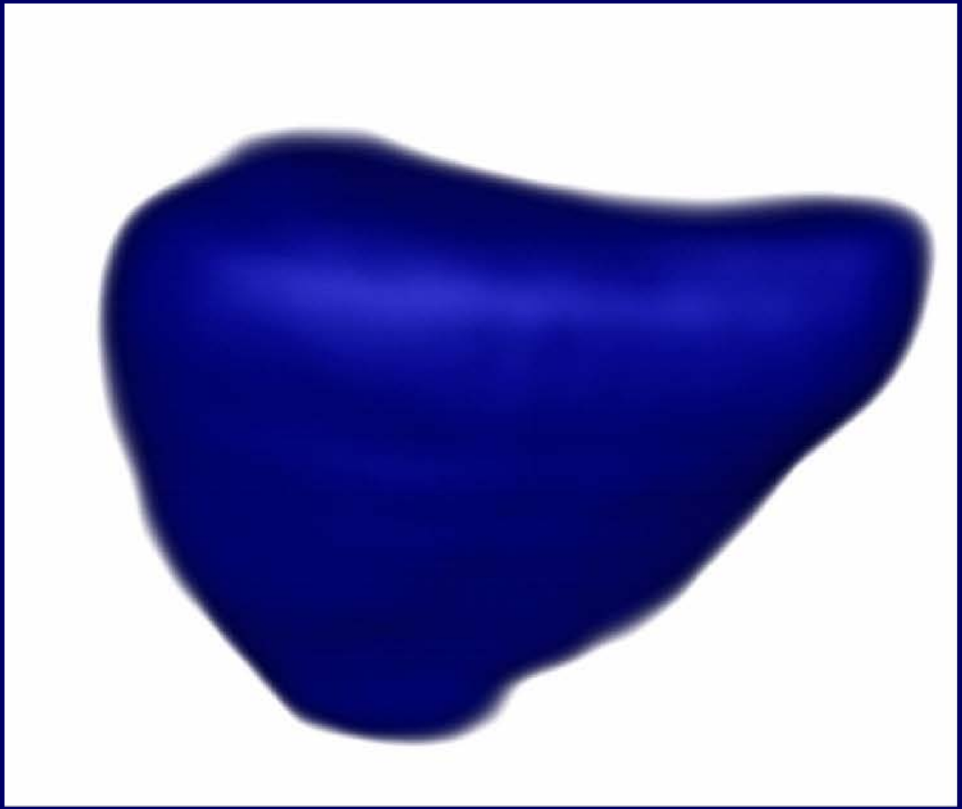
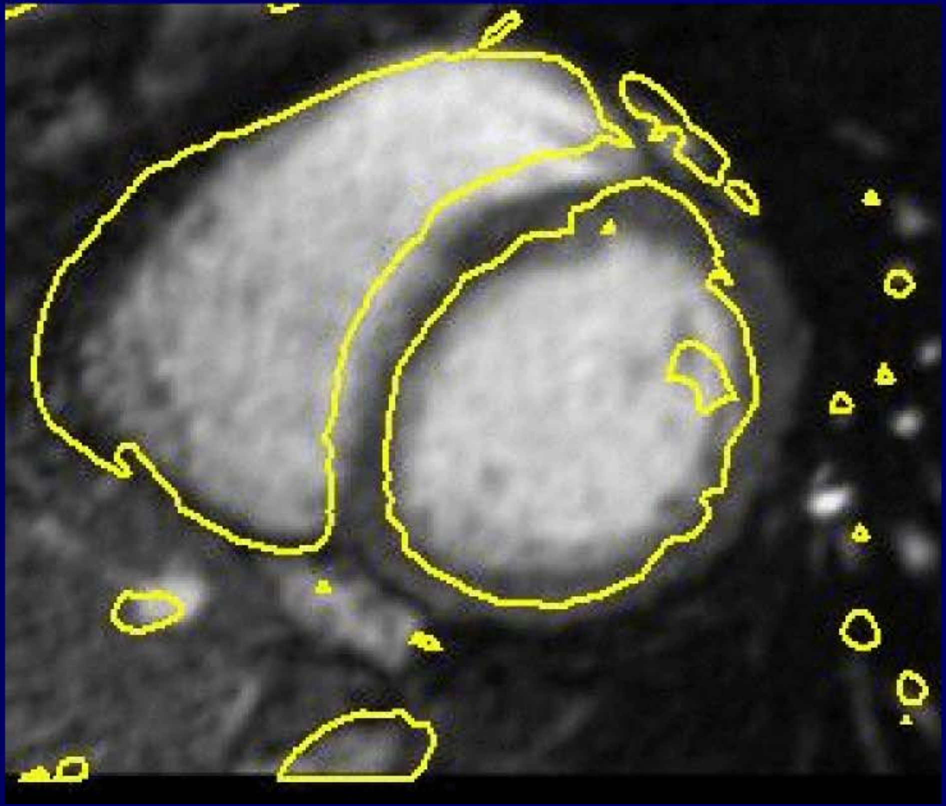
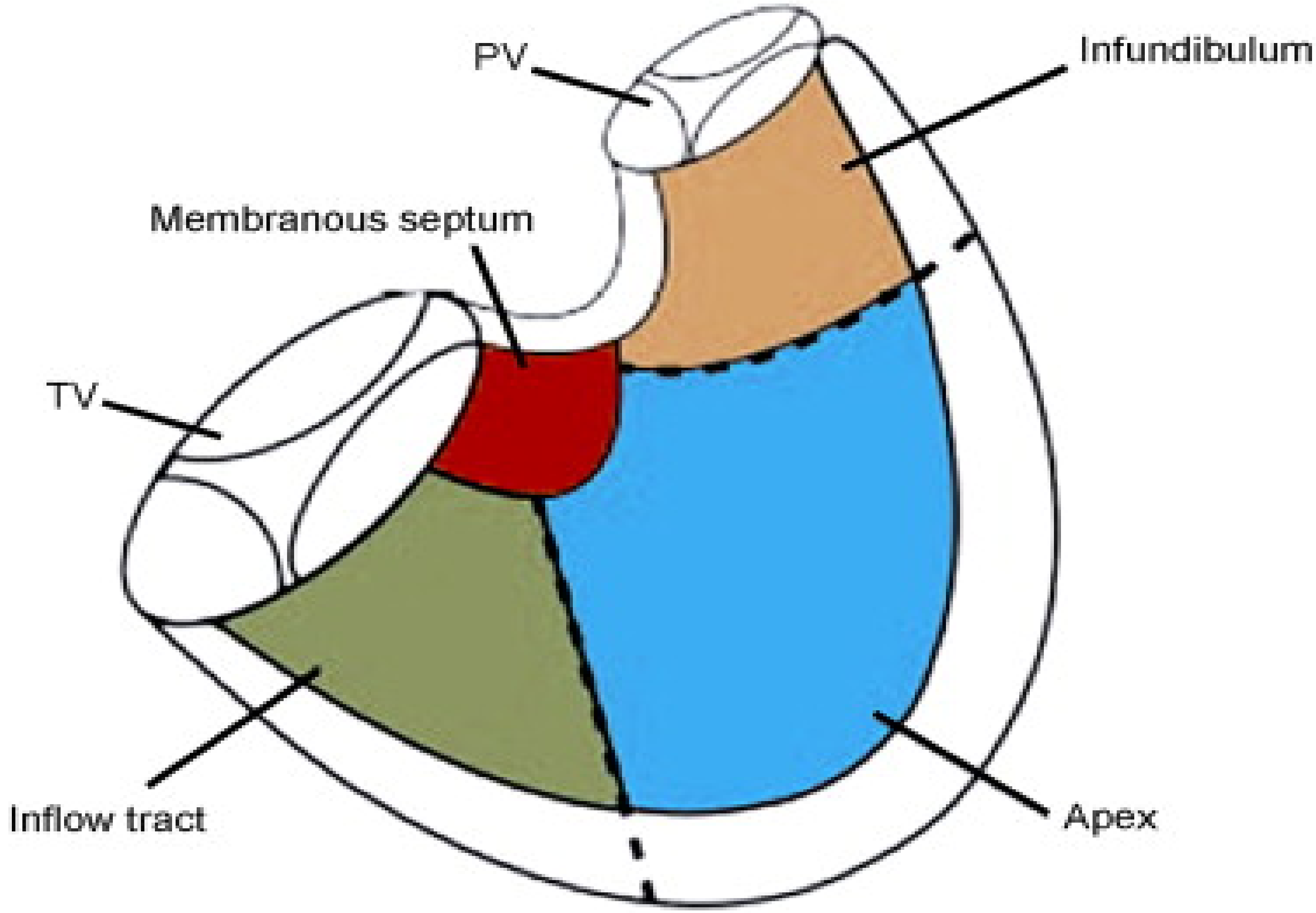
- ASSESSMENT OF THE RIGHT VENTRICLE BY ECHOCARDIOGRAPHY

Anatomy of the Right Ventricle





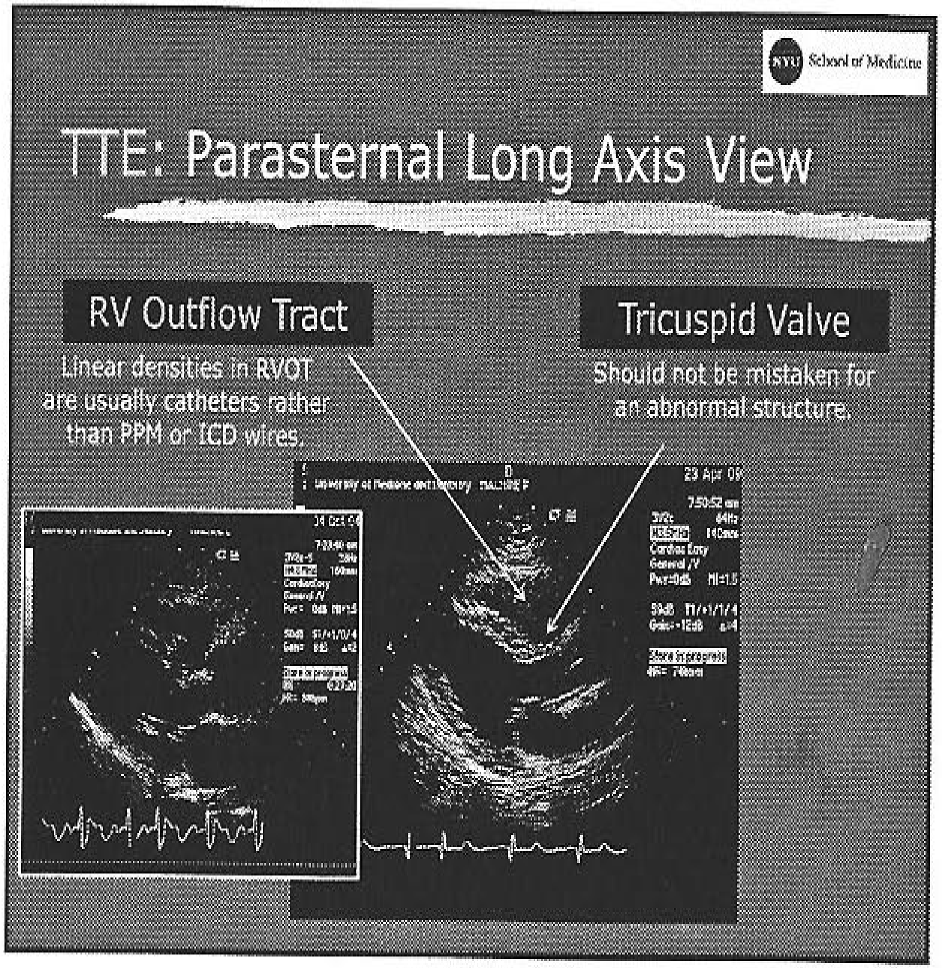
- RIGHT VENTRICULAR ANATOMY

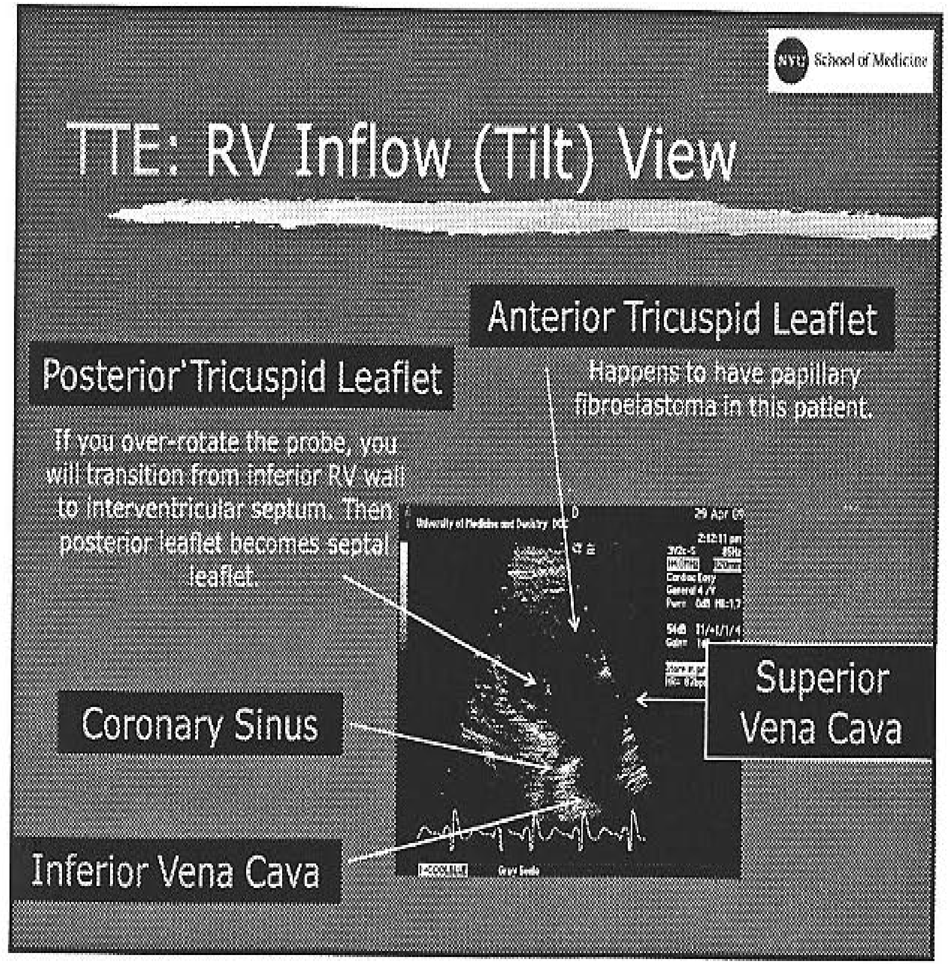


- 3 MUSCULAR BANDS

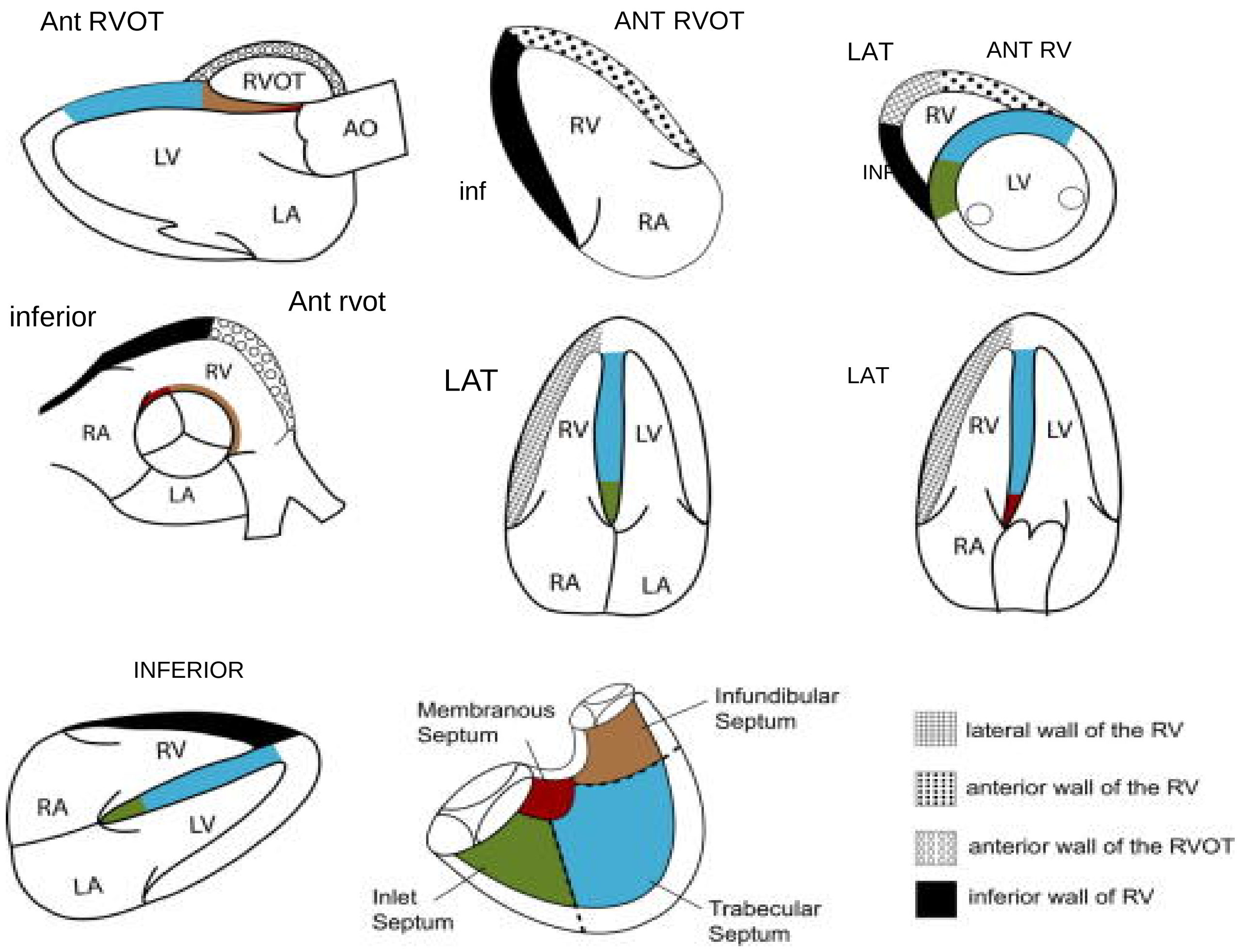
- THE PARIETAL BAND
- SEPTOMARGINAL BAND
- MODERATOR BAND(DEFINES ANATOMIC RIGHT VENTRICLE FROM LEFT)

• RV OUTFLOW ANATOMY





RV WALL SEGMENTS

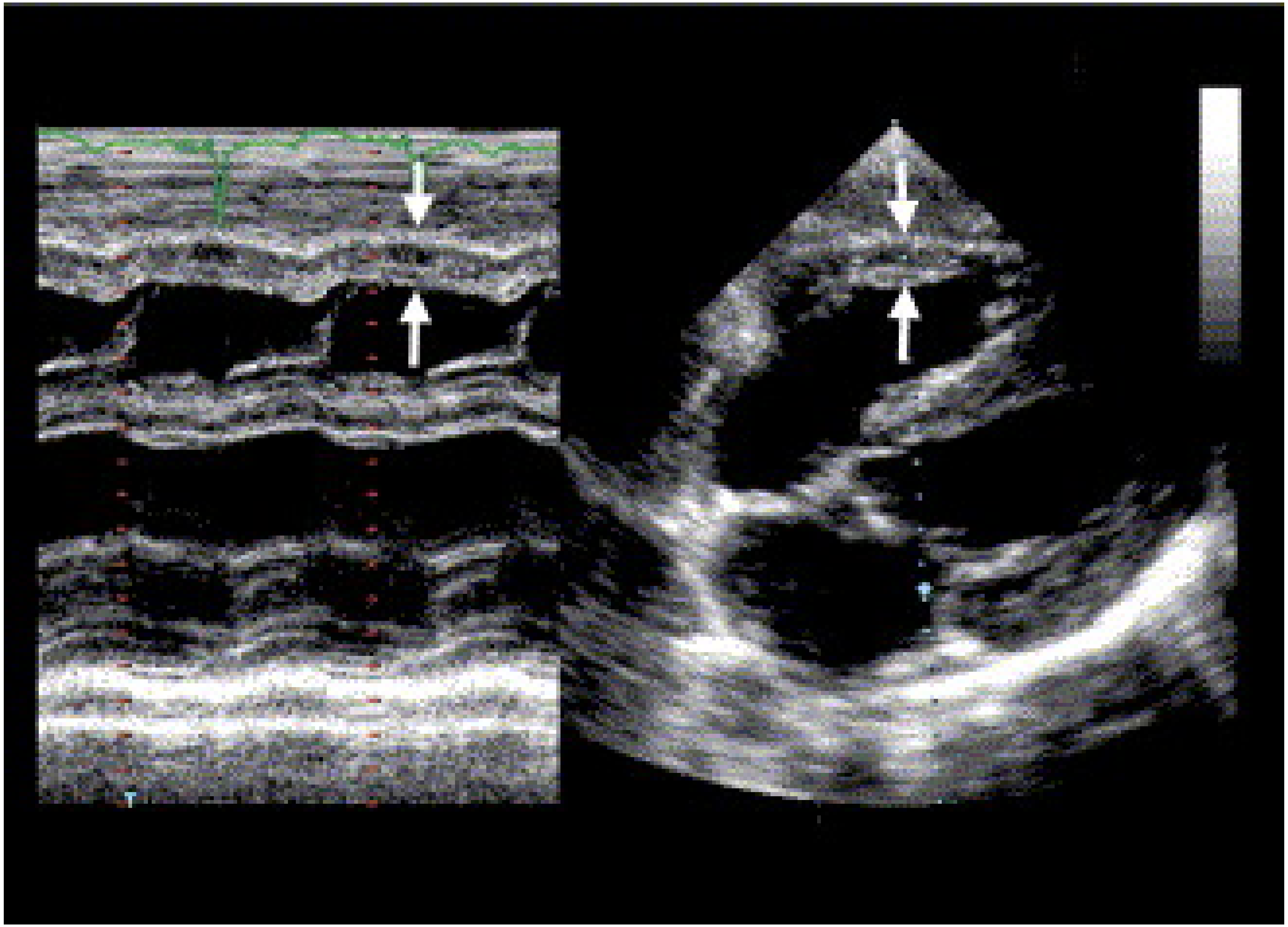


- RV WALL THICKNESS AND CHAMBER SIZE

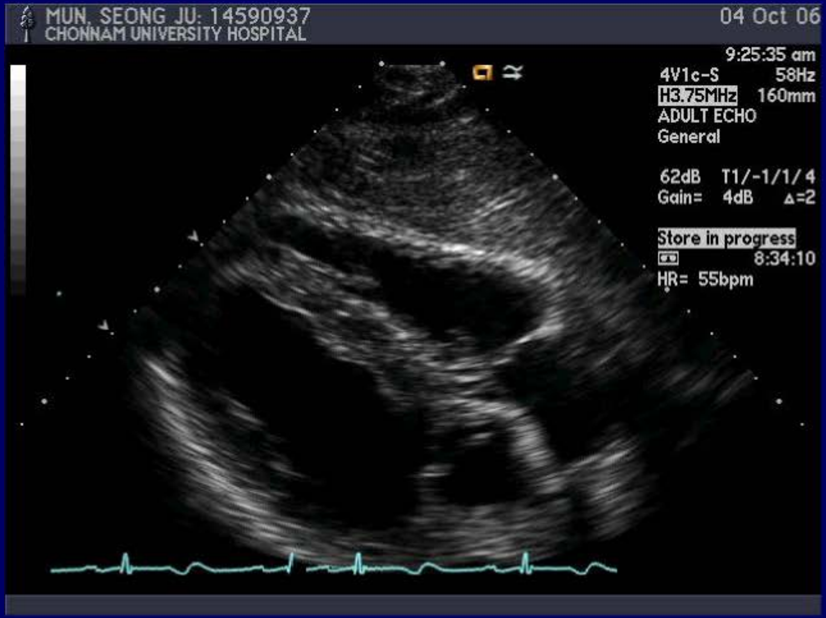
RV
INFERIOR WALL

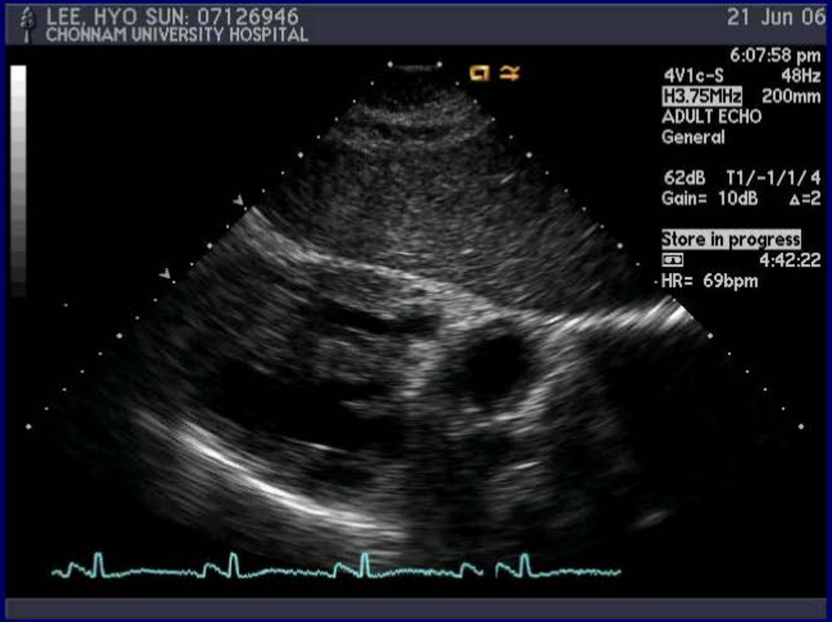
SUBCOSTAL VIEW

N=<0.5cm
Measured at peak r wave



2D and M-mode: Thickness of RV Free Wall





- Normal: less than 0.5 cm
- Measure at the level of TV chordae and at the peak of R wave of ECG on subcostal view
- Well correlated with peak RV systolic pressure

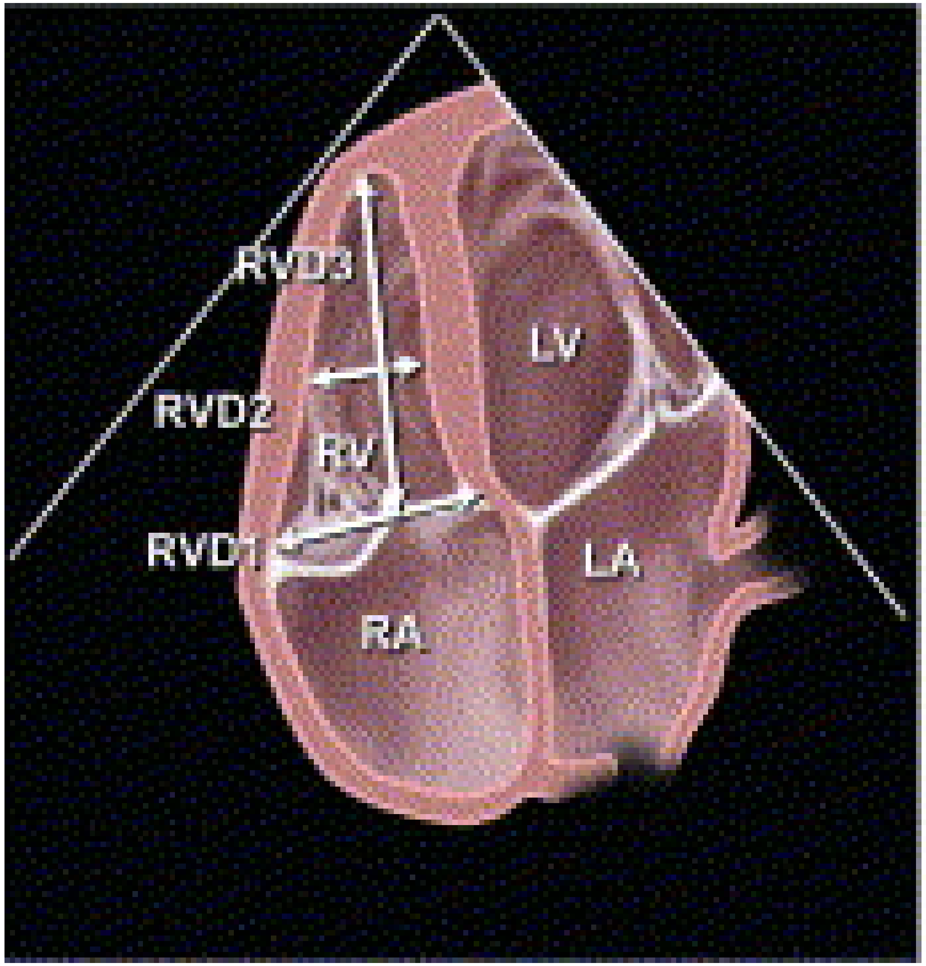
RV DIMENTIONS

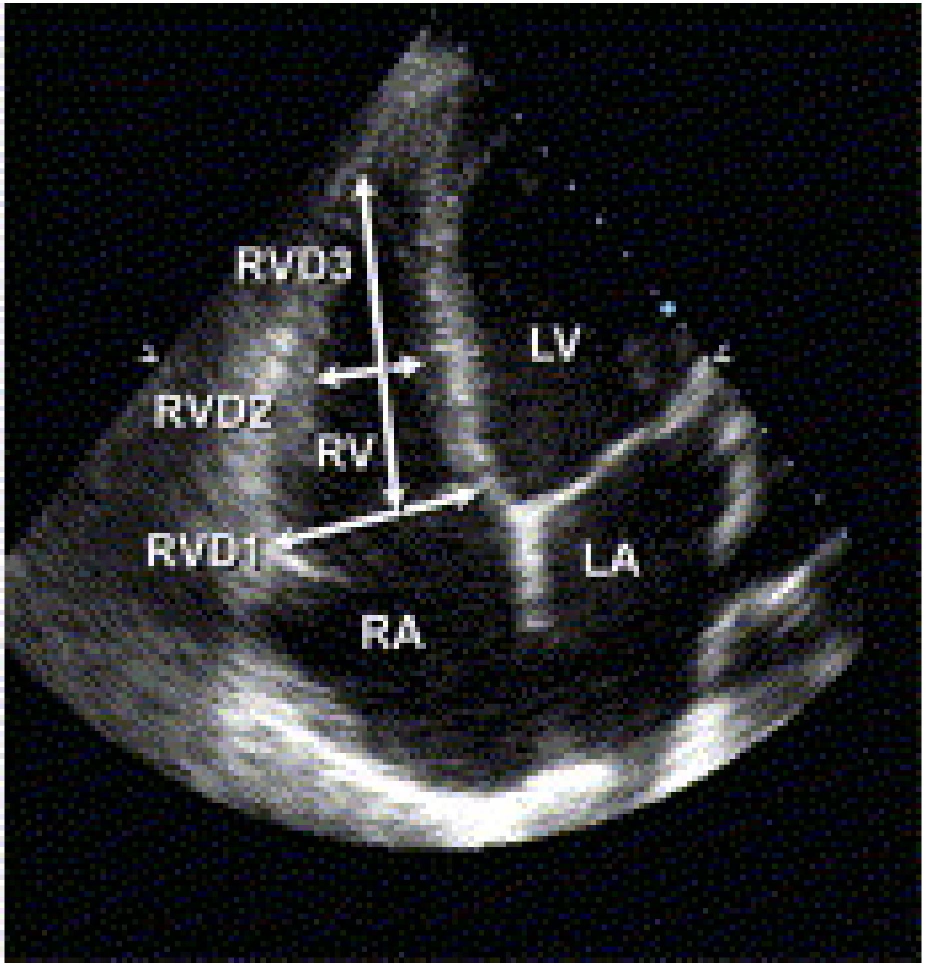
DIAMETERS ABOVE THE TRICUSPID VALVE ANNULUS

MID RV CAVITY

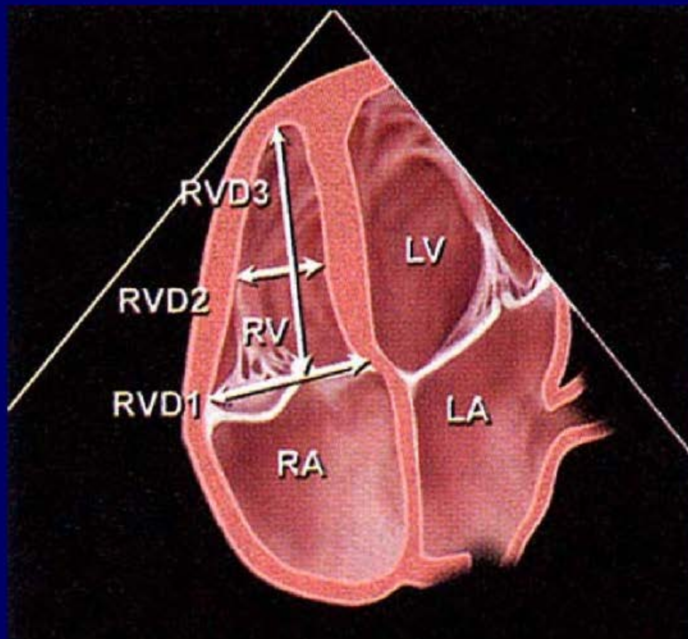
DISTANCE FROM THE TV ANNULUS TO RV APEX

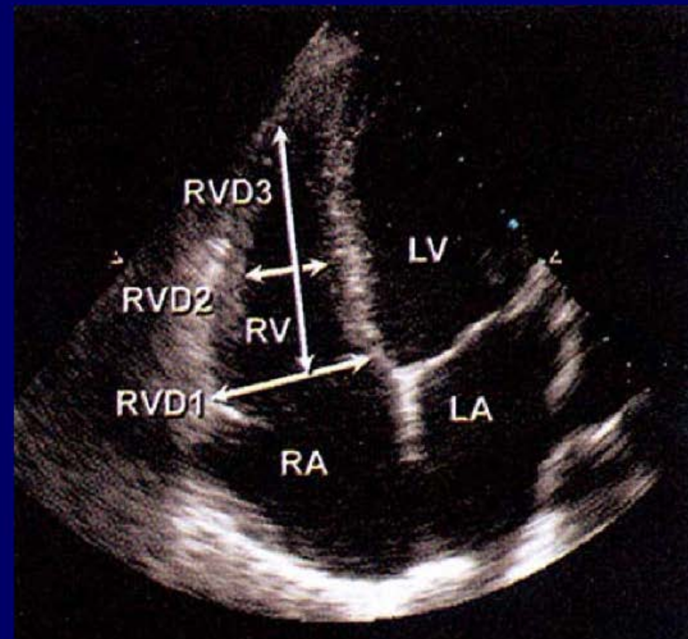
» RV DIMENTIONS





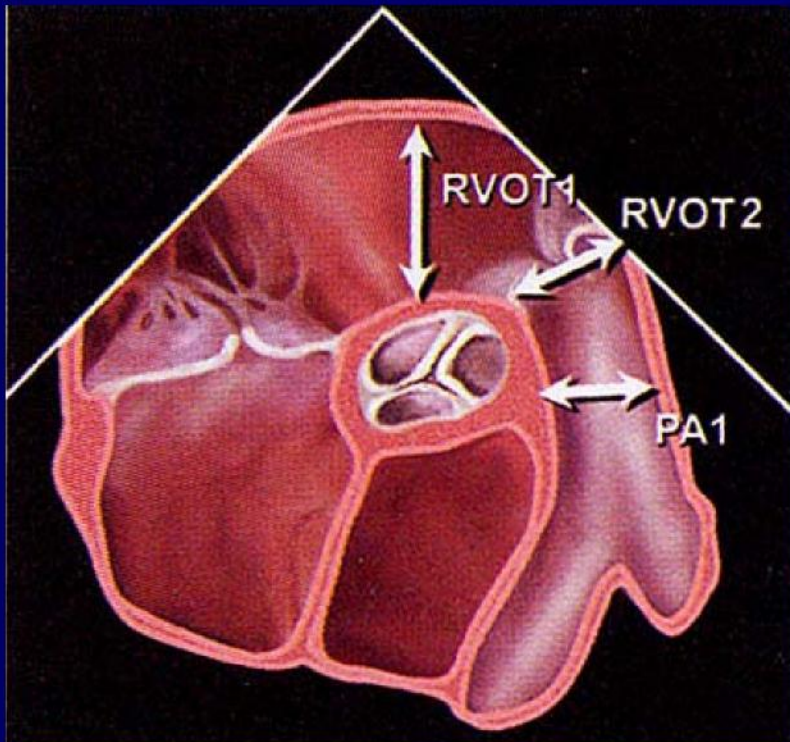
2D and M-mode: RV Dimension

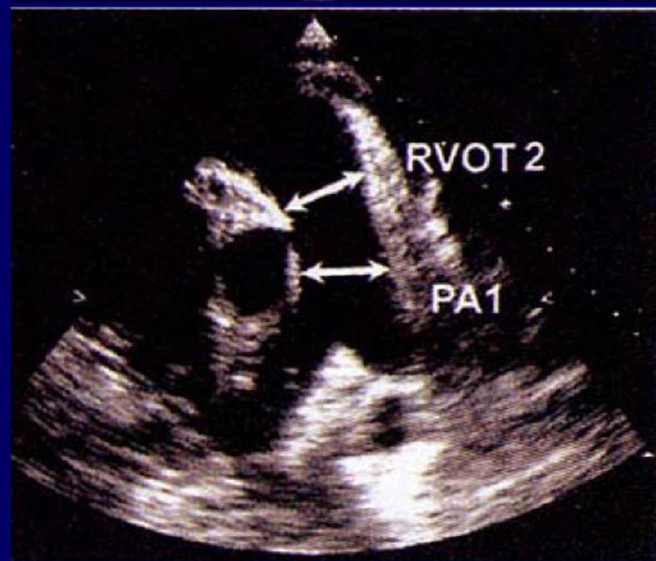




	Reference range	Mildly abnormal	Moderately abnormal	Severely abnormal
Basal RV diameter (RVD1), cm	2.0-2.8	2.9-3.3	3.4-3.8	≥3.9
Mid-RV diameter (RVD2), cm	2.7-3.3	3.4-3.7	3.8-4.1	≥4.2
Base–to-apex (RVD3). cm	7.1-7.9	8.0-8.5	8.6-9.1	≥9.2

2D and M-mode: RVOT and PA Size

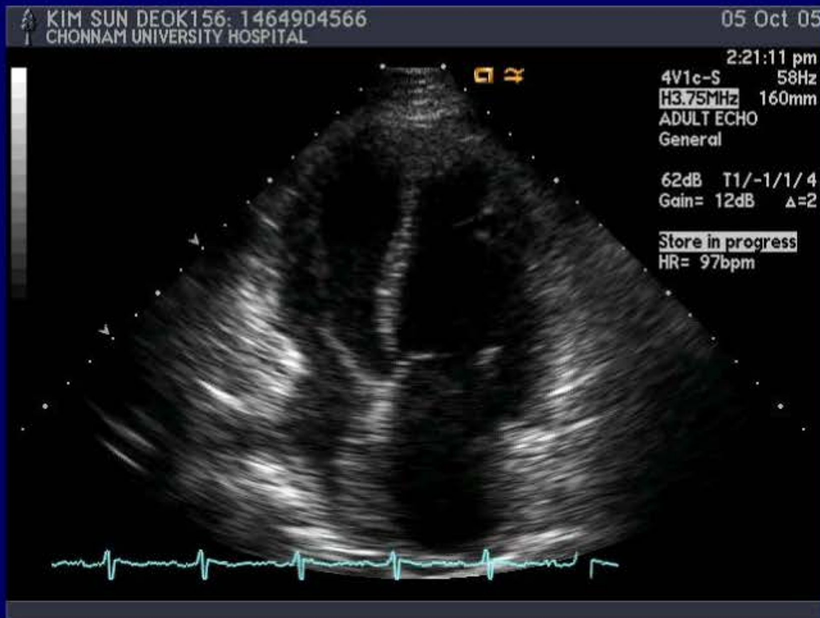




2D and M-mode: RVOT and PA Size

	Reference range	Mildly abnormal	Moderately abnormal	Severely abnormal
RVOT diameters, cm				
Above aortic valve(RVOT1)	2.5-2.9	3.0-3.2	3.3-3.5	≥3.6
Above pulmonic valve(RVOT2)	1.7-2.3	2.4-2.7	2.8-3.1	≥3.2
PA diameter, cm				
Below pulmonic valve (PA1)	1.5-2.1	2.2-2.5	2.6-2.9	≥3.0

2D and M-mode: RV Size



- Normal RV is approximately 2/3 of the size of the LV
- RV Dilatation

  : appears similar or larger than LV size

  : shares the apex

Limitations of Echocardiography in The Evaluations of RV Function

- Difficulties in the estimation of RV volume

  : crescentic shape of RV

  : separation between RV inflow and outflow

  no uniform geometric assumption for measuring volume

- Difficulties in the delineation of endocardial border owing to well developed trabeculation

- Difficulties in the adequate image acquisition owing to the location just behind the sternum

Limitations of Echocardiography in The Evaluations of RV Function

- Difficult to standardize the evaluation method of RV function

  : Variations in the direction or location of the RV are common

  : Easily affected by preload, afterload, or LV function

- Different complex contraction-relaxation mechanism among the segments of the RV
- Cannot image the entire RV in a single view

Function of the Right Ventricle

Why should we measure RV function?

- RV is not just a conduit of blood flow

  : has its unique function
- Prognostic significance in various clinical settings
- Risk stratification or guide to optimal therapy

Function of the Right Ventricle

- Conduit of blood flow
- Maintain adequate pulmonary artery perfusion pressure to improve gas exchange
- Maintain low systemic venous pressure to prevent congestion of tissues or organs
- Affect LV function

  : limit LV preload in RV dysfunction

  : Ventricular interdependence
- Prognostic significance in various clinical settings

RV Function and Prognosis

- RV ejection fraction: an indicator of increased mortality in patients with CHF associated with CAD

(Polak et al. J Am Coll Cardiol 1983)

- RV function predicts exercise capacity and survival in advanced heart failure

(Di Salvo et al. J Am Coll Cardiol 1983)

- RV function is a crucial determinant of short-term prognosis in severe chronic heart failure

(Gavazzi et al. J Heart Lung Transplant 1997)

RV Function and Prognosis

- RV ejection fraction: independent predictor of survival in patients with moderate heart failure

(De Groote et al. J Am Coll Cardiol 1998)

- RV function predicts prognosis in patients with chronic pulmonary disease

(Burgess et al. J Am Soc Echocardiogr 2002)

- RV contractile reserve is associated with one year mortality in patients with DCMP

(Otasevic et al. Eur J Echocardiography 2005)

Measurements of RV Function

- 2 D and M-mode echocardiography

  : chamber size or wall thickness

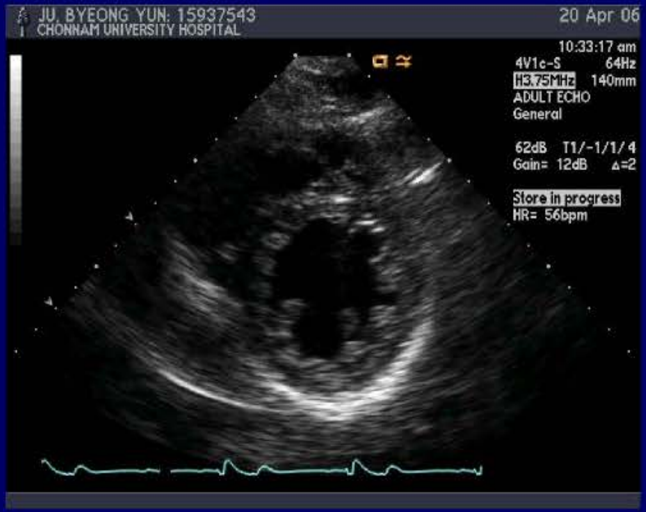
  : RV area or fractional area change

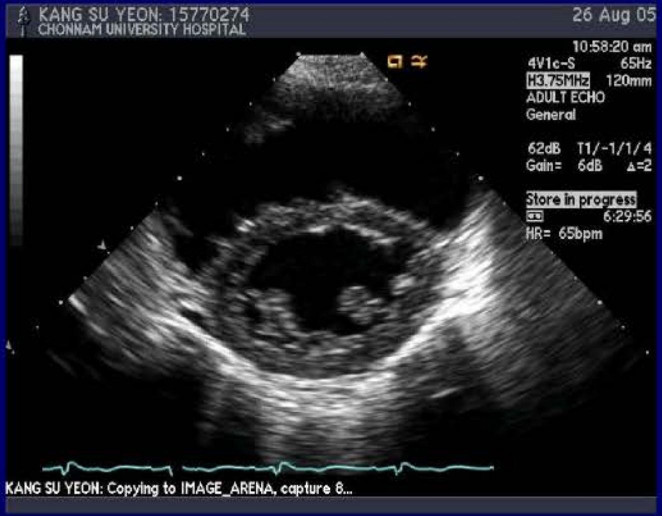
  : RV volume or EF

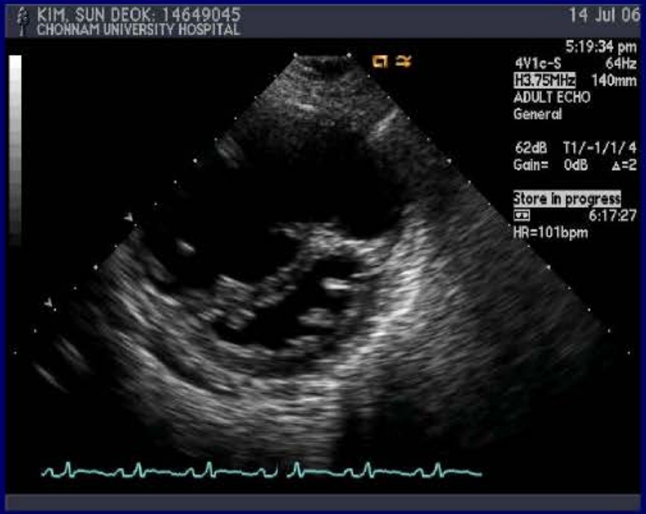
  : Tricuspid annular systolic plane excursion (TAPSE)

- Doppler echocardiography
- 3 Dimensional Echocardiography

2D and M-mode: Eccentricity Index

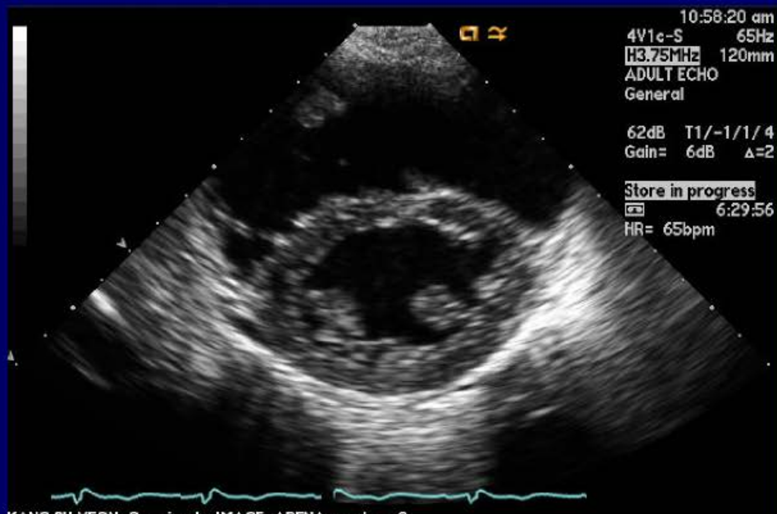


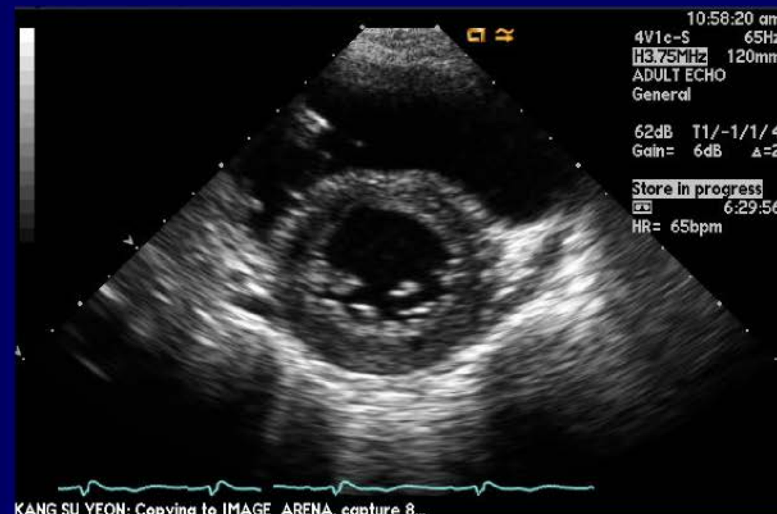


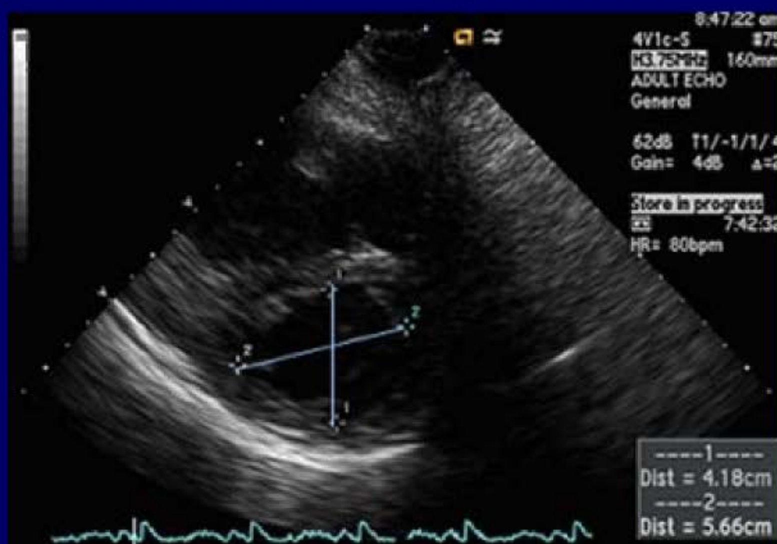


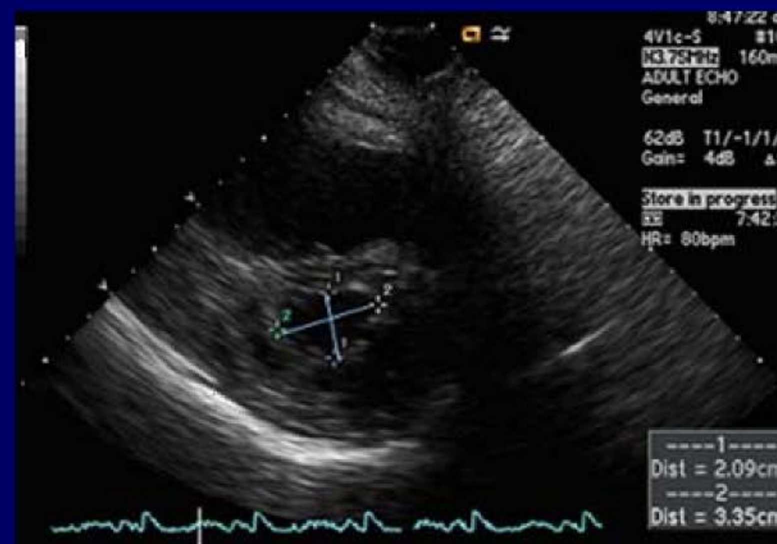
- The ratio of two orthogonal minor axis left ventricular chordae, measured from short axis view
  - Reflects the degree of septal flattening resulting in abnormal LV shape
- Normal: approximately 1.0 in both diastole and systole

2D and M-mode: Eccentricity Index



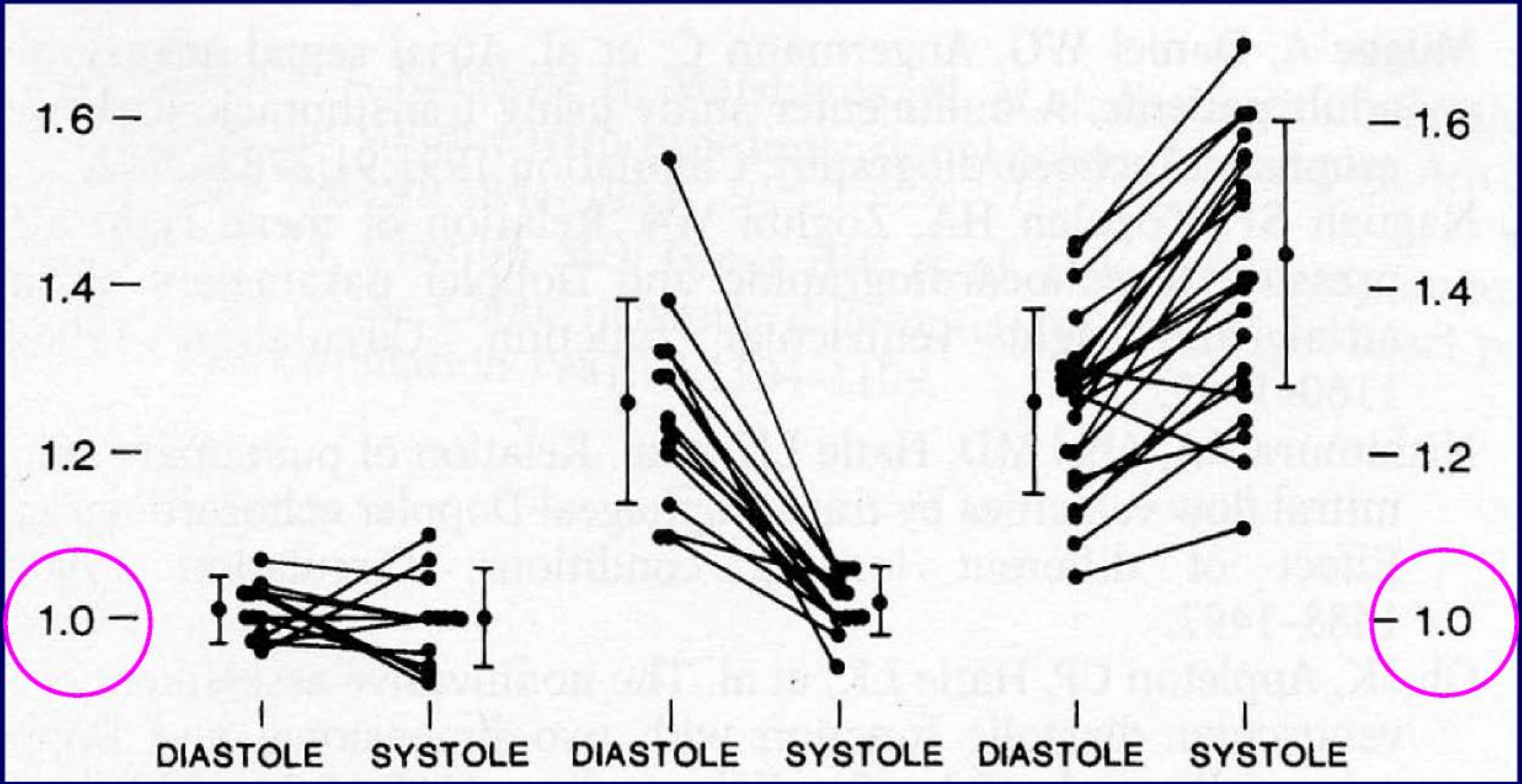






2D and M-mode: Eccentricity Index

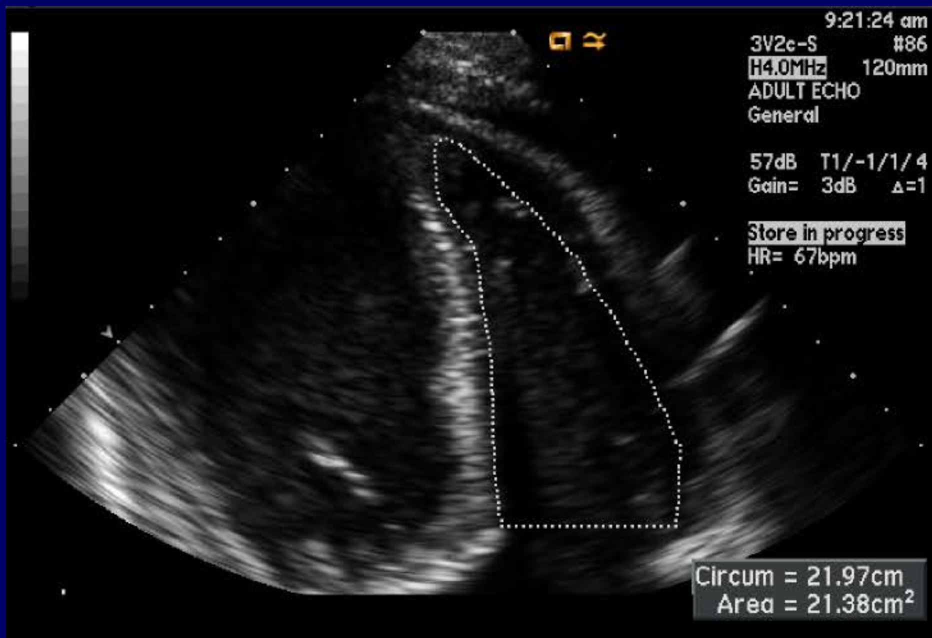
Eccentricity Index

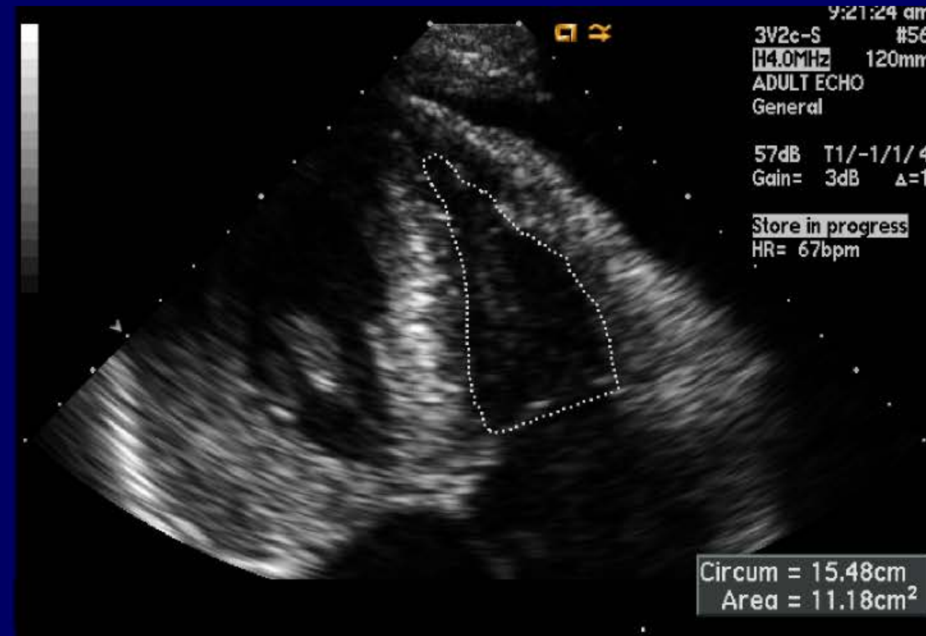


RV volume overload

RV pressure overload

2D and M-mode: Fractional Area Change (FAC)





$$\frac{\text{(End-diastolic area)} - \text{(end-systolic area)}}{\text{(end-systolic area)}} \times 100$$

2D and M-mode: RV Area and FAC in A4C

	Reference range	Mildly abnormal	Moderately abnormal	Severely abnormal
RV diastolic area (cm^2)	11-28	29-32	33-37	≥38
RV systolic area (cm^2)	7.5-16	17-19	20-22	≥23
RV FAC (%)	32-60	25-31	18-24	≤17

- Well correlated with RV function measured by radionuclide ventriculography or MRI
- Good predictor of prognosis
- Limitations: fail to measure FAC due to inadequate RV tracing

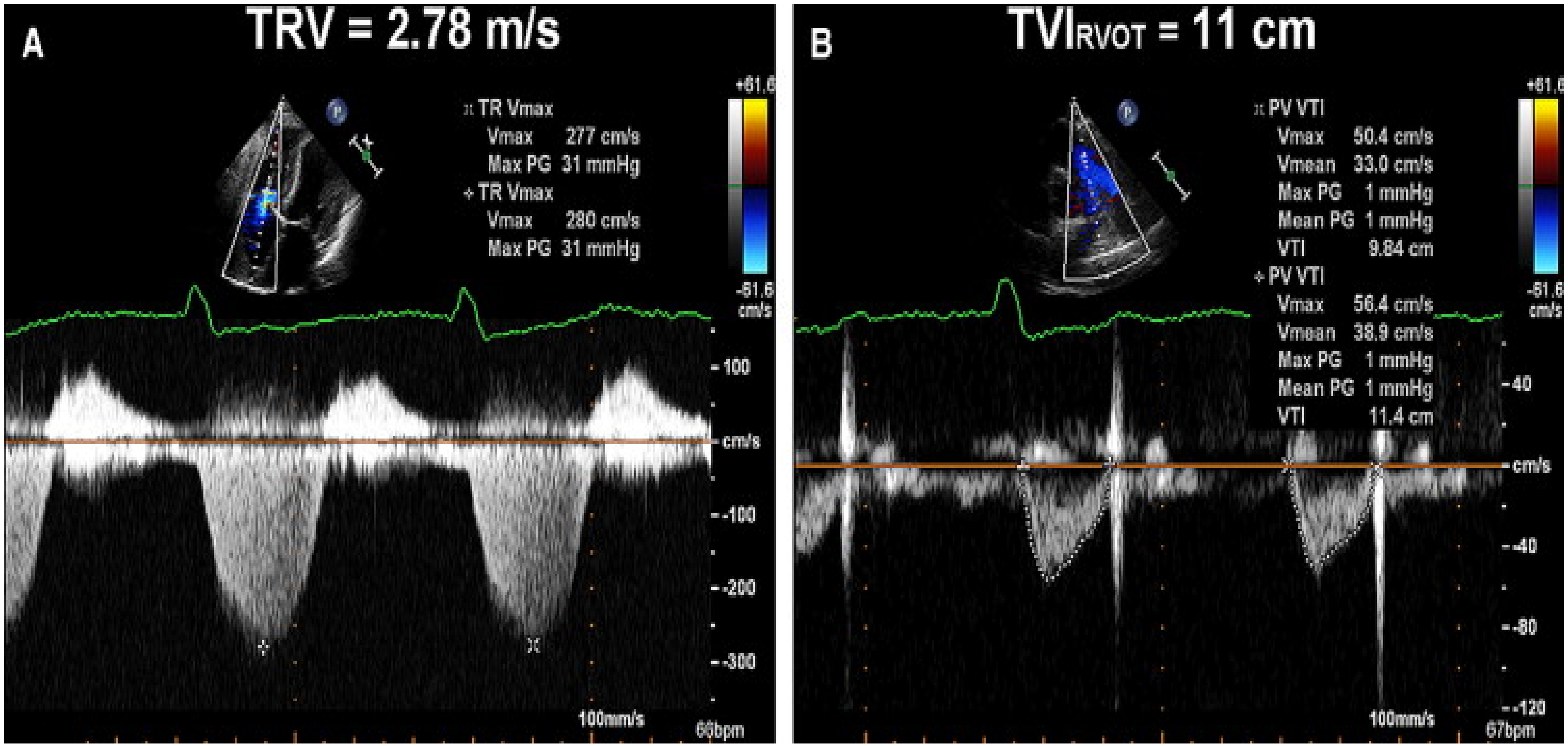
2D and M-mode: RV Volume or EF

- Remains problematic given the complex geometry of the RV and the lack of standard methods for assessing RV volumes
- RVEF (%) = { (EDV – ESV) / EDV } x 100 (%)

	Normal Range		Ellipsoidal model	
	LV	RV	LV	RV
EDVI (ml/m^2)	52-87	63-103	59.17	70.0
ESVI (ml/m^2)	14-35	22-56	22.64	32.6
SV (ml/m^2)	18-52	40-41	36.42	37.31
EF (%)	59-74	43-65	61.20	53.91

Kovalova et al. Eur J Echocardiography 2006

PVR BY DOPPLER ECHO



$PVR = TRV/TVI_{RVOT} X10 + 0.16$ (Nl value is 1.5-2.5)

Tricuspid Annular Plane Systolic Excursion

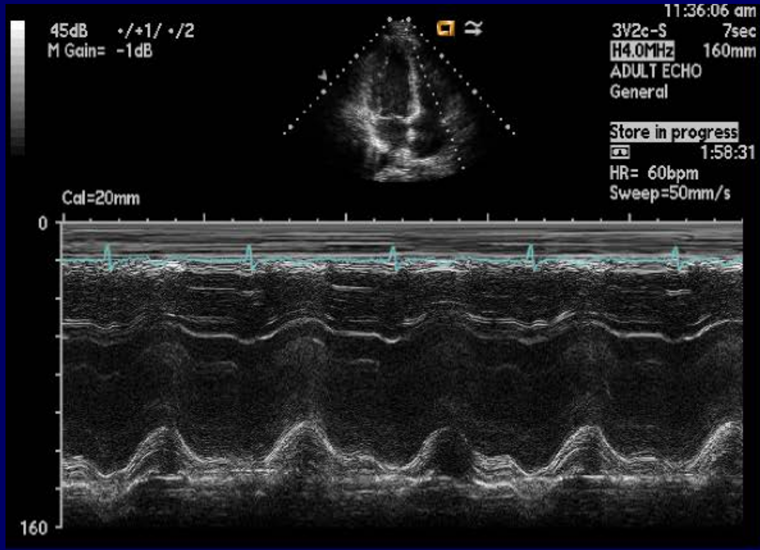
- Degree of systolic excursion of TV lateral annulus on A4C

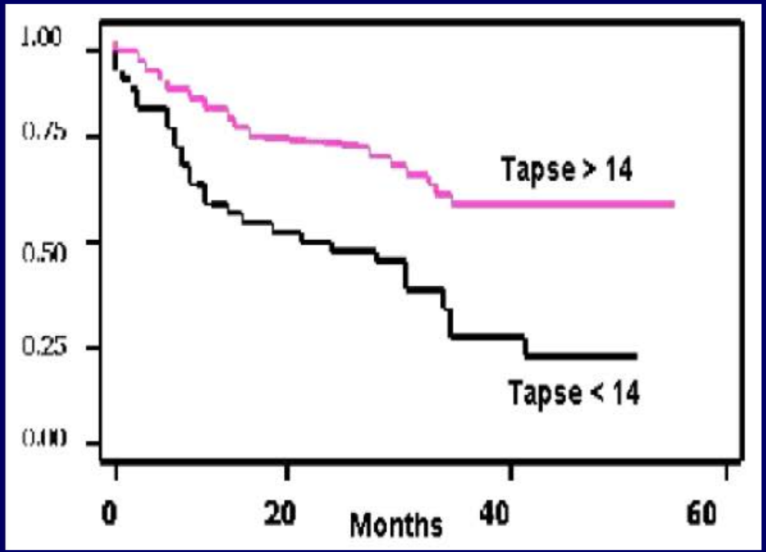
  : 1.5-2.0 cm in normal

  : Value less than 1.5 cm is considered as abnormal

- Well correlated with RVEF measured by RVG
- Reproducible
- Strong predictor of prognosis in patients with CHF

Tricuspid Annular Plane Systolic Excursion





※ TAPSE and RV ejection fraction

: TAPSE 2cm = RVEF 50%

: TAPSE 1.5cm = RVEF 40%

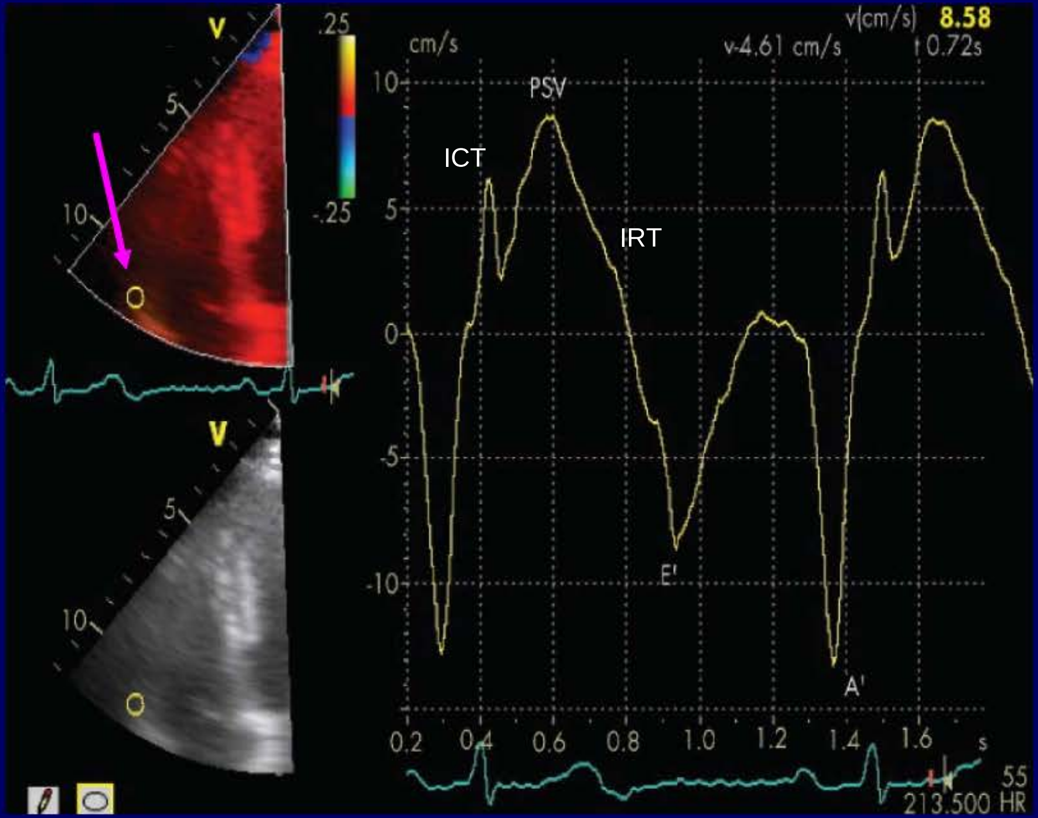
: TAPSE 1cm = RVEF 30%

: TAPSE 0.5cm = RVEF 20%

Event free survival according to TAPSE in patients with CHF

Doppler Echocardiography: Tissue Doppler Imaging

Peak systolic velocity (PSV)
Normal <11.5



Tricuspid lateral annular velocities

Doppler Echocardiography: Tissue Doppler Imaging

- Allows quantitative assessment of RV systolic and diastolic function by measurement of myocardial velocities
- Peak systolic velocity (PSV)

  : PSV < 11.5 cm/s identifies the presence of RV dysfunction

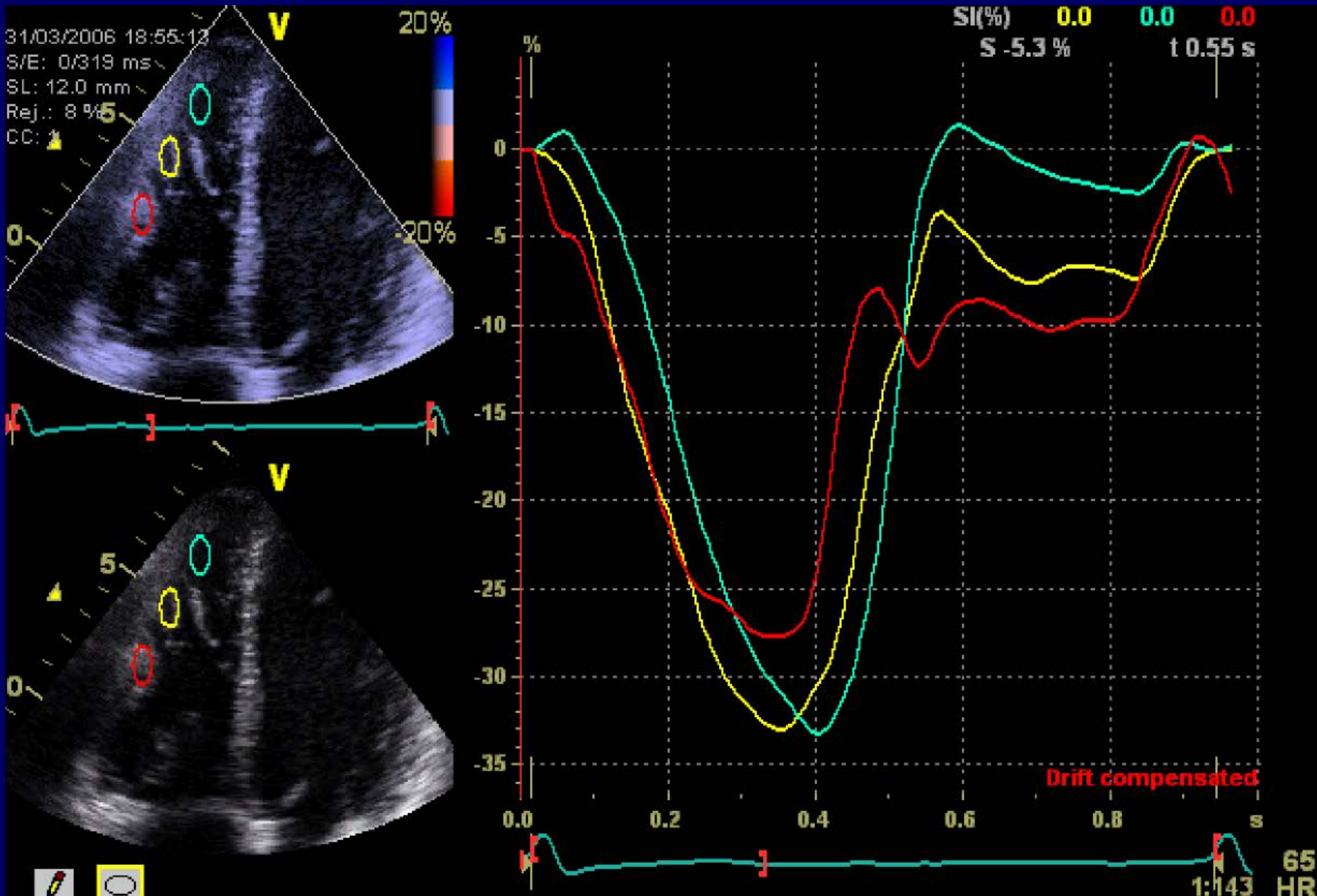
  : Sensitivity of 90%, specificity of 85%

  : Less affected by HR, loading condition, and degree of TR
- Tricuspid lateral annular velocities

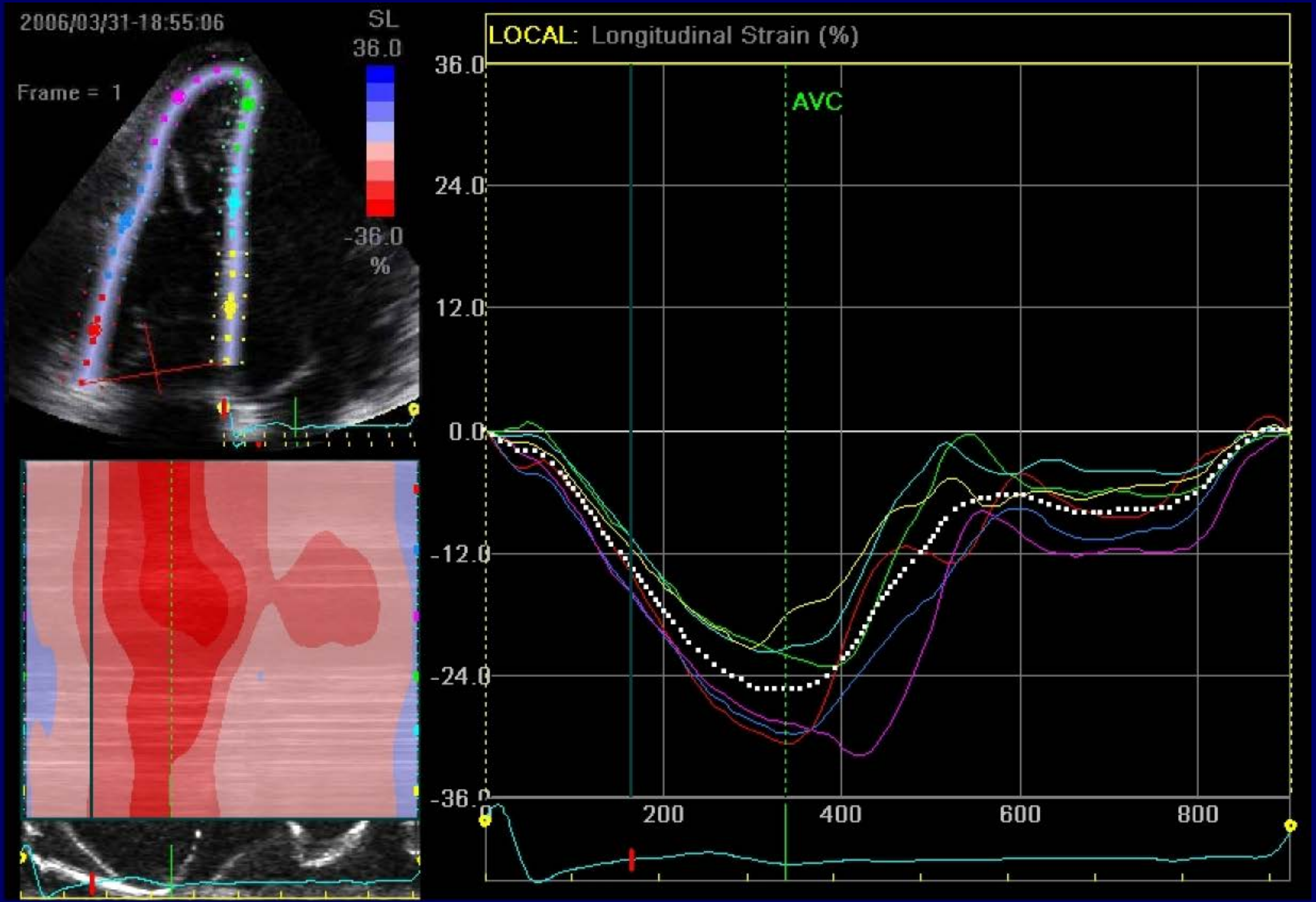
  : Reduced in patients with inferior MI and RV involvement

  : Associated with the severity of RV dysfunction in patients with heart failure

Doppler Echocardiography: Strain Rate Imaging



Doppler Echocardiography: Strain Rate Imaging



Doppler Echocardiography: Strain Rate Imaging

- RV longitudinal strain in apical view
  : Feasible in clinical setting
  : Baso-apical gradient with higher velocities at the base
  : RV velocities are consistently higher as compared to LV
- Strain and strain rate values
  : More inhomogeneously distributed in the RV
  : Reverse baso-apical gradient, reaching the highest values in the apical segments and outflow tract
- Acute increase in RV afterload
  : Increase in RV myocardial strain rate
  : Decrease in peak systolic strain, indicating a decrease in SV

Doppler Echocardiography: 3D Echocardiography

- **Advantages of RT3DE**

  : Volume analysis does not rely on geometric assumptions

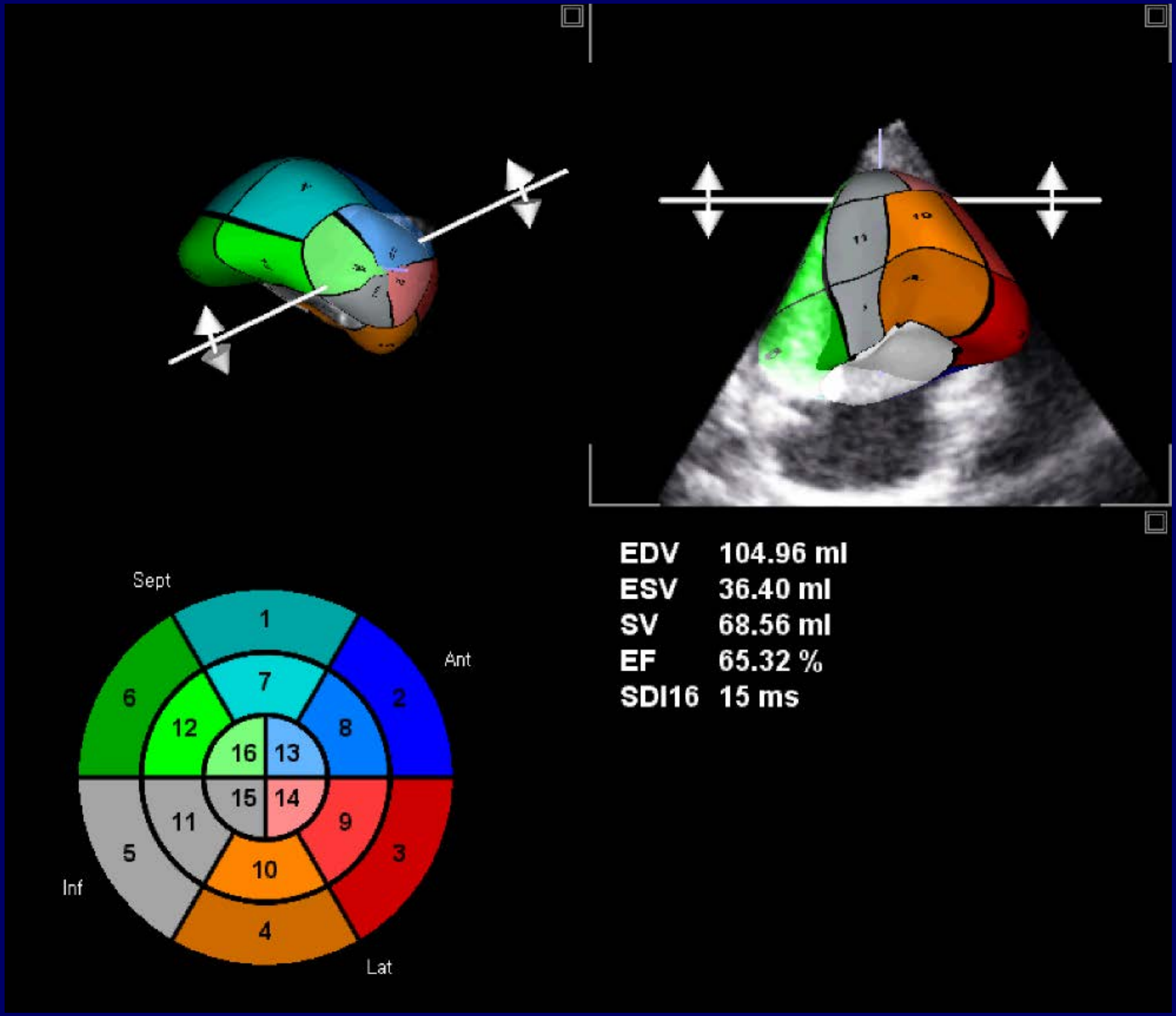
  : Little artifacts associated with motion or respiration

- **Multiple slices may be obtained from the base to the apex of the heart as in the method of discs**

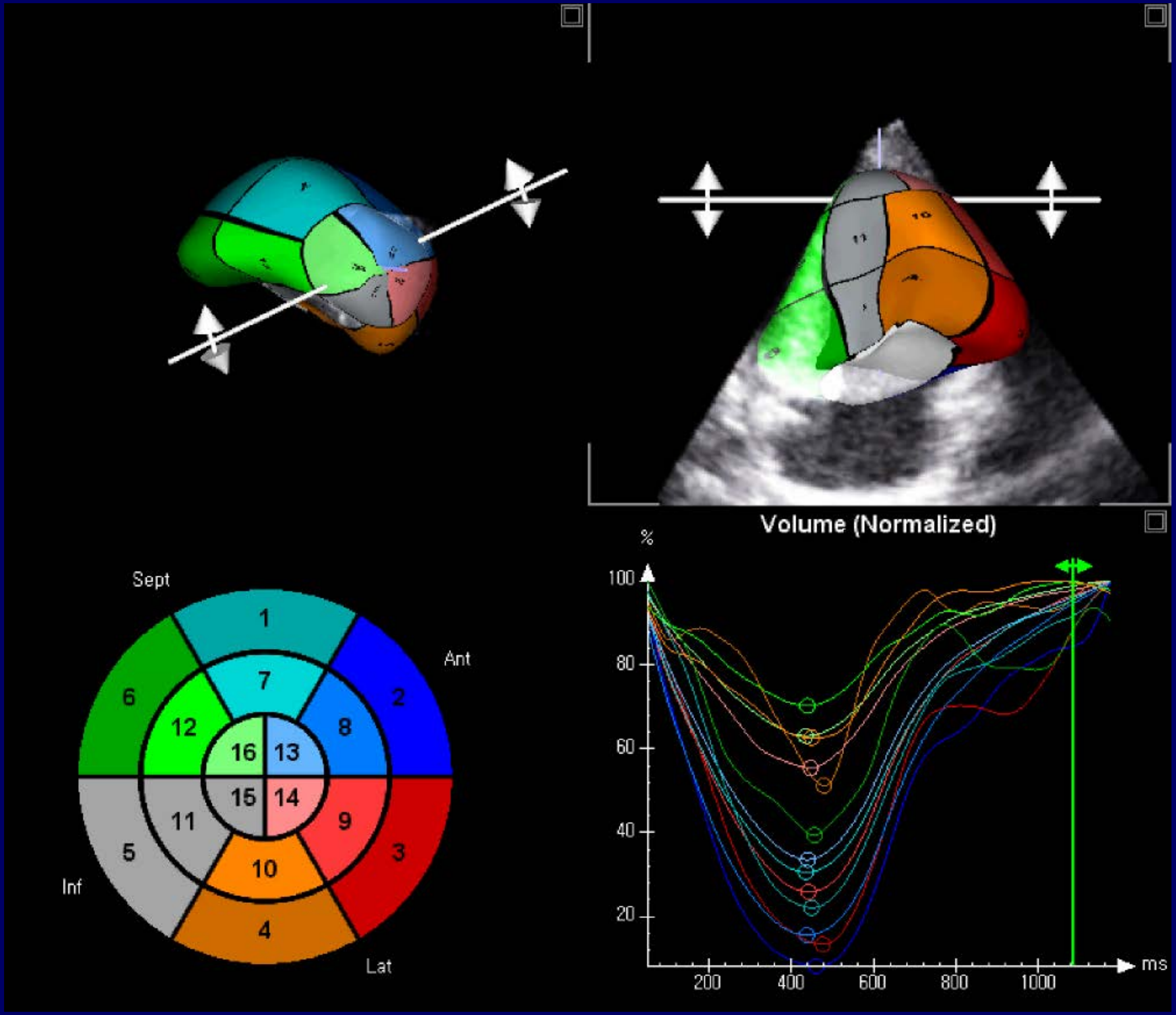
  : Measure entire RV volume

  : Well correlated with RV volume measured by MRI

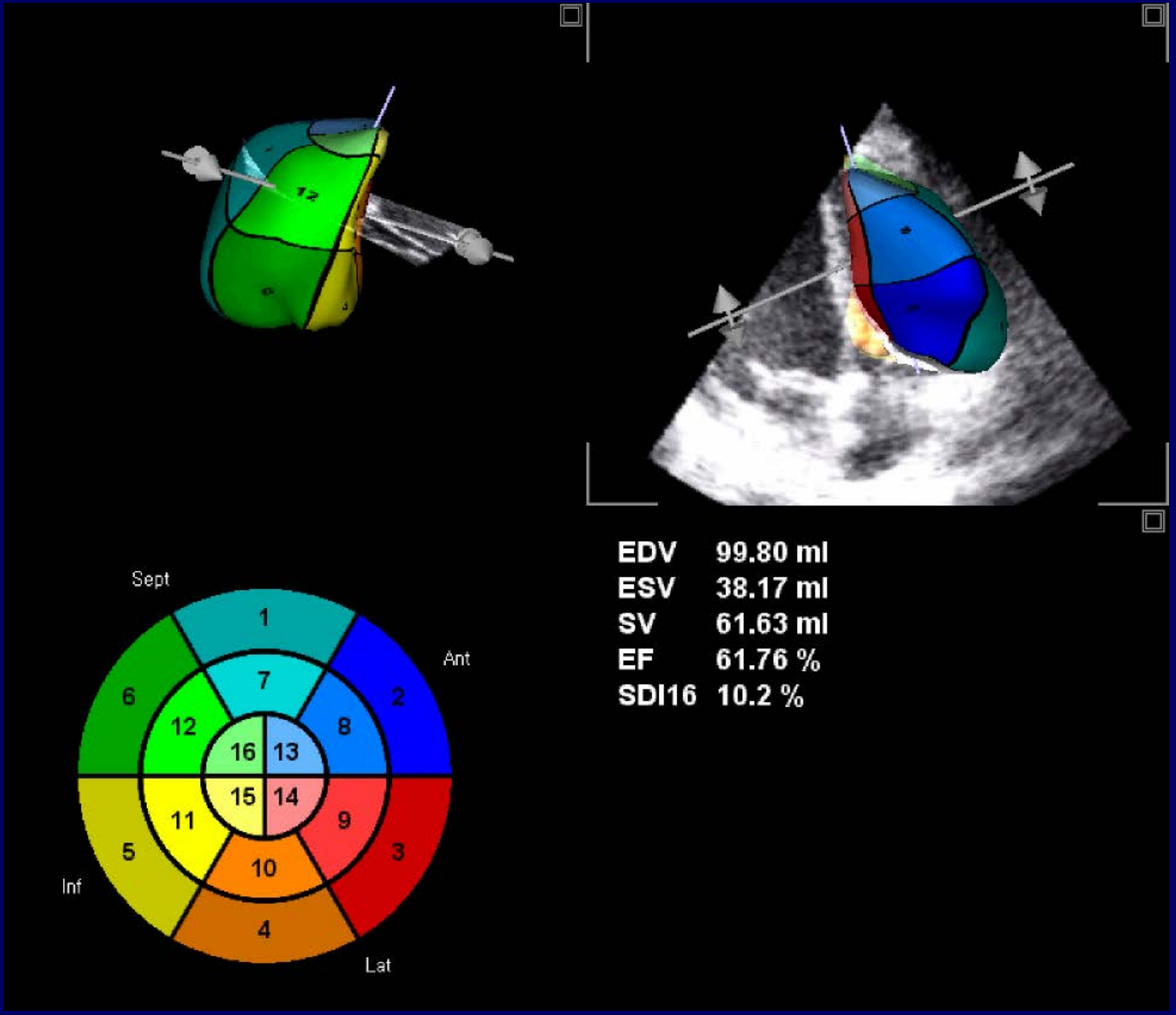
RV Function: 3D Echocardiography



RV Function: 3D Echocardiography



RV Function: 3D Echocardiography



Conclusion

- RV function is an important parameter in cardiac disease
- 2DE is a relatively feasible method to assess RV dysfunction in clinical practice
- Several new echocardiographic techniques such as TDI, SRI, RT3DE may give us further information in assessing RV function