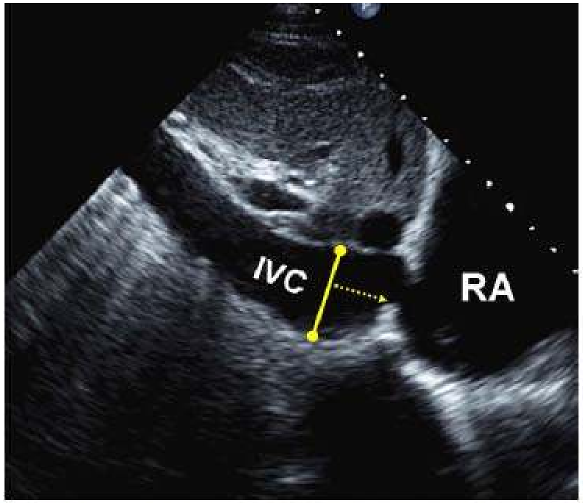


Figure 3 Tracing of the right atrium (RA) is performed from the plane of the tricuspid annulus (TA), along the interatrial septum (IAS), superior and anterolateral walls of the RA. The right atrial major dimension is represented by the *green line* from the TA center to the superior right atrial wall, and the right atrial minor dimension is represented by the *blue line* from the anterolateral wall to the IAS.

RA pressure

- Mostly estimated by IVC diameter and the presence of inspiratory collapse.*
- In patients being ventilated using positive pressure, the degree of IVC collapse cannot be used to reliably estimated RA pressure and RA pressure measured by transduction of a central line should be used if available.
  - An IVC $\leq$ 12 mm in these patients appears accurate in identifying patients with RA pressure < 10mm Hg.
  - In the same patients group, if the IVC is small and collapses, this suggest hypovolemia.

IVC dimension



- Subcostal view
- Measured just proximal to the entrance of hepa veins
- Normal RA pressure of 3 mmHg(0-5mmHg)
  - IVC ≦ 2.1 cm that collapse > 50% with a sniff
- High RA pressure of 15 mmHg(10-20 mmHg)
  - IVC > 2.1 cm that collapses < 50% with a sniff

- In normal young athletes, the IVC may be dilated in the presence of normal pressure

- IVC is commonly dilated and may not collapse in patients on ventilators, so it should not be used in such cases to estimate RA pressure.

Elevated RA pressure

- Hepatic vein systolic filling fraction
  - Vs/(Vs+Vd)
  - < 55% to be the most sensitive and specific sign of elevated RA pressure.
- Other 2D signs of increased RA pressure (qualitative and comparative)
  - A dilated right atrium
  - An interatrial septum bulging into the LA throughout the cardiac cycle.

Table 3 Estimation of RA pressure on the basis of IVC diameter and collapse

Variable	Normal (0-5 [3] mm Hg)	Intermediate (5-10 [8] mm Hg)		High (15 mm Hg)
IVC diameter	≤2.1 cm	≤2.1 cm	>2.1 cm	>2.1 cm
Collapse with sniff	>50%	<50%	>50%	<50%
Secondary indices of elevated RA pressure				• Restrictive filling • Tricuspid E/E′ > 6 • Diastolic flow predominance in hepatic veins (systolic filling fraction < 55%)

Ranges are provided for low and intermediate categories, but for simplicity, midrange values of 3 mm Hg for normal and 8 mm Hg for intermediate are suggested. Intermediate (8 mm Hg) RA pressures may be downgraded to normal (3 mm Hg) if no secondary indices of elevated RA pressure are present, upgraded to high if minimal collapse with sniff (<35%) and secondary indices of elevated RA pressure are present, or left at 8 mm Hg if uncertain.

IVC, Inferior vena cava; *RA*, right atrial.

tegrated. These include restrictive right-sided diastolic filling pattern, tricuspid E/E′ ratio > 6, and diastolic flow predominance in the hepatic veins (which can be quantified as a systolic filling fraction < 55%). In indeterminate cases, if none of these secondary indices of elevated RA pressure are present, RA pressure may be downgraded to 3 mm Hg. If there is minimal IVC collapse with a sniff (<35%) and secondary indices of elevated RA pressure are present, RA pressure may be upgraded to 15 mm Hg. If uncertainty remains, RA pressure may be left at the intermediate value of 8 mm Hg. In patients who are unable to adequately perform a sniff, an IVC that collapses < 20% with quiet inspiration suggests elevated RA pressure. This method of assigning an RA pressure is preferable to assuming a fixed RA pressure value for all patients.

Conventional 2D assessment of RV

- RV wall thickness
- RV linear dimensions

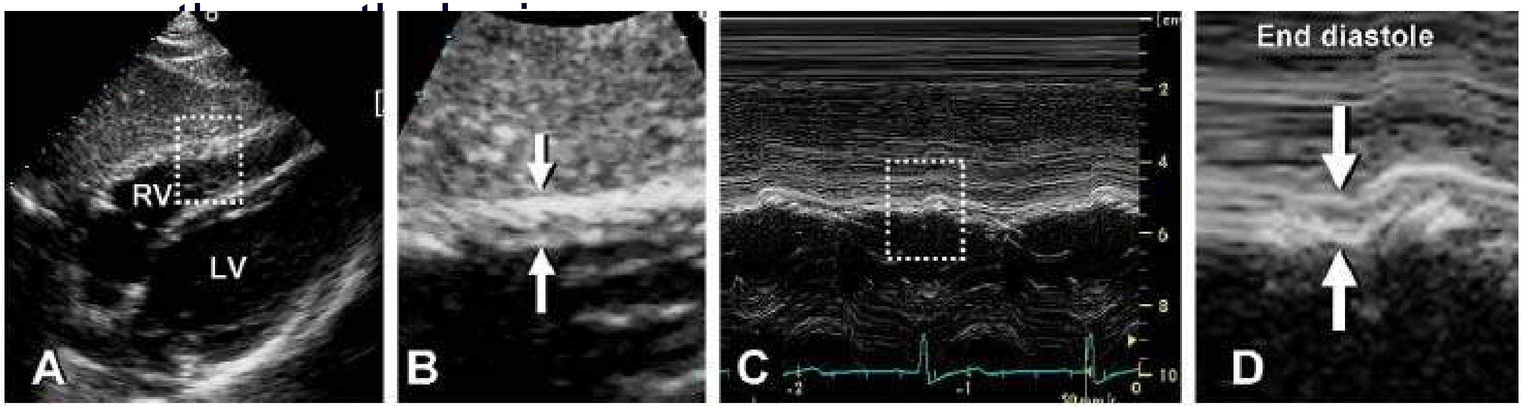
RV wall thickness

- Useful measurement for RVH, usually the result of RVSP overload.
- Increased RV thickness can be seen in
  - infiltrative cardiomyopathies,
  - hypertrophic cardiomyopathies,
  - in patients with significant LVH, even in the absence of PH

- Conditions associated with RV wall thinning:
    - Uhl anomaly,
    - arrhythmogenic RV cardiomyopathy(ARVD).
  - There are no accepted echocardiographic criteria to define an abnormally thin RV wall

RV wall thickness

- Measured in diastole.
- From the subcostal view using either M-mode or 2D imaging
- Alternative view: left parasternal view
- RVH:
  - Thickness > 5mm
  - May suggest RV pressure overload in the absence of



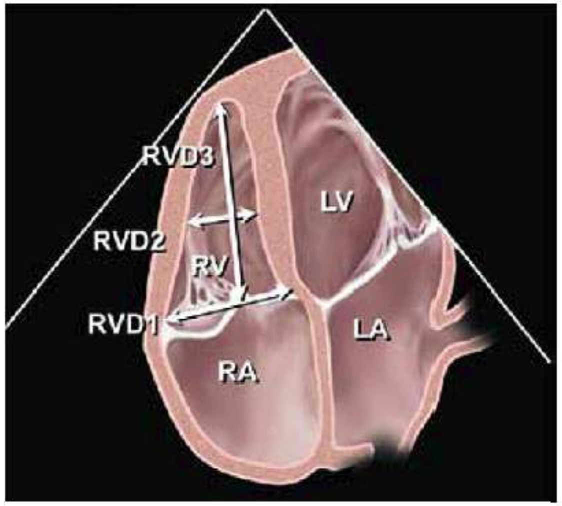
RV linear dimensions

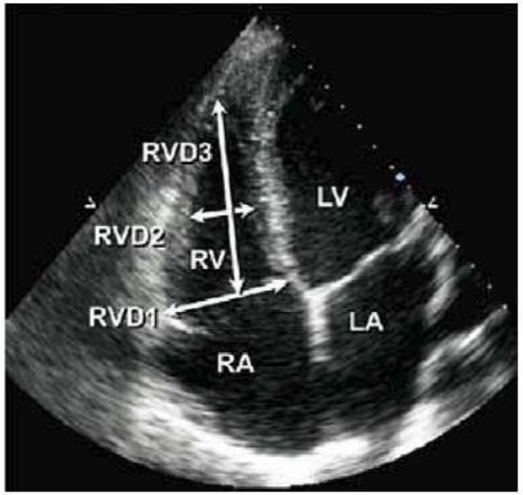
- RV dilated in response to chronic volume and/or pressure overload and with RV failure.
- RVEDD index:
  - A predictor of survival in patients with chronic pulmonary disease
- RVEDD/LVEDD ratio:
  - A predictor of adverse clinical events and/or hospital survival in patients with acute pulmonary embolism
- Correlation with RV linear dimensions with RV EDV appears to worsen with increased preload or afterload.

Right ventricle dimension

- Best estimated at end-diastole from a RV-focused apical 4-chamber view

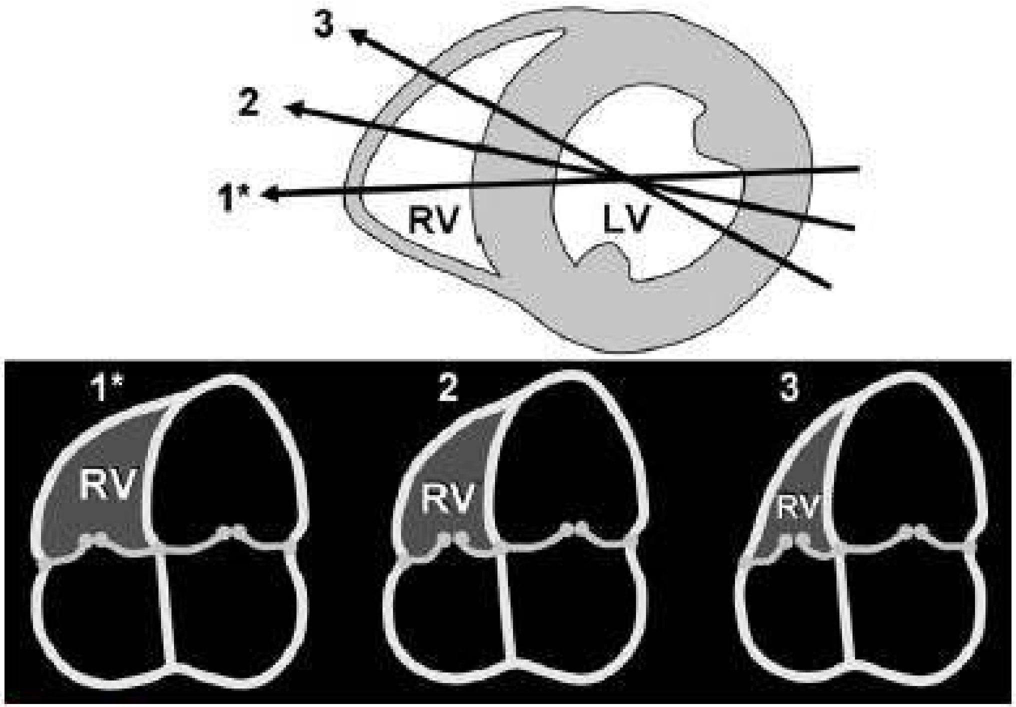
- RV enlargement:
  - Diameter > 42 mm at the base
  - Diameter > 35 mm at the mid level
  - Longitudinal dimension > 86mm





Limitation of RV imaging by TTE

- Lack of fixed reference points to ensure optimization o



- RV dimensions can be distorted and falsely enlarged in patients with chest and thoracic spine deformities.

Conventional 2D assessment of RVOT

- RVOT includes
  - The subpulmonary infundibulum
  - Cornus
  - The pulmonary valve

- The RVOT is often the 1st segment of the RV to show diastolic inversion in the setting of tamponade.

Conventional 2D assessment of RVOT

- Best viewed from
  - The parasternal and subcostal windows
  - The apical window in thin individuals or adults with large rib spaces
- Measured at end-diastole on the QRS

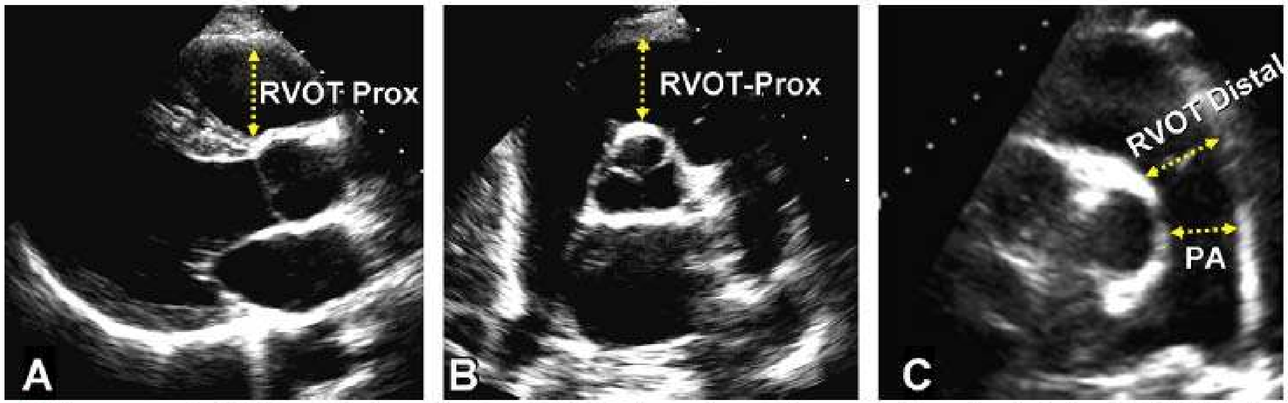
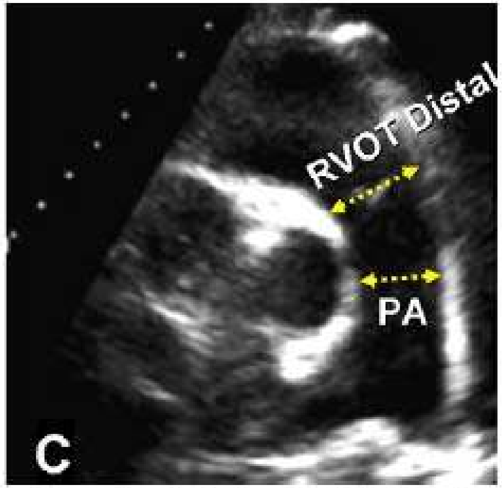
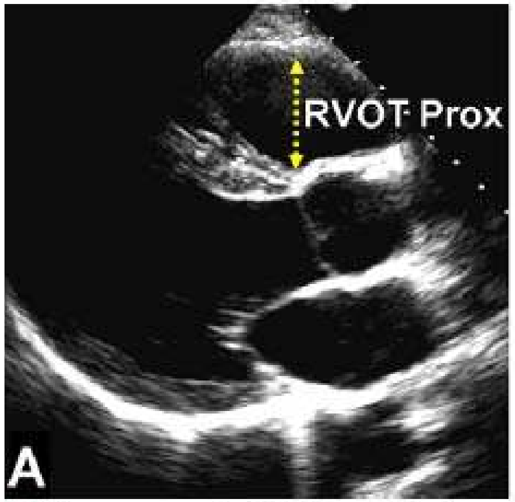


Figure 8 Measurement of right ventricular outflow tract (RVOT) dimensions at the proximal or subvalvular level (RVOT-Prox) and at the distal or pulmonic valve (RVOT-Distal) in the **(A)** parasternal long-axis RVOT anterior portion view, **(B)** basal parasternal short-axis view, and **(C)** parasternal short-axis of pulmonary bifurcation view. *PA*, Pulmonary artery dimension between valve and the bifurcation point.

RVOT dimension

- Left PSAX: at the level of the pulmonic valve (distal diameter)
- Left PLAX: the proximal portion of the RVOT (proximal diameter)
- RVOT dilatation:
  - Diameter> 27 mm (PSAX) and > 33 mm (PLAX) at end-diastole at distal diameter





RVOT dimensions can be distorted and falsely enlarged in patients with chest and thoracic spine deformities.

RV systolic functions

- *Right ventricular index of myocardial performance (RIMP)*
- *Tricuspid annular plane systolic excursion(TAPSE)*
- *2D RV fractional area change(FAC)*
- 2D RV EF
- 3D RV EF
- *Tissue Doppler-derived tricuspid lateral systolic velocity (S')*
- Longitudinal strain and strain rate

RV systolic functions

- Fractional area change and volumetric assessment
  - RA area and FAC
  - 2D volume and EF estimation
  - 3D volume estimation
- The RV and interventricular septal morphology

RV systolic functions

- Hemodynamic assessment of the RV and pulmonary circulation
  - Systolic pulmonary artery pressure(SPAP)
  - PA diastolic pressure
  - Mean PA pressure
  - Pulmonary vascular resistance
  - Measurement of PA pressured during exercise

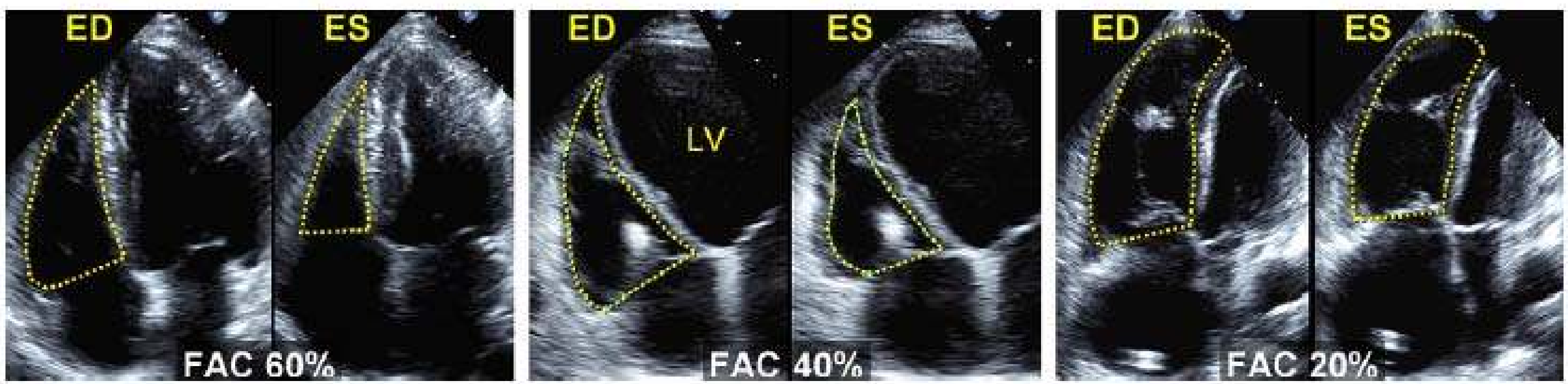
- Nonvolumic assessment of RV function
  - Global assessment
    - RVdp/dt
    - RIMP
  - Regional assessment
    - TAPSE or tricuspid annular motion(TAM)
    - Doppler tissue image
    - Myocardial acceleration during isovolumic contraction
    - Regional RV stain and strain rate
    - 2D strain

2D RV fractional area change(FAC)

- (RV end-diastolic area – RV end-systolic area)/ RV end-diastolic area x 100
- A measure of RV systolic function
- An independent predictors of
  - heart failure,
  - sudden death,
  - stroke, and/or
  - mortality in studies of patients after pulmonary embolism and MI.

2D RV fractional area change(FAC)

- An estimate of RV systolic function
- RV systolic dysfunction
  - 2D FAC < 35%



2D volume and EF estimation

- 2D echo methods of calculating RV volume
  - Area-length method
    - Biplane angiography
    - Require an approximation of RV geometry
      - Based on modified pyramidal or ellipsoidal models
    - Underestimating MRI-derived RV volume
    - Inferior in comparison with 3D echo methods of RV volume estimation

  - Disk summation method
    - To determine a RV “ body” volume
      - Using predominantly the apical 4-chamber view.
    - Underestimation of RV volume because of the exclusion of the RVOT and technical limitations of the echo images

2D volume and EF estimation

- RV EF= (RVEDV-RVESV)/ RVEDV
  - The lower reference limit: 44% (38-50% with a 95% CI)

2D derived estimation of RV EF is not recommended, because of the heterogeneity of methods and the numerous geometric assumptions.

3D echo estimation of RV volume

- The disk summation and apical rotational methods for RV volume and EF calculation are most commonly use in 3D TTE or TEE.
  - Both correlate with MRI-derived RV volumes.
- Less underestimation of RVEDV
- Improved test-retest variability compared with 2D echo.
- Indexed RVEDV < $89 ml/m^2$
- Indexed RVESV < $45 ml/m^2$
- RVEF > 44%

3D echo estimation of RV volume

Advantages: RV volumes and EF may be accurately measured by 3D echocardiography using validated real-time 3D algorithms.

Disadvantages: Limited normative data are available, with studies using different methods and small numbers of subjects. RV volumes by both 2D and 3D echocardiography tend to underestimate MRI-derived RV volumes, although 3D methods are more accurate. Moreover, the 3D disk summation method is a relatively time-consuming measurement to make. Finally, fewer data are available in significantly dilated or dysfunctional ventricles, making the accuracy of 3D volumes and EFs less certain.

Recommendations: In studies in selected patients with RV dilatation or dysfunction, 3D echocardiography using the disk summation method may be used to report RV EFs. A lower reference limit of 44% has been obtained from pooled data. Until more studies are published, it may be reasonable to reserve 3D methods for serial volume and EF determinations.

Table 4 Systolic function

Variable	Studies	n	LRV (95% CI)	Mean (95% CI)	URV (95% CI)
TAPSE (mm) (Figure 17)	46	2320	16 (15-18)	23 (22-24)	30 (29-31)
Pulsed Doppler velocity at the annulus (cm/s)	43	2139	10 (9-11)	15 (14-15)	19 (18-20)
Color Doppler velocities at the annulus (cm/s)	5	281	6 (5-7)	10 (9-10)	14 (12-15)
Pulsed Doppler MPI (Figures 16 and 18)	17	686	0.15 (0.10-0.20)	0.28 (0.24-0.32)	0.40 (0.35-0.45)
Tissue Doppler MPI (Figure 18)	8	590	0.24 (0.16-0.32)	0.39 (0.34-0.45)	0.55 (0.47-0.63)
FAC (%) (Figure 8)	36	1276	35 (32-38)	49 (47-51)	63 (60-65)
RV EF (%) (Figure 8)	12	596	44 (38-50)	58 (53-63)	71 (66-77)
3D RV EF (%)	9	524	44 (39-49)	57 (53-61)	69 (65-74)
IVA (m/s^2)	12	389	2.2 (1.4-3.0)	3.7 (3.0-4.4)	5.2 (4.4-5.9)

CI, Confidence interval; *EF*, ejection fraction; *FAC*, fractional area change; *IVA*, isovolumic acceleration; *LRV*, lower reference value; *MPI*, myocardial performance index; *RV*, right ventricular; *TAPSE*, tricuspid annular plane systolic excursion; *3D*, three-dimensional; *URV*, upper reference value.

The RV and interventricular septal morphology

Primary pulmonary hypertension | s/p tricuspid valve resection

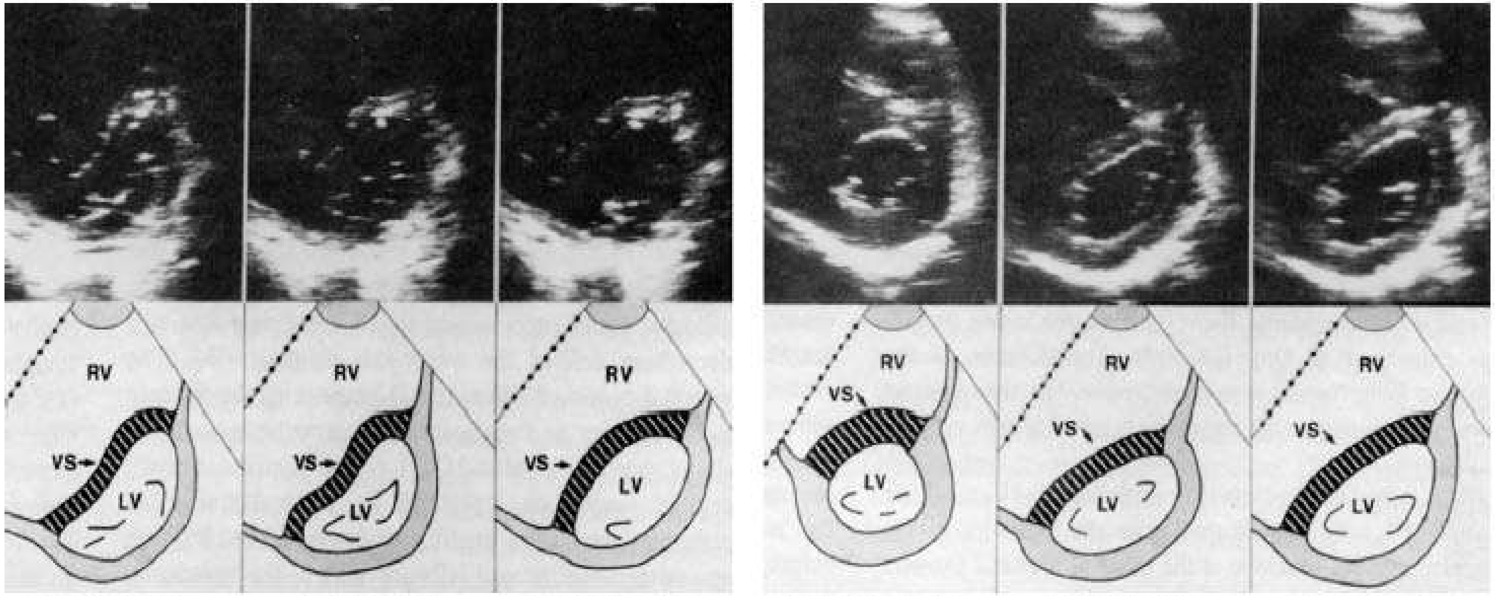


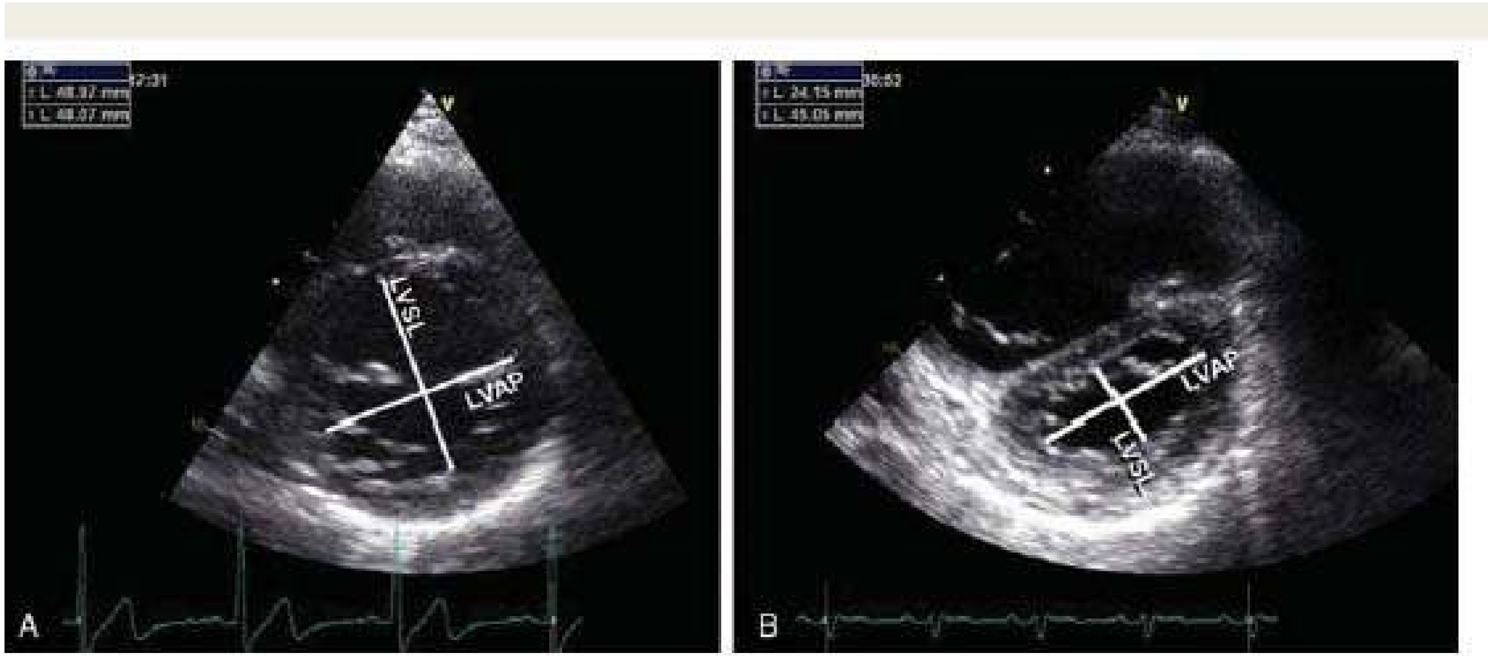
Figure 10 Serial stop-frame short-axis two-dimensional echocardiographic images of the left ventricle at the mitral chordal level with diagrams from a patient with isolated right ventricular (RV) pressure overload due to primary pulmonary hypertension *(left)* and from a patient with isolated RV volume overload due to tricuspid valve resection *(right)*. Whereas the left ventricular (LV) cavity maintains a circular profile throughout the cardiac cycle in normal subjects, in RV pressure overload there is leftward ventricular septal (VS) shift and reversal of septal curvature present throughout the cardiac cycle with most marked distortion of the left ventricle at end-systole. In the patient with RV volume overload, the septal shift and flattening of VS curvature occurs predominantly in mid to late diastole with relative sparing of LV deformation at end-systole. Reproduced with permission from *J Am Coll Cardiol*.[69]

Eccentricity index(EccIx) of LV

- Defined as
  - the ratio of the LV antero-posterior to septo-lateral diameters in a short-axis view,
  - measured at both end systole and end diastole
- Normal individuals
  - a value of 1 in both systole and diastole
- Value > 1
  - at end diastole: RV volume overload
  - at end systole and end diastole : RV pressure overload.

Eur J Echocardiogr 2010;11:81-9

Eccentricity index(EccIx) of LV



Normal heart with diastolic EccIx =1

Patient with pulmonary hypertension with diastolic EccIx > 1.8

Eur J Echocardiogr 2010;11:81-96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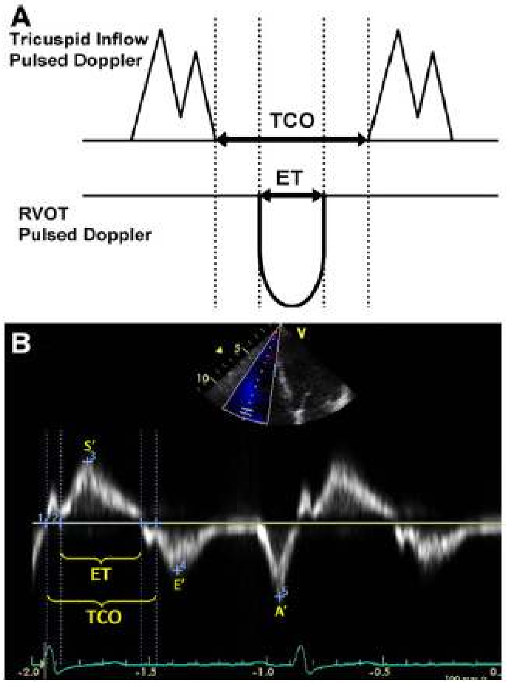
Right ventricular index of myocardial performance (RIMP)

- An index of RV global functio
- RV dysfunction
  - RIMP > 0.40 by pulse Doppler
  - RIMP > 0.55 by tissue Doppler



Falsely low in conditions associated with elevated RA pressures, which will decrease the IVRT.

Tricuspid annular plane systolic excursion(TAPSE)

- A measure of RV longitudinal function
- RV systolic dysfunction
  - TAPSE < 16 mm
- Measured from the tricuspid lateral annulus

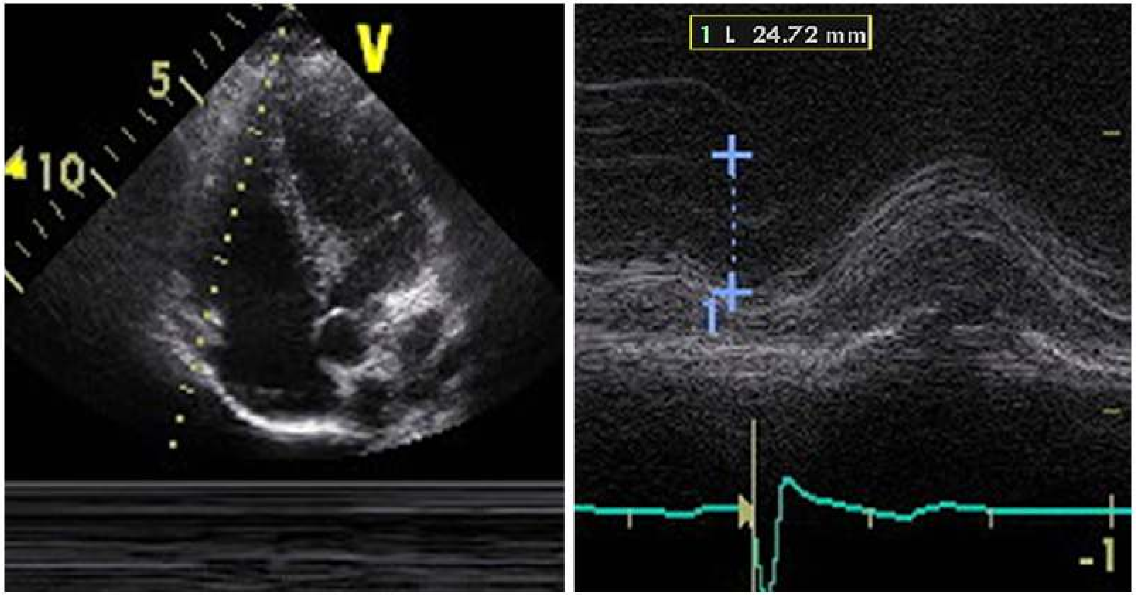
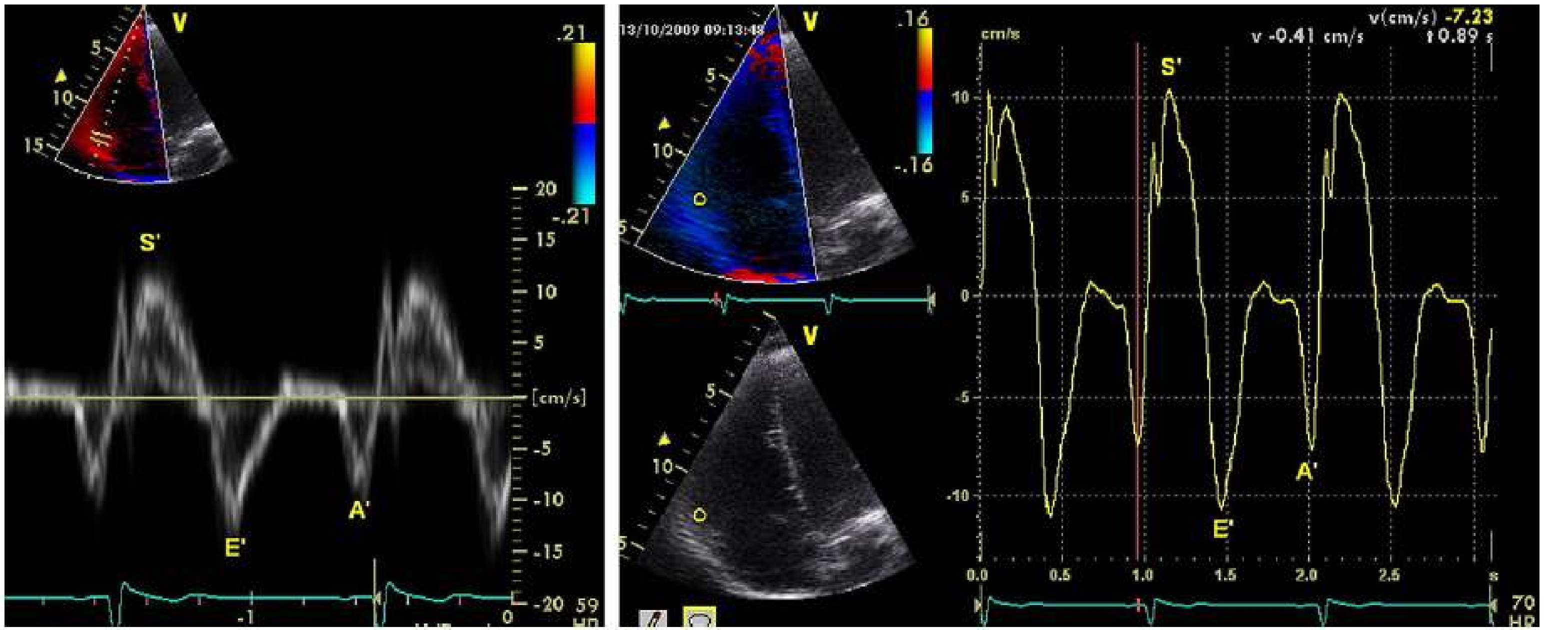


Figure 17 Measurement of tricuspid annular plane systolic excursion (TAPSE).

Tissue Doppler-derived tricuspid lateral systolic velocity (S’)

- RV systolic dysfunction
  - S’ velocity < 10 cm/s



igure 18 Tissue Doppler of the tricuspid annulus in a patient with normal right ventricular systolic function: *(left)* pulsed and *(right)* olor-coded offline analysis.

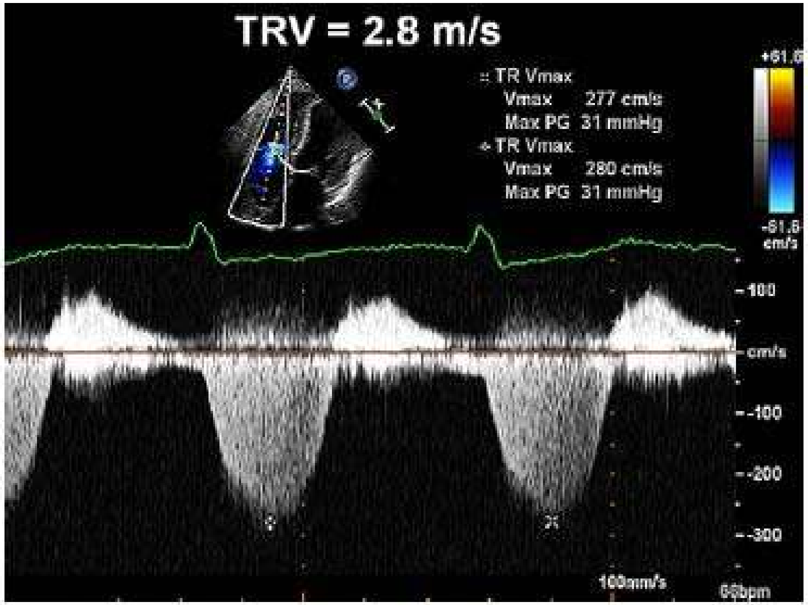


Figure 11 Doppler echocardiographic determination of systolic pulmonary artery pressure (SPAP). Spectral continuous-wave Doppler signal of tricuspid regurgitation corresponding to the right ventricular (RV)–right atrial (RA) pressure gradient. SPAP was calculated as the sum of the estimated RA pressure (RAP) and the peak pressure gradient between the peak right ventricle and the right atrium, as estimated by application of the modified Bernoulli equation to peak velocity represented by the tricuspid regurgitation Doppler signal. In this example, SPAP is estimated at 31 + central venous pressure, or 34 mm Hg, if RAP is assumed to be 3 mm Hg. Adapted with permission from *J Am Soc Echocardiogr*.[52]

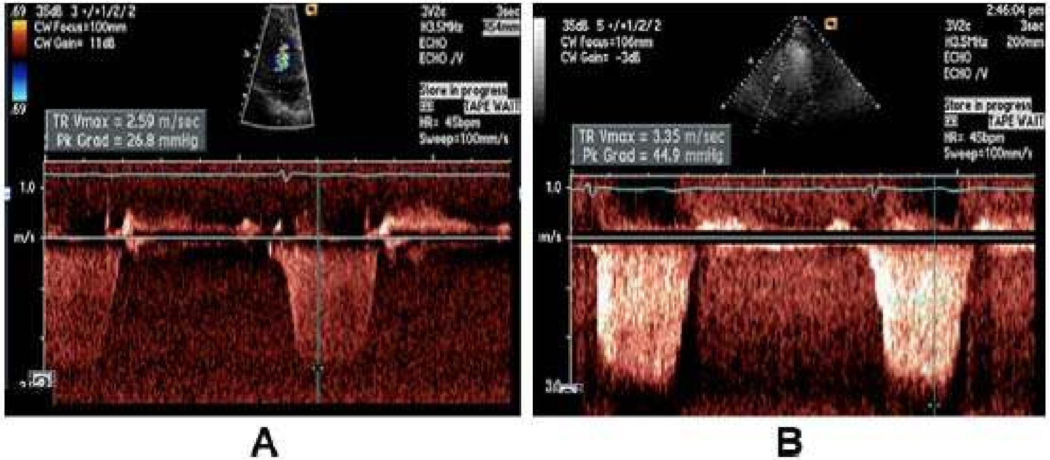


Figure 12 **(A)** Tricuspid regurgitation signal that is not contrast enhanced and correctly measured at the peak velocity. **(B)** After contrast enhancement, the clear envelope has been obscured by noise, and the reader erroneously estimated a gradient several points higher. As this example shows, it is critical that only well-defined borders be used for velocity measurement, as slight errors are magnified by the second-order relationship between velocity and derived pressure.

RV systolic pressure (RVSP)

- The velocity reliably permits estimation of RVSP with the addition of RA pressure, assuming no significant RVOT obstruction*
- TR velocity > 2.8-2.9m/s, corresponding to SPAP of approximately 36 mmHg, assuming an RA pressure of 3-5 mmHg indicates elevated RV systolic and PA pressure.
- Elevated SPAP
  - Age, obesity, stroke volume and systolic blood pressure
- Elevated SPAP may not always indicate increased pulmonary vascular resistance (PVR)
- RV diastolic function parameters and SPAP are influenced by the systolic and diastolic function of the left heart
- PA pressure should be reported along with systemic blood pressure or mean arterial pressure.

RV diastolic dysfunction

- Pulsed Doppler of the tricuspid inflow
- Tissue Doppler of the lateral tricuspid annulus
- Pulsed Doppler of the hepatic veins
- Measurements of IVC size and collapsibility

The E/A ratio, deceleration time, the E/E' ratio and RA size are recommended.

Grading of RV diastolic function

- Impaired relaxation
  - tricuspid E/A ratio < 0.8
- Pseudonormal filling
  - tricuspid E/A 0.8-2.1 with E/E'>6 or diastolic flow predominance in hepatic veins
- Restrictive filling
  - tricuspid E/A > 2.1 with deceleration time < 120 ms