대한 순환기 학회 – 2006 추계 학술대회

# Evaluation of Right Ventricular Function Using Echocardiography

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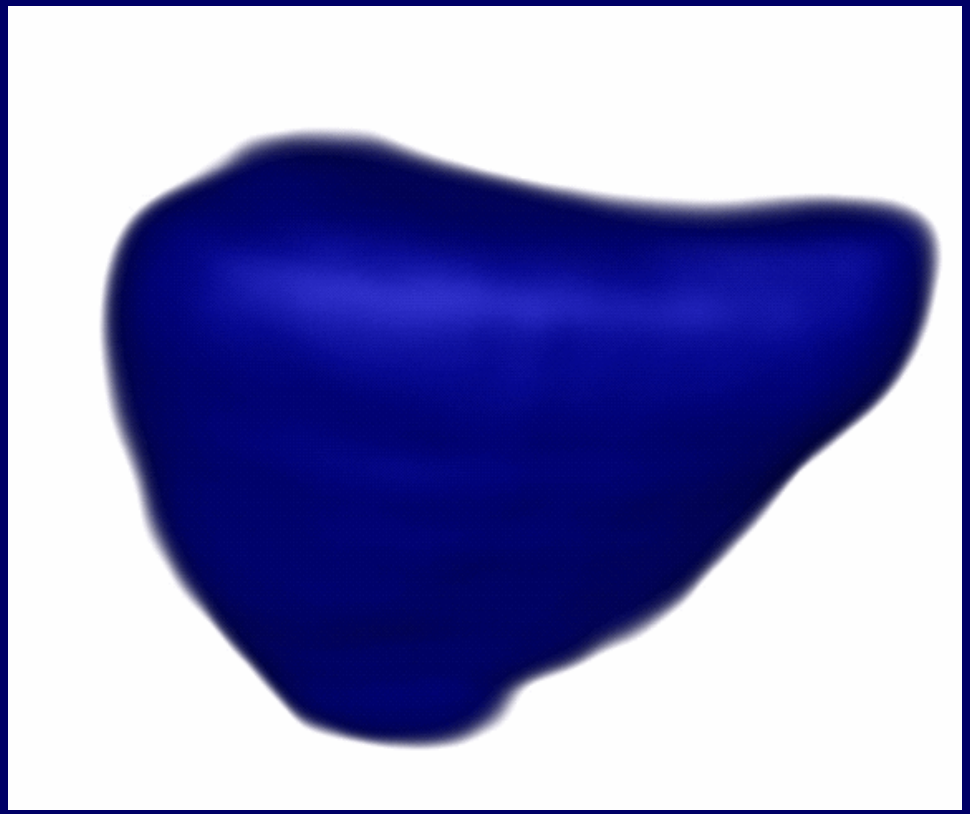
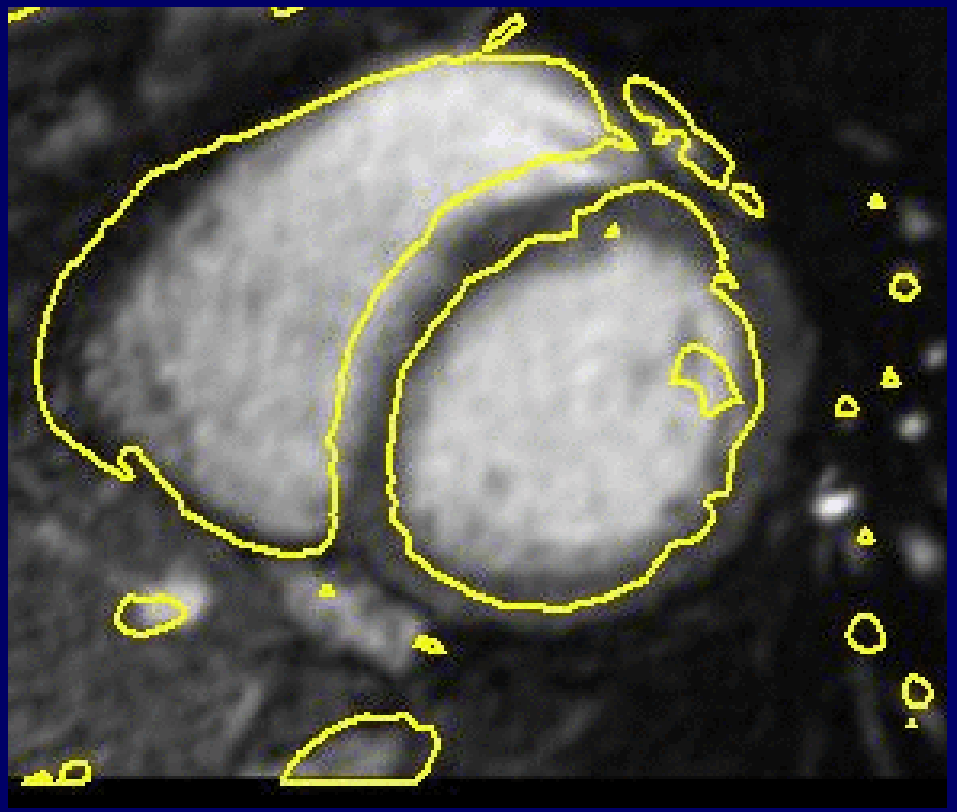
# Anatomy of the Right Ventricle





# 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

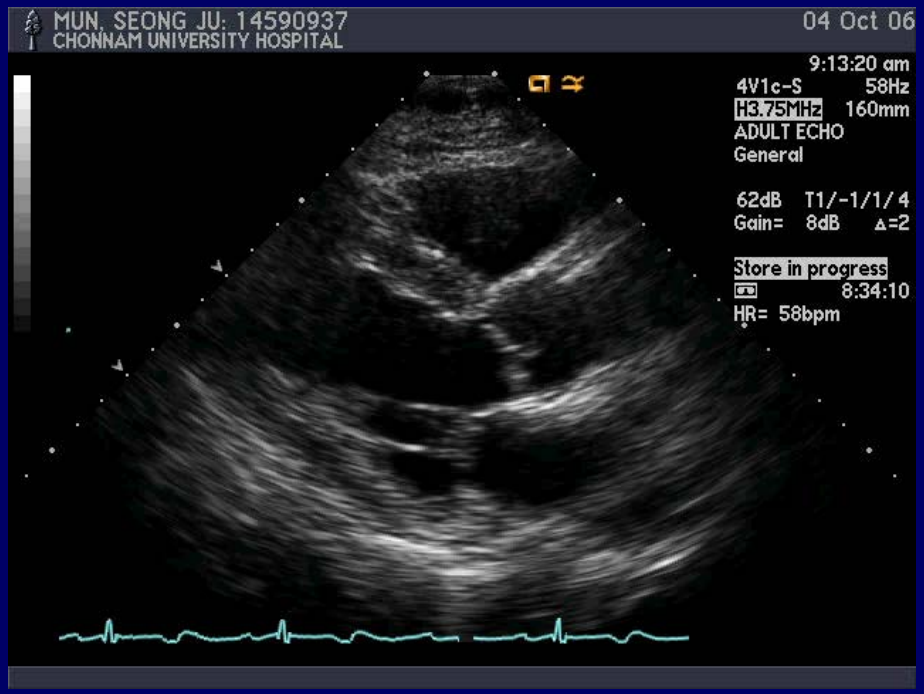
  : RV volume or EF

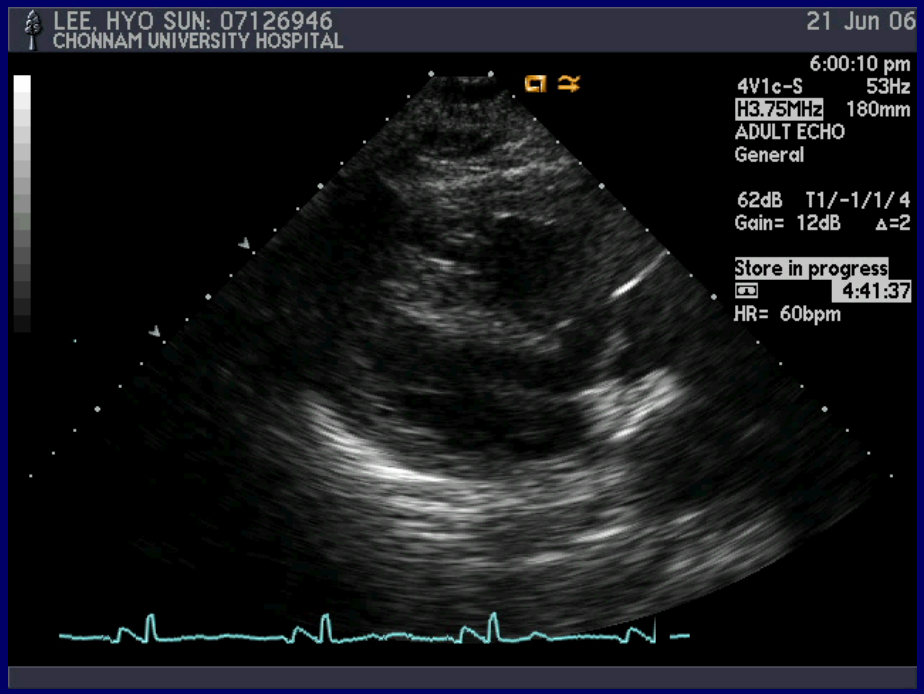
  : Tricuspid annular systolic plane excursion (TAPSE)

- Doppler echocardiography

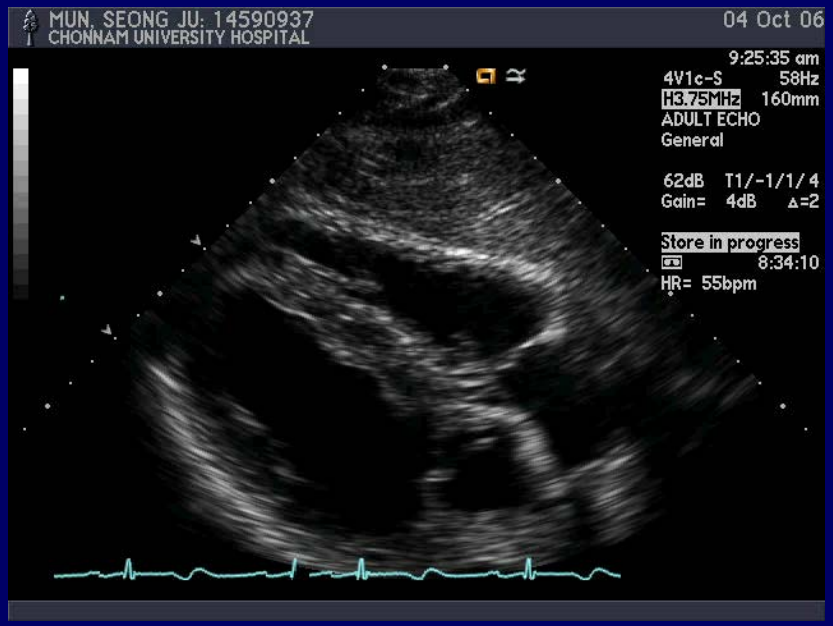
- 3 Dimensional Echocardiography

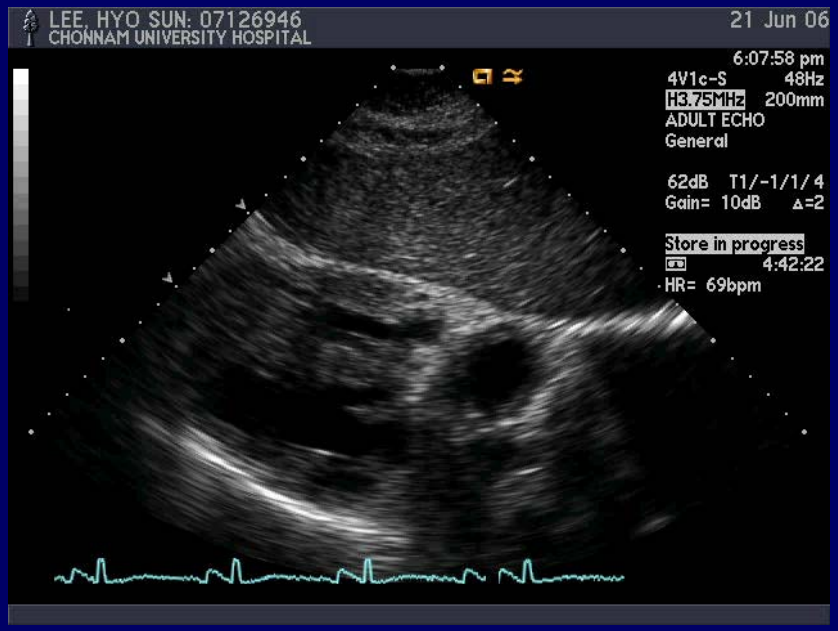
# 2D and M-mode: Thickness of RV Free Wall



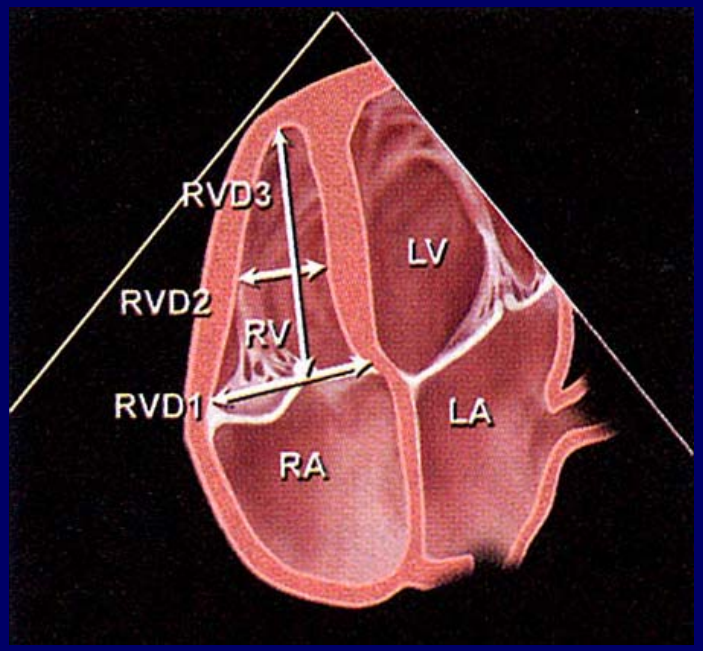
# 2D and M-mode: Thickness of RV Free Wall

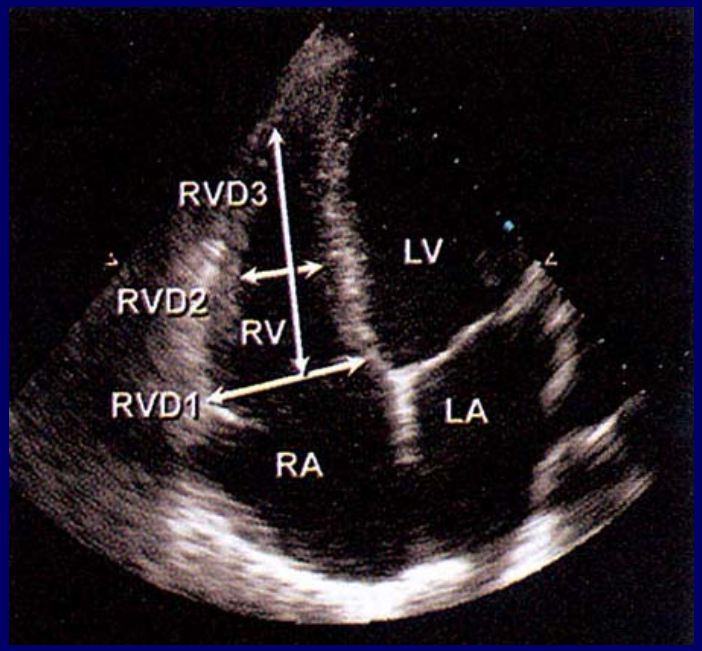



- Normal: less than 0.5 cm
- Measure at the level of TV chordae and at the peak of R wave of ECG on subcostal view
- Well correlated with peak RV systolic pressure

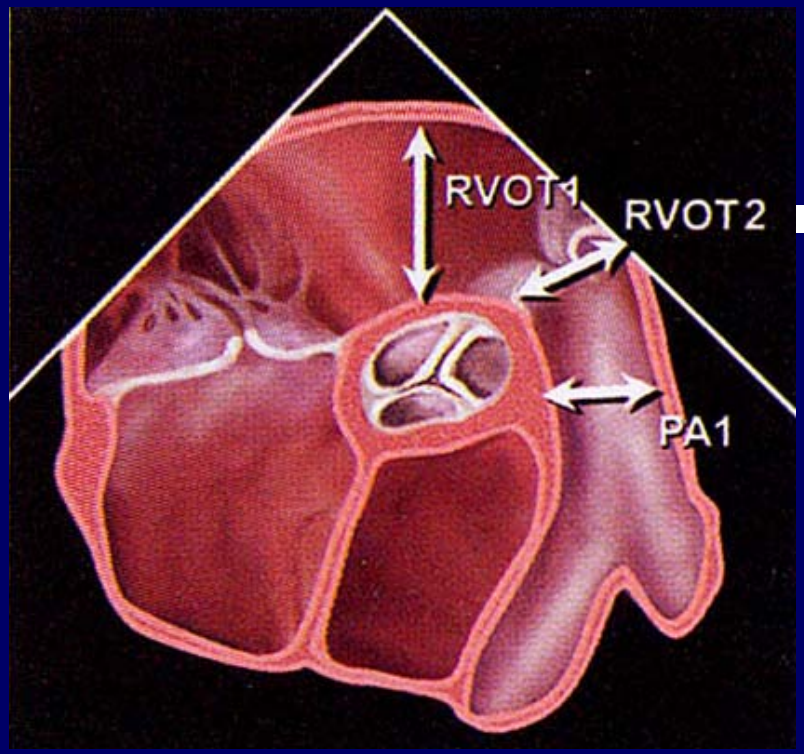
# 2D and M-mode: RV Dimension

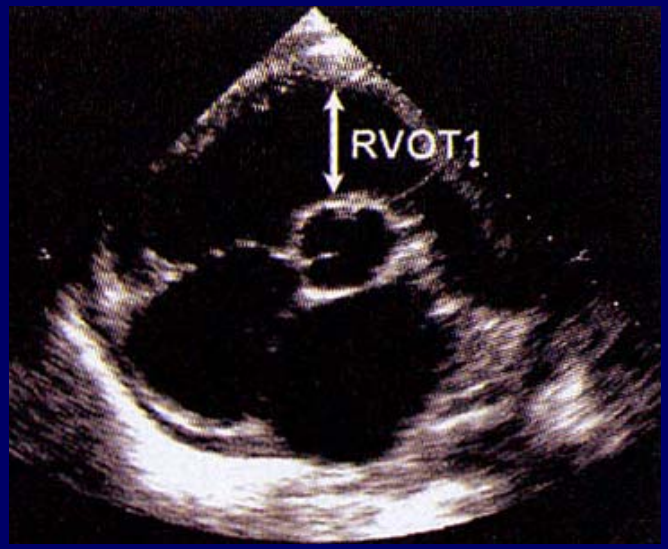


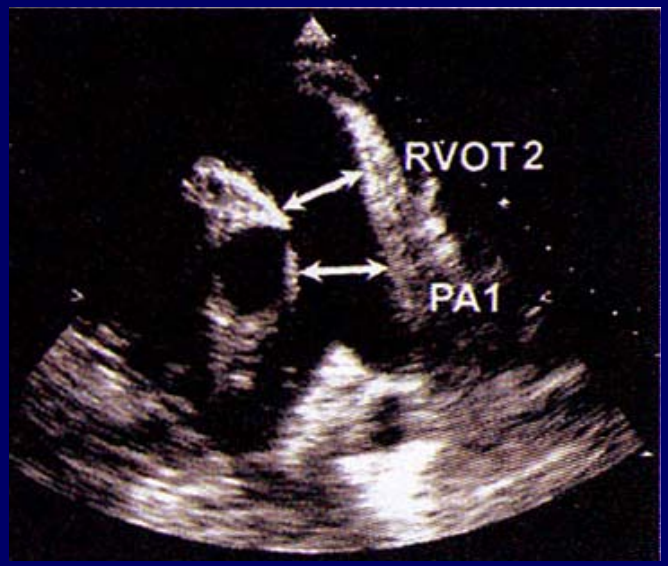




| | Reference range | Mildly abnormal | Moderately abnormal | Severely abnormal |
|---|---|---|---|---|
| Basal RV diameter (RVD1), cm | 2.0-2.8 | 2.9-3.3 | 3.4-3.8 | ≥3.9 |
| Mid-RV diameter (RVD2), cm | 2.7-3.3 | 3.4-3.7 | 3.8-4.1 | ≥4.2 |
| Base–to-apex (RVD3). cm | 7.1-7.9 | 8.0-8.5 | 8.6-9.1 | ≥9.2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

# 2D and M-mode: RVOT and PA Size



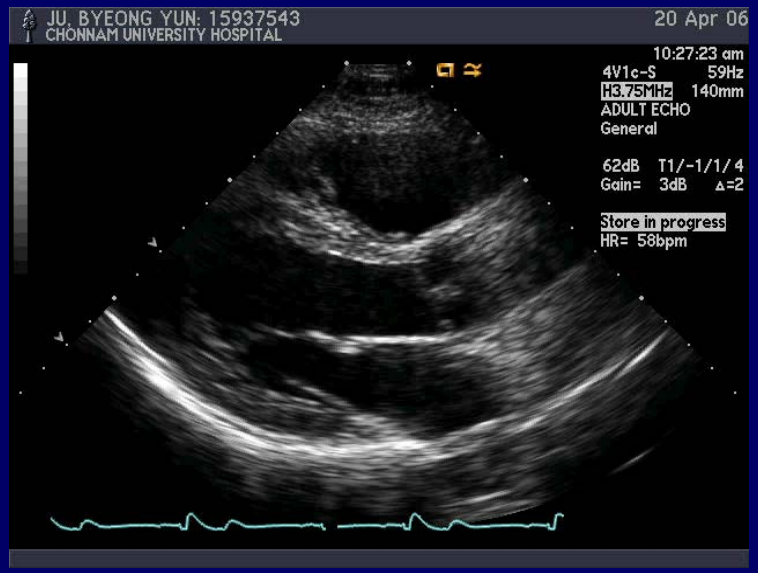



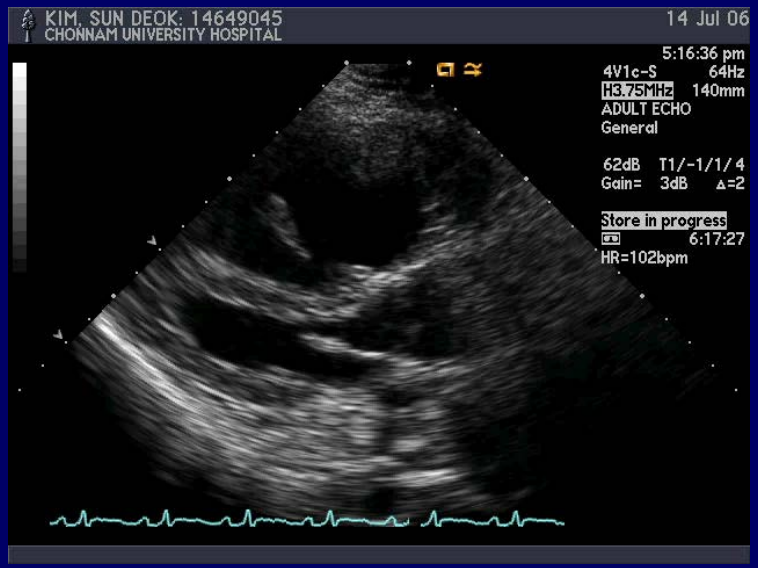



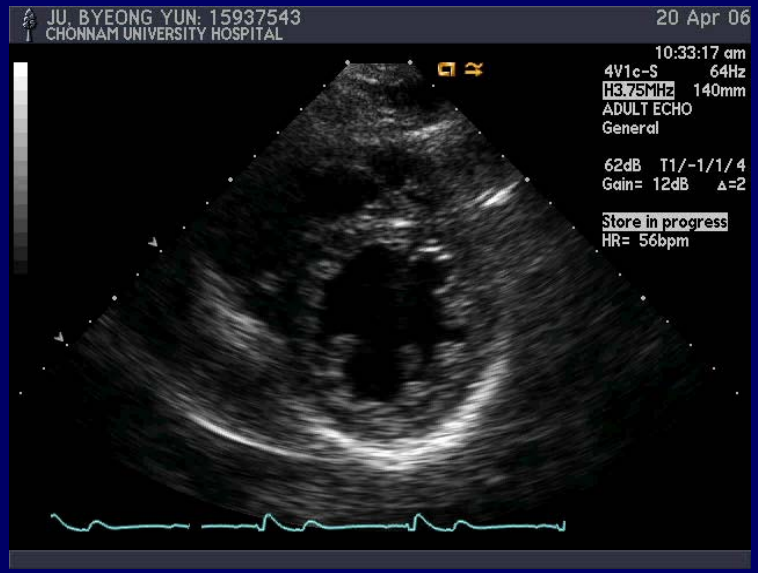
# 2D and M-mode: RVOT and PA Size

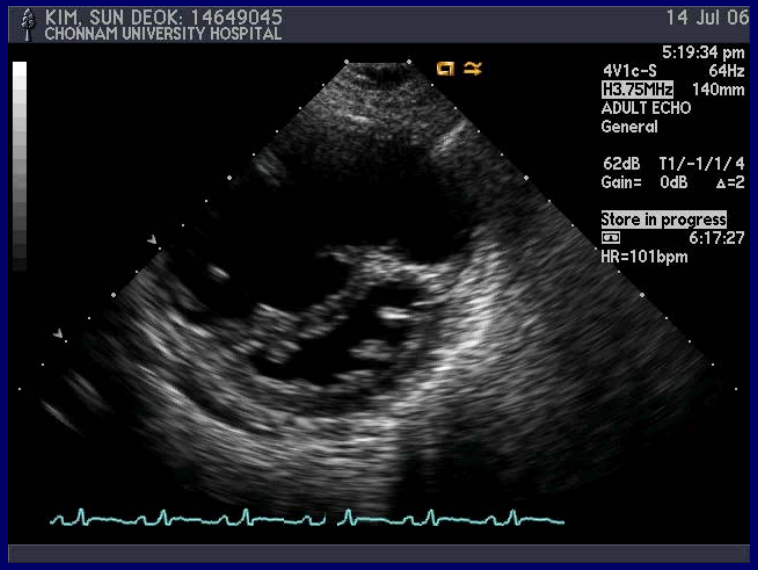
| | Reference range | Mildly abnormal | Moderately abnormal | Severely abnormal |
|---|---|---|---|---|
| **RVOT diameters, cm** | | | | |
| Above aortic valve(RVOT1) | 2.5-2.9 | 3.0-3.2 | 3.3-3.5 | ≥3.6 |
| Above pulmonic valve(RVOT2) | 1.7-2.3 | 2.4-2.7 | 2.8-3.1 | ≥3.2 |
| **PA diameter, cm** | |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

# 2D and M-mode: Dimension and Wall motion

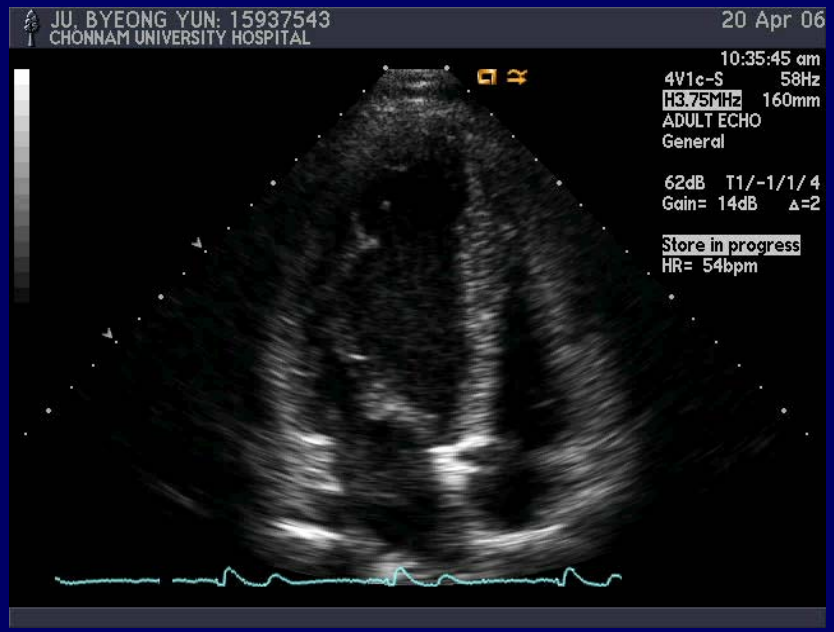


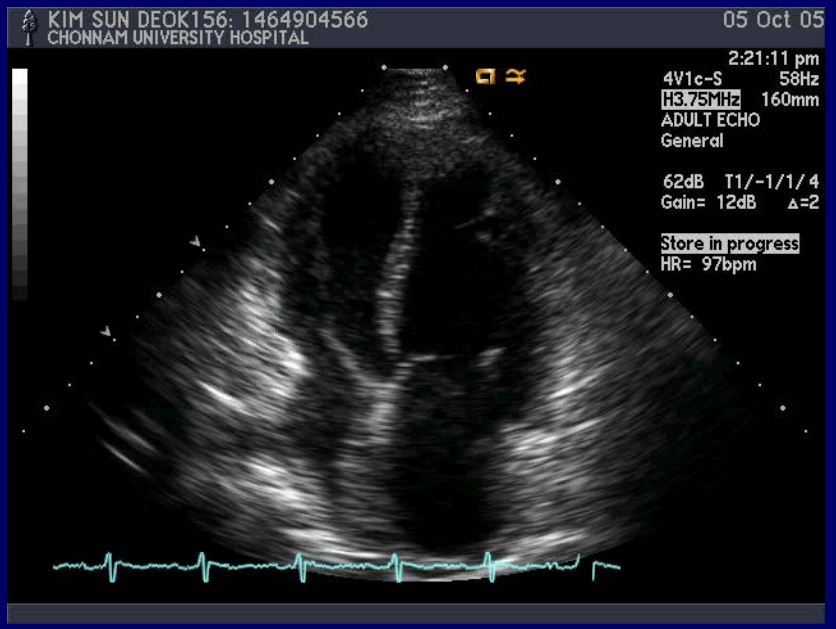



# 2D and M-mode: RV Size



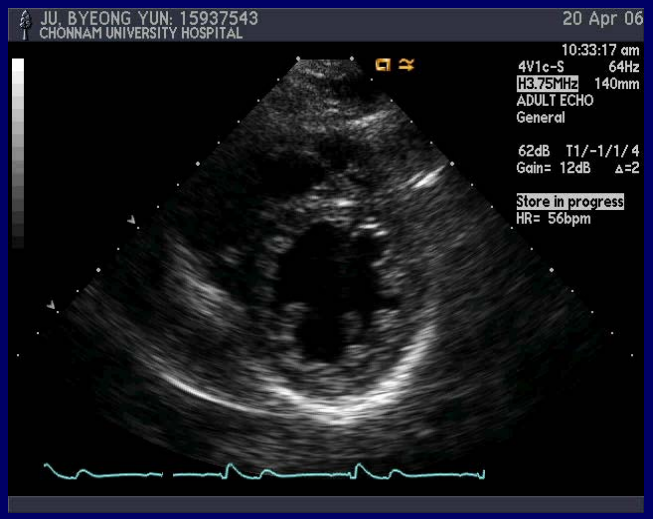



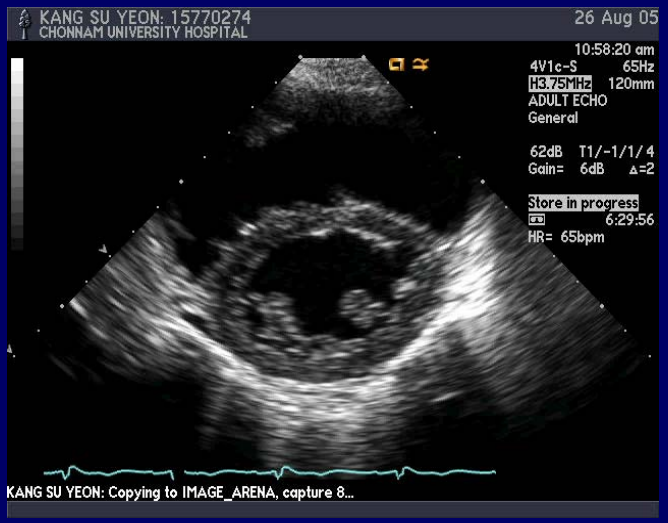

- Normal RV is approximately 2/3 of the size of the LV
- RV Dilatation

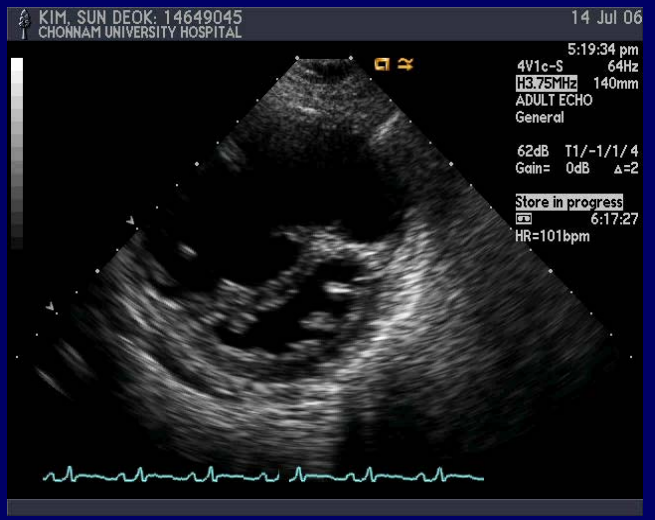
  : appears similar or larger than LV size

  : shares the apex

# 2D and M-mode: Eccentricity Index

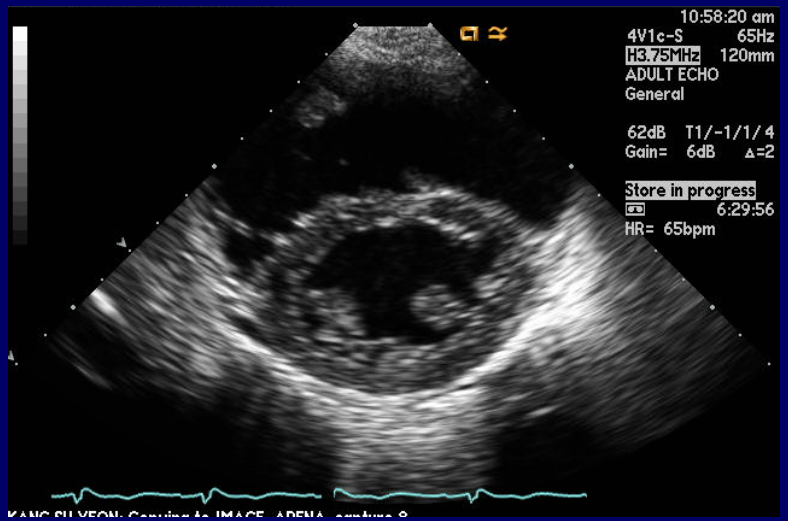


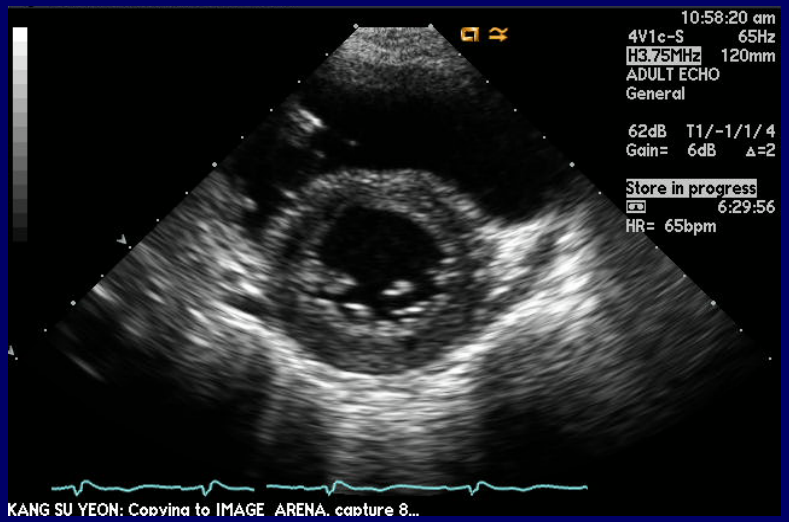



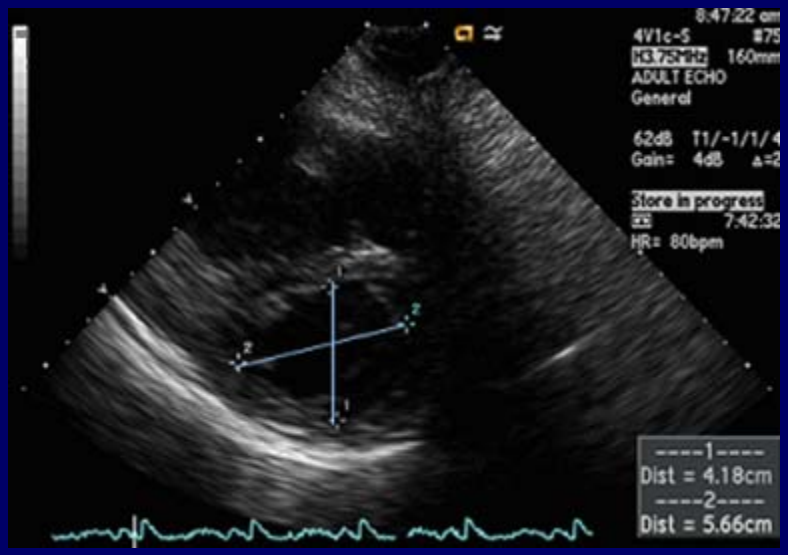



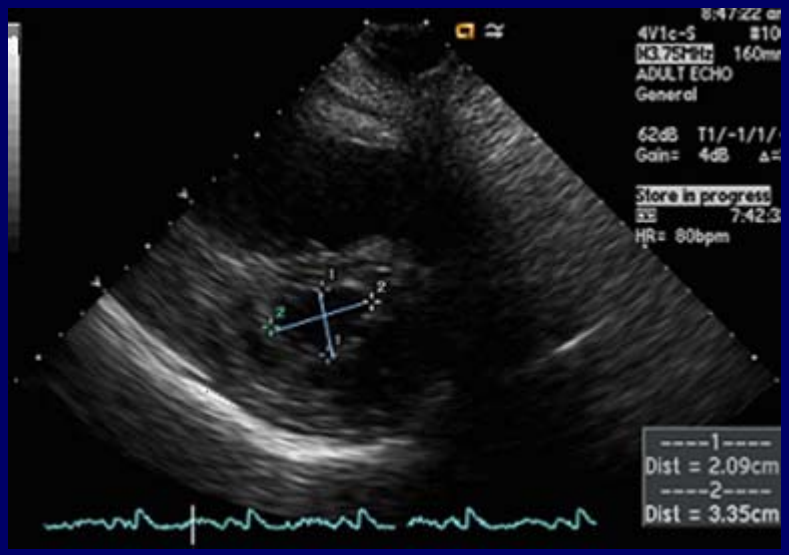

- The ratio of two orthogonal minor axis left ventricular chordae, measured from short axis view
- Reflects the degree of septal flattening resulting in abnormal LV shape
- Normal: approximately 1.0 in both diastole and systole

# 2D and M-mode: Eccentricity Index

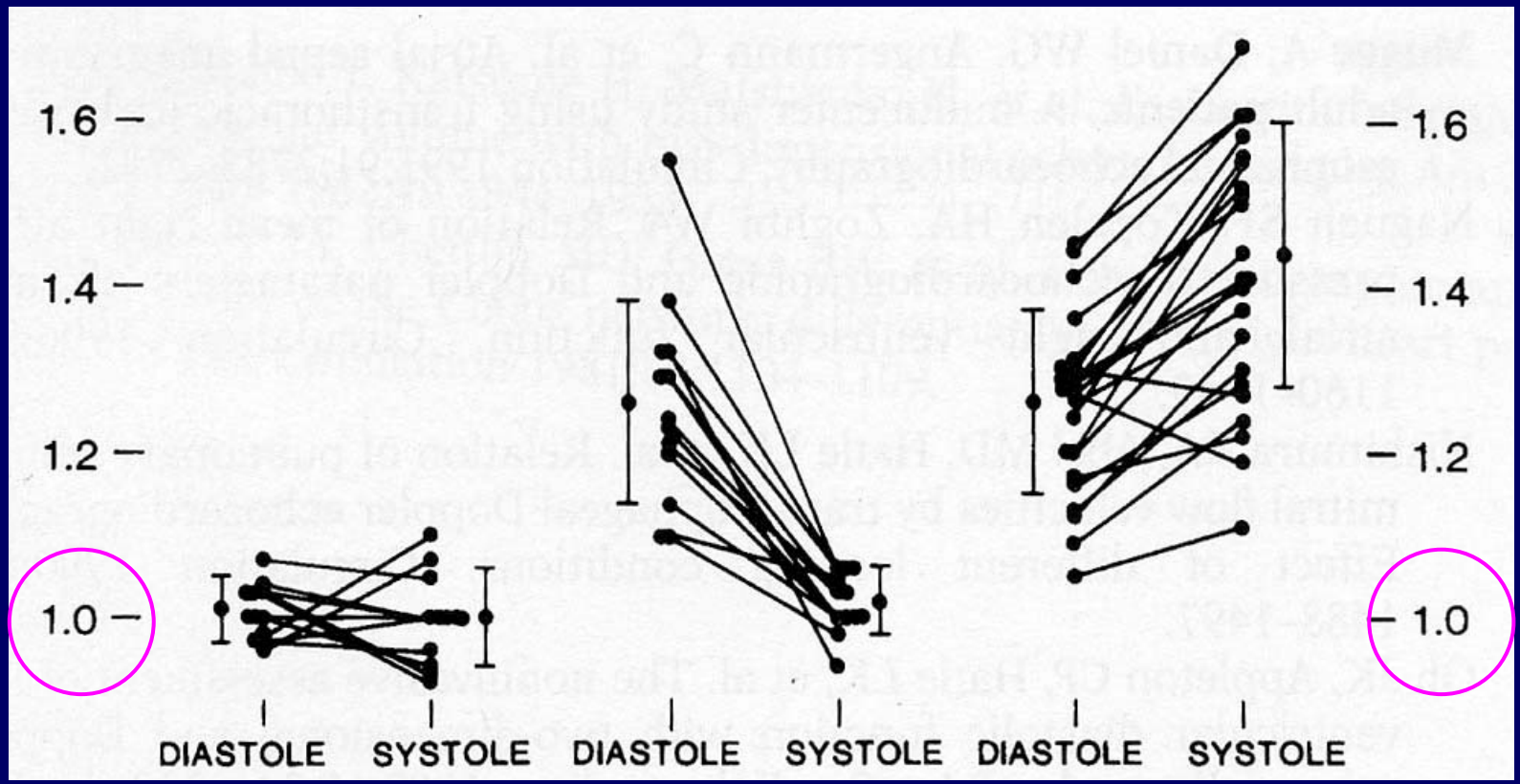


# 2D and M-mode: Eccentricity Index

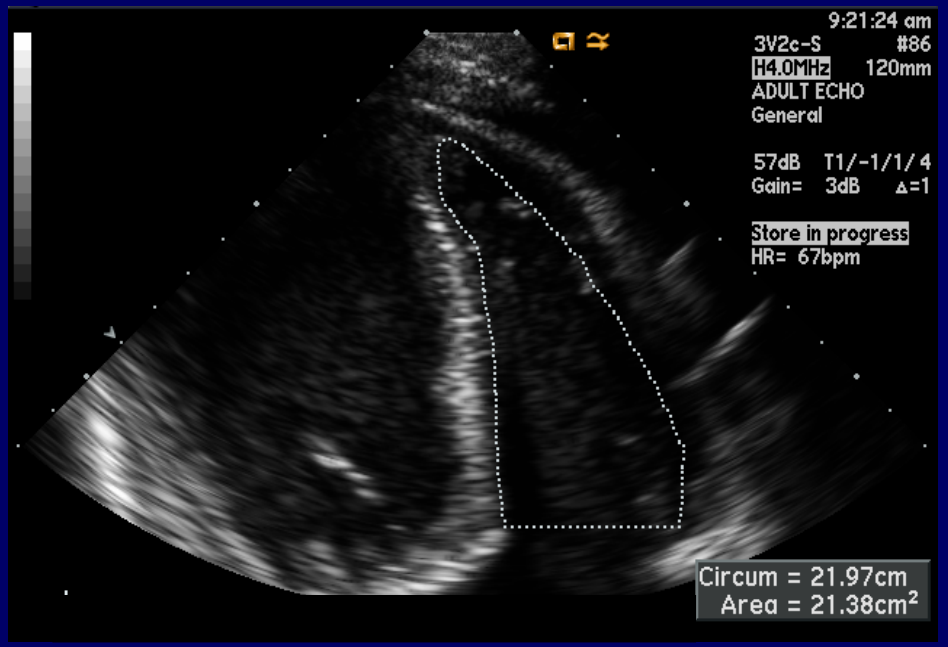


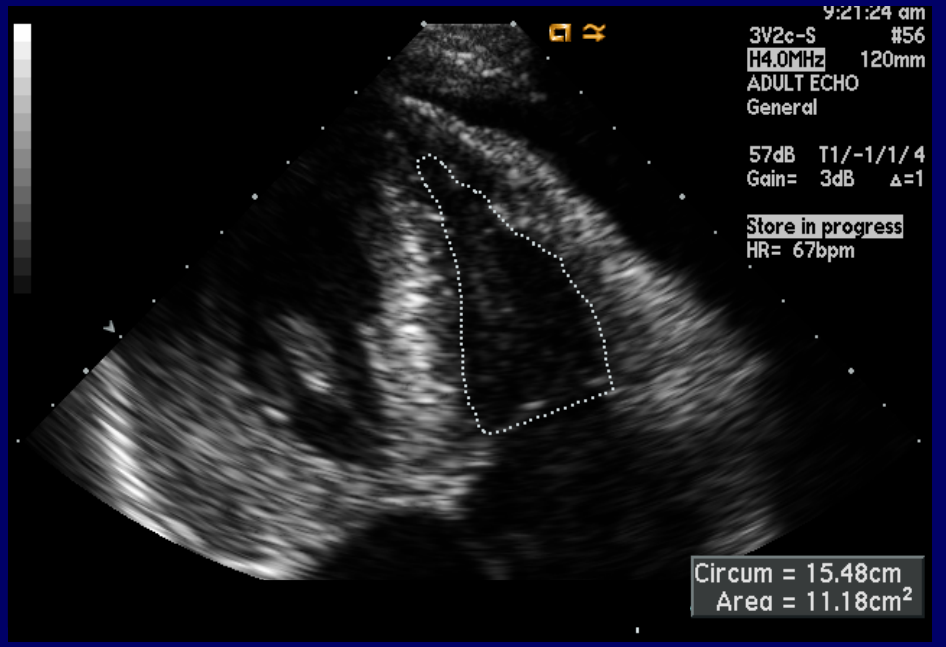

Normal

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

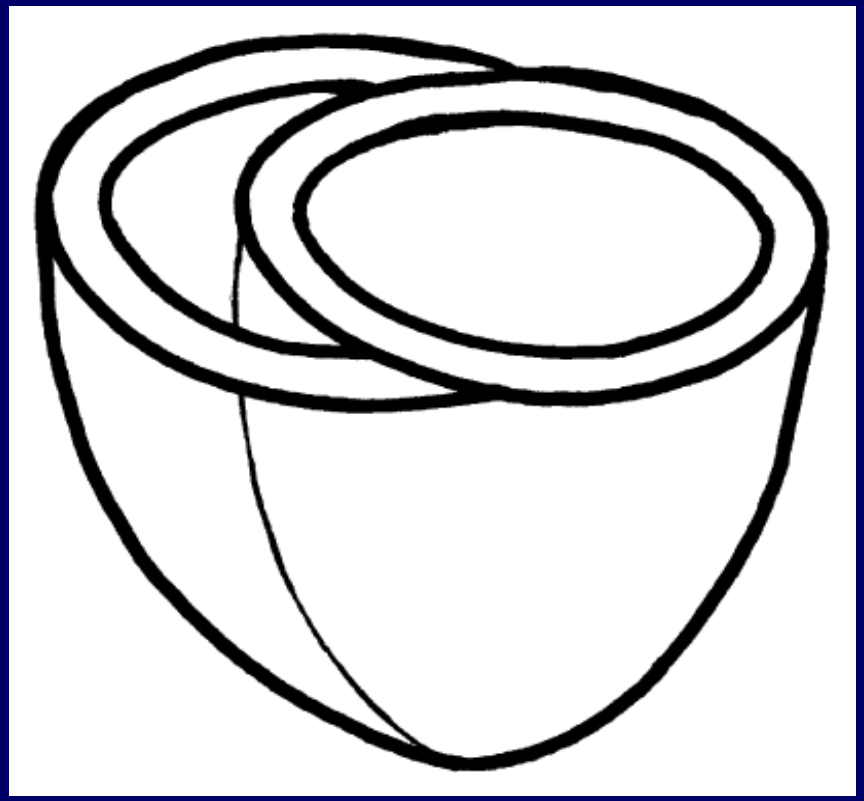
# 2D and M-mode: RV Volume or EF

- 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

# 2D and M-mode: RV Volume or EF



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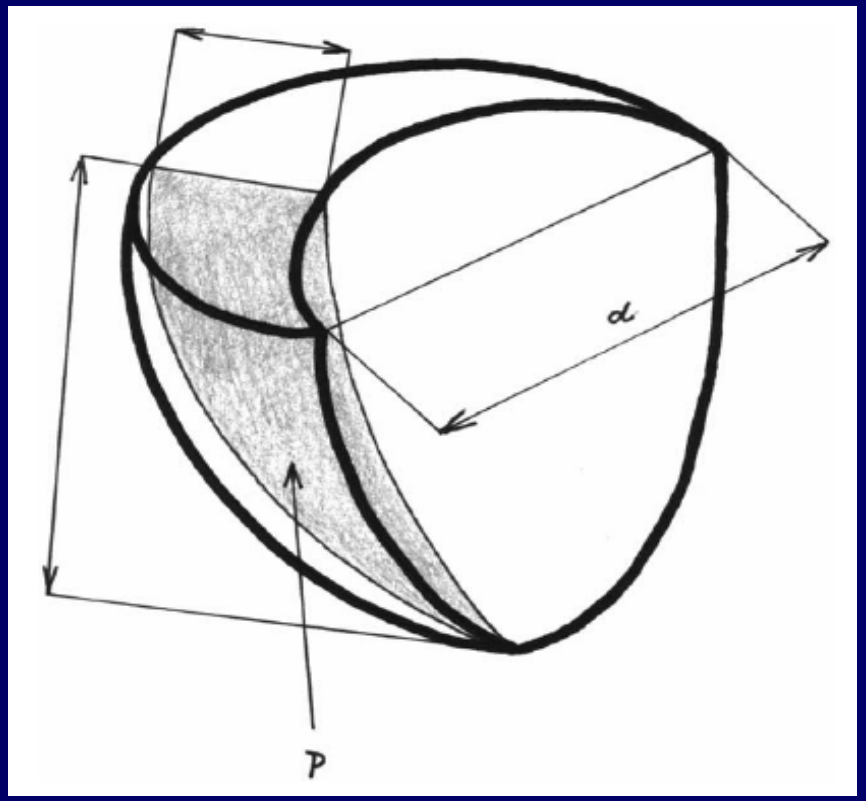



**Right ventricular volume = 2/3 Pd**

Kovalova et al. Eur J Echocardiography 2006

# Tricuspid Annular Plane Systolic Excursion

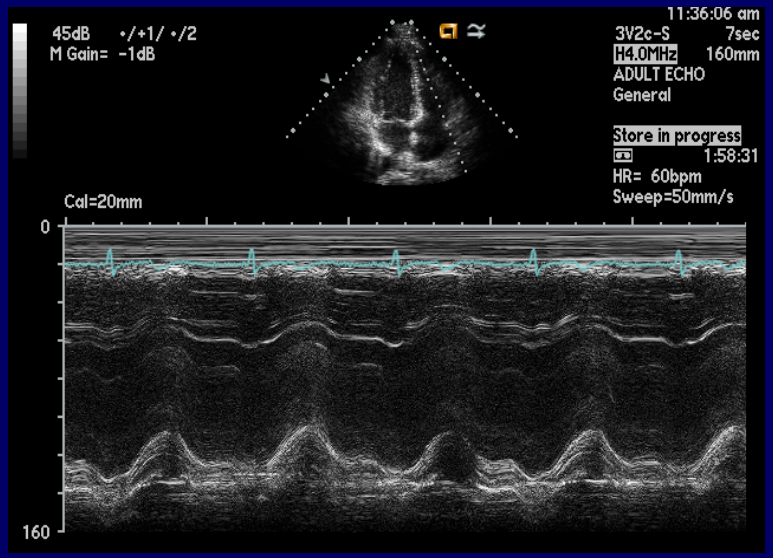
- Degree of systolic excursion of TV lateral annulus on A4C

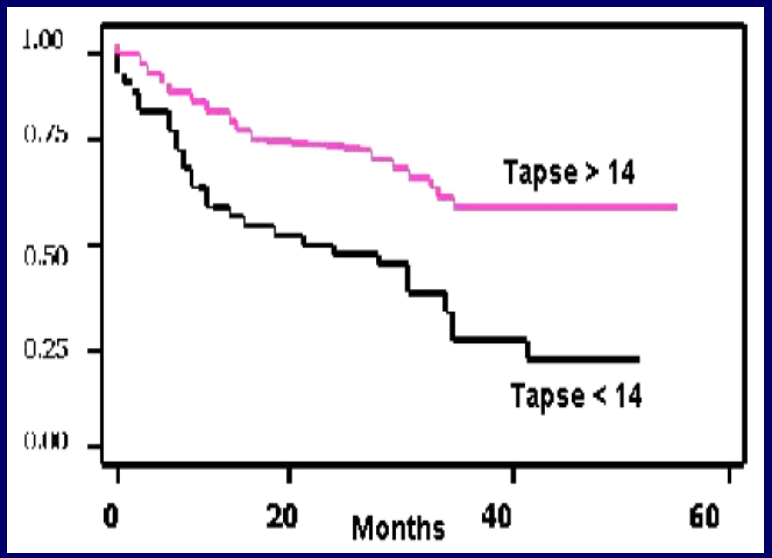
  : 1.5-2.0 cm in normal

  : 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

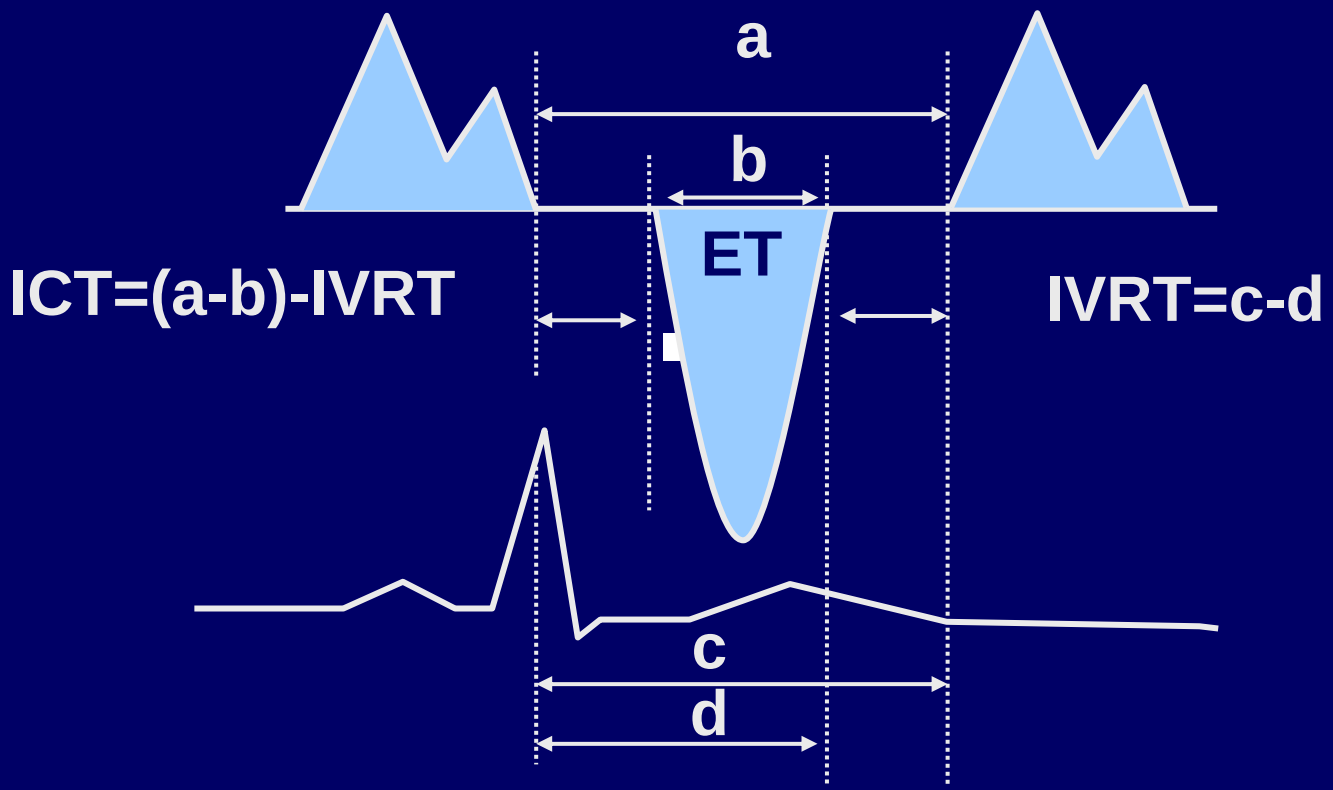
- CW Doppler of TR jet

  : Measure of systolic pulmonary artery pressure

  : Measure of the velocity of early RV systolic pressure rise

- Systolic time interval
- Pulmonary artery flow acceleration time
- Index of myocardial performance (IMP or Tei index)
- Tissue Doppler imaging (TDI)
- Strain rate imaging

# Doppler Echocardiography: IMP (Tei index)




**IMP = (a-b) / b = (IVCT + IVRT) / ET**

# Doppler Echocardiography: IMP (Tei index)

- IMP or Tei index

  : Initially described by Tei to measure global LV function

  : Recently introduced to measure RV function

- Advantages

  : Independent of geometry

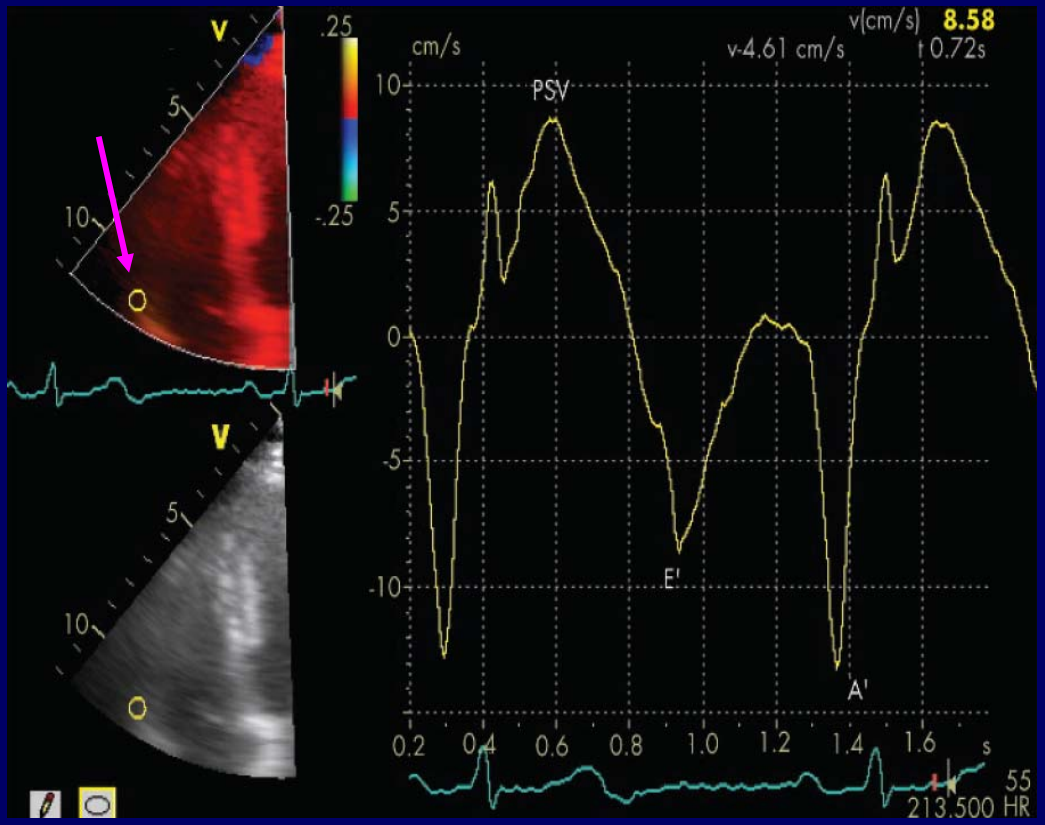
  : Useful in patients with inadequate RV image

  : Less affected by HR, loading condition, and degree of TR

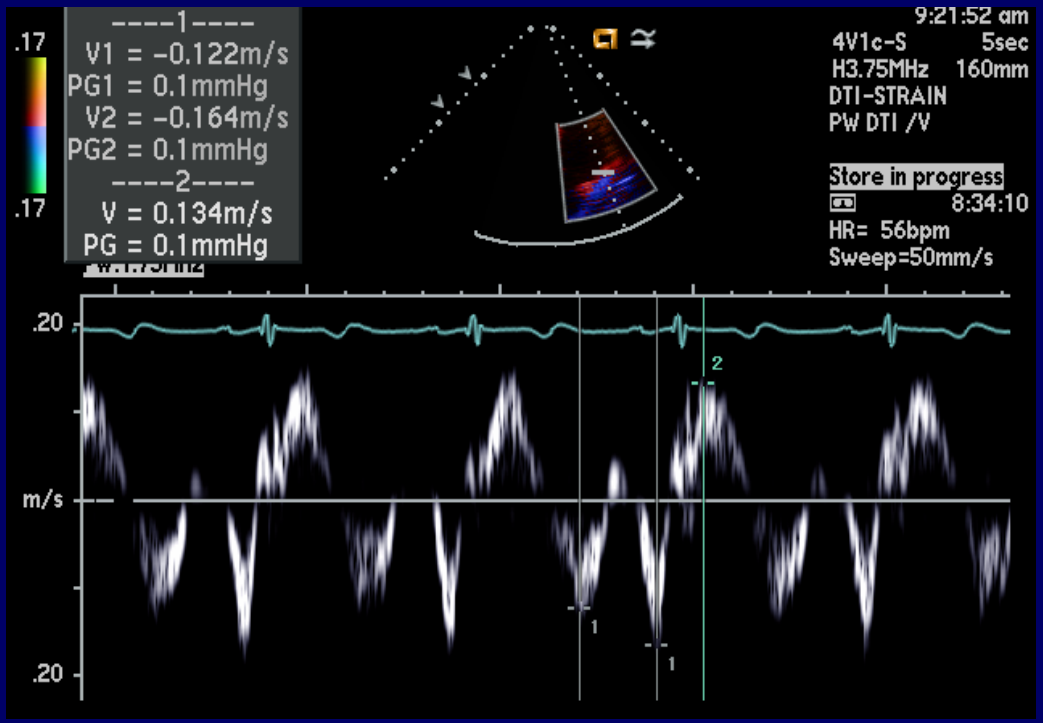
- Good predictor of prognosis in patients with congenital heart disease, PPH, and COPD

# Doppler Echocardiography: Tissue Doppler Imaging

## Peak systolic velocity (PSV)



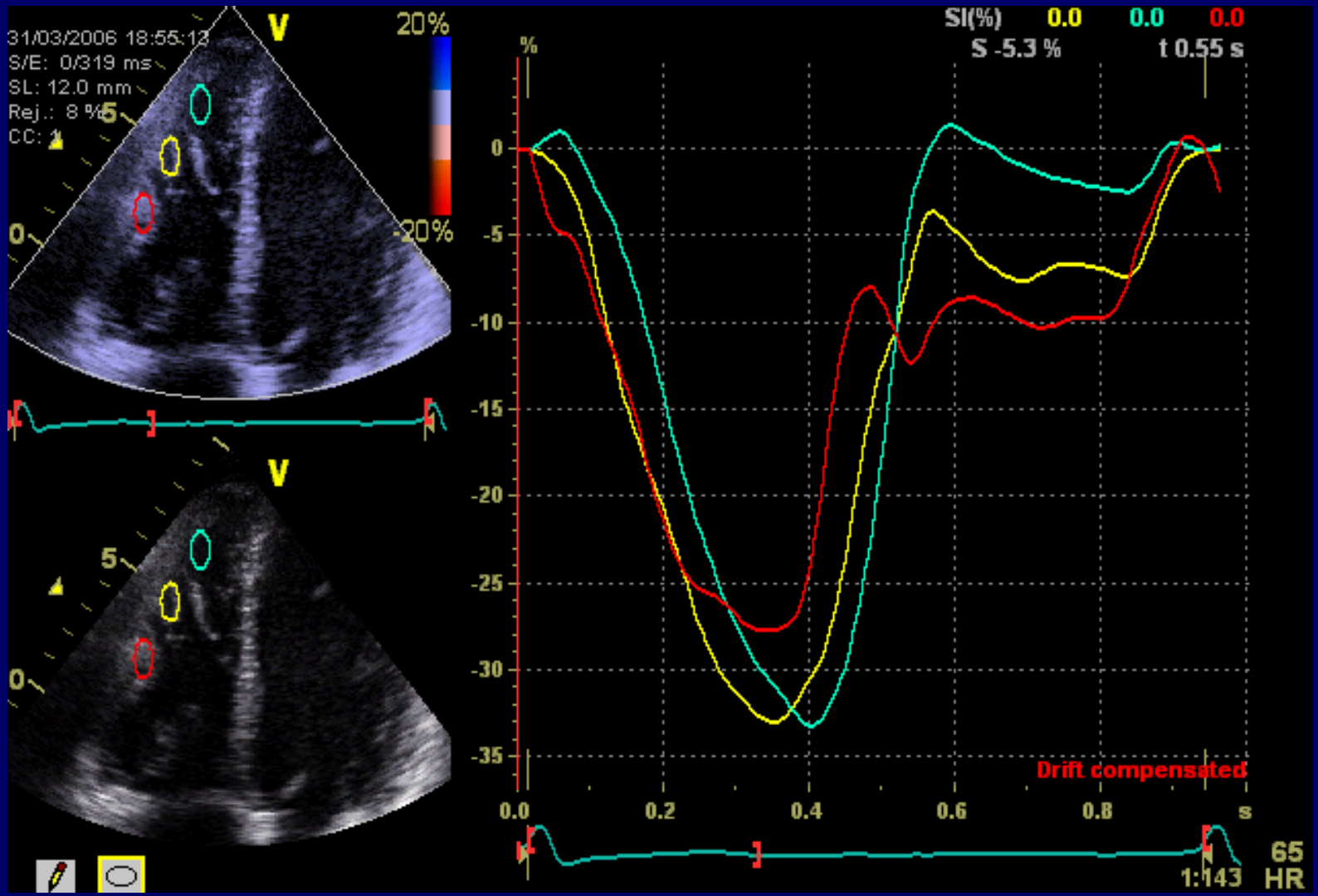

## Tricuspid lateral annular velocities



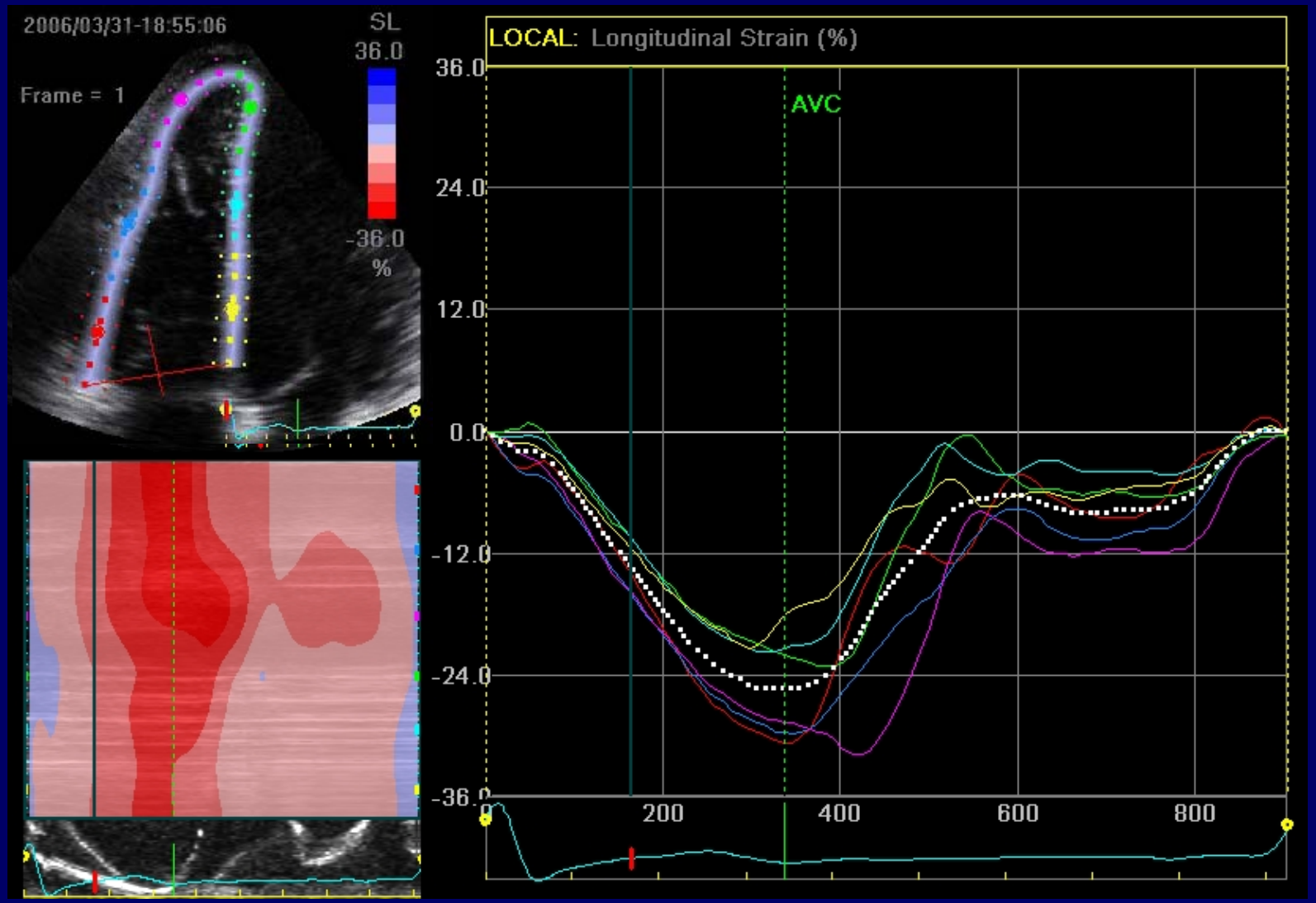
# Doppler Echocardiography: Tissue Doppler Imaging

- 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

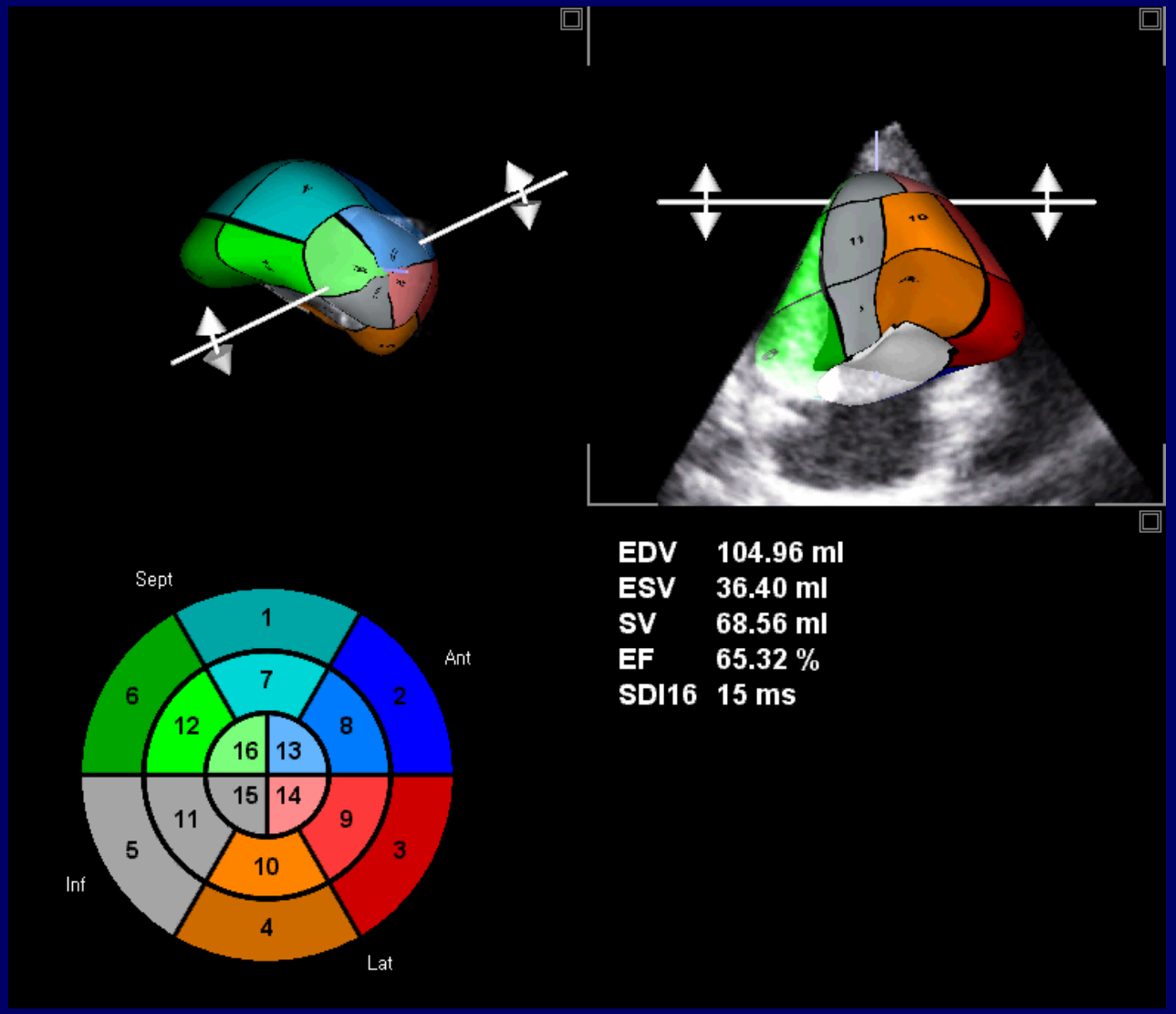
- RV longitudinal strain in apical view
  - : Feasible in clinical setting
  - : Baso-apical gradient with higher velocities at the base
  - : RV velocities are consistently higher as compared to LV
- Strain and strain rate values
  - : More inhomogeneously distributed in the RV
  - : Reverse baso-apical 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

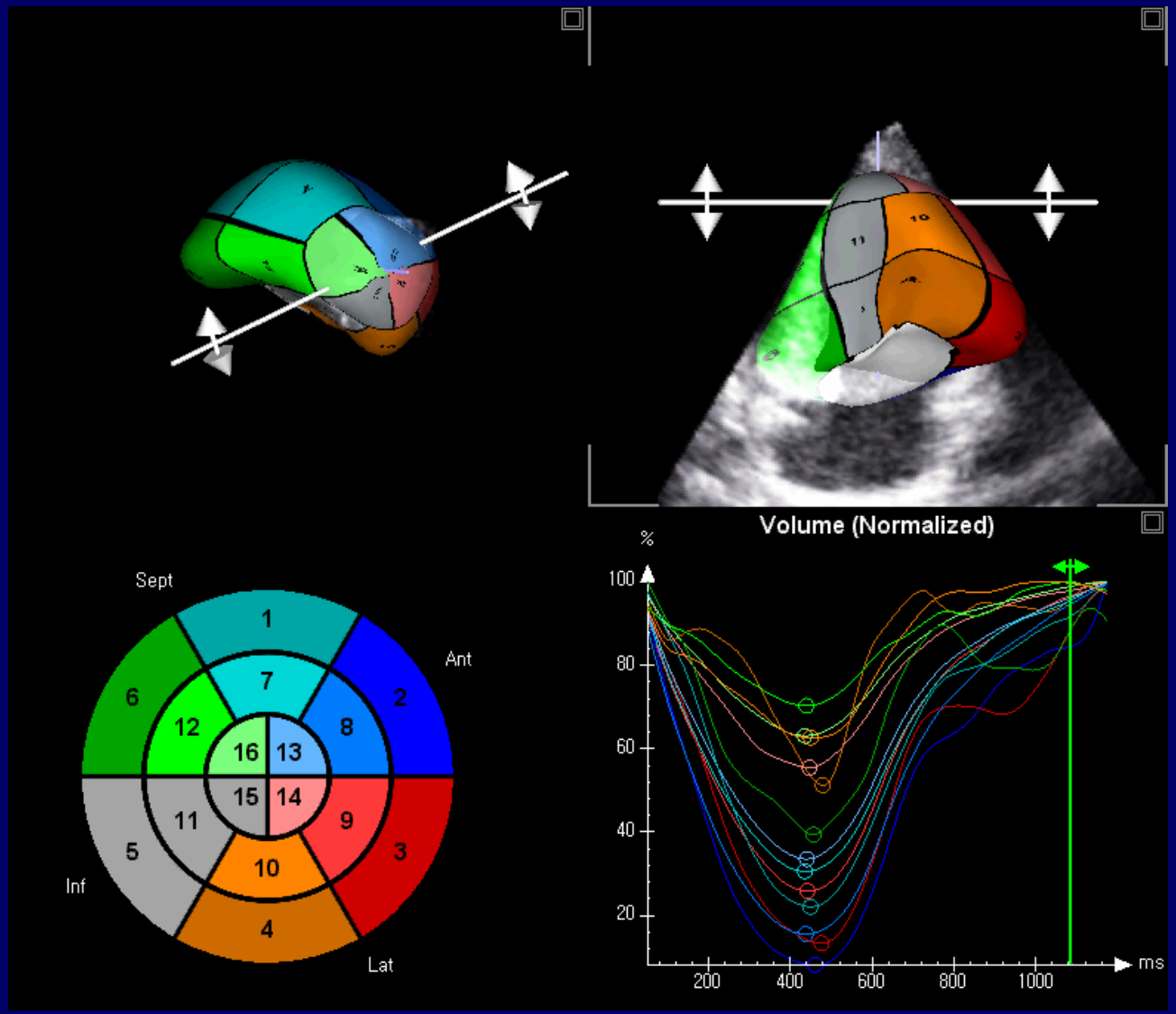
- Advantages of RT3DE
  - : Volume analysis does not rely on geometric assumptions
  - : Little artifacts associated with motion or respiration

- 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

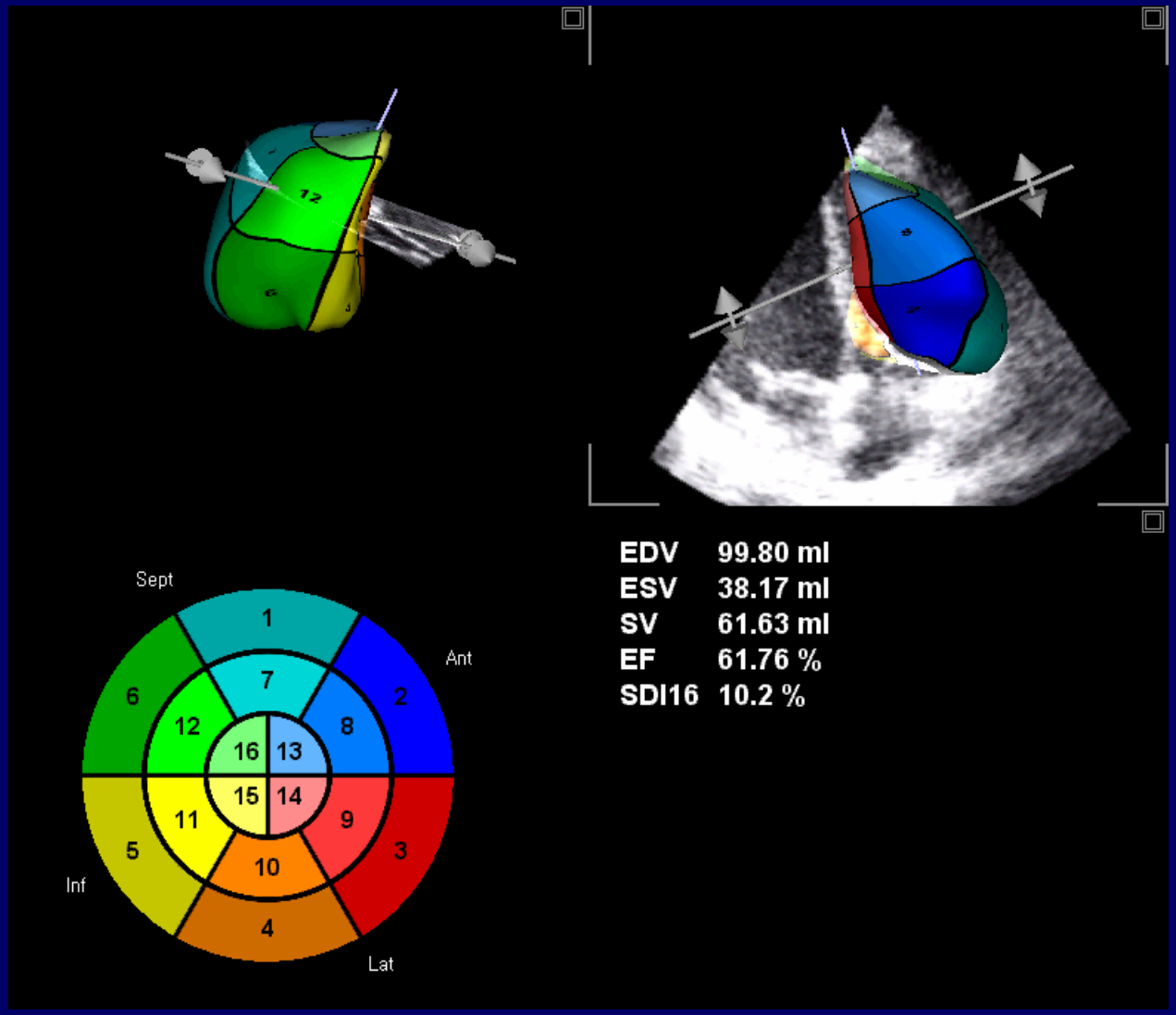
# RV Function: 3D Echocardiography



# 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


경청해 주셔서
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