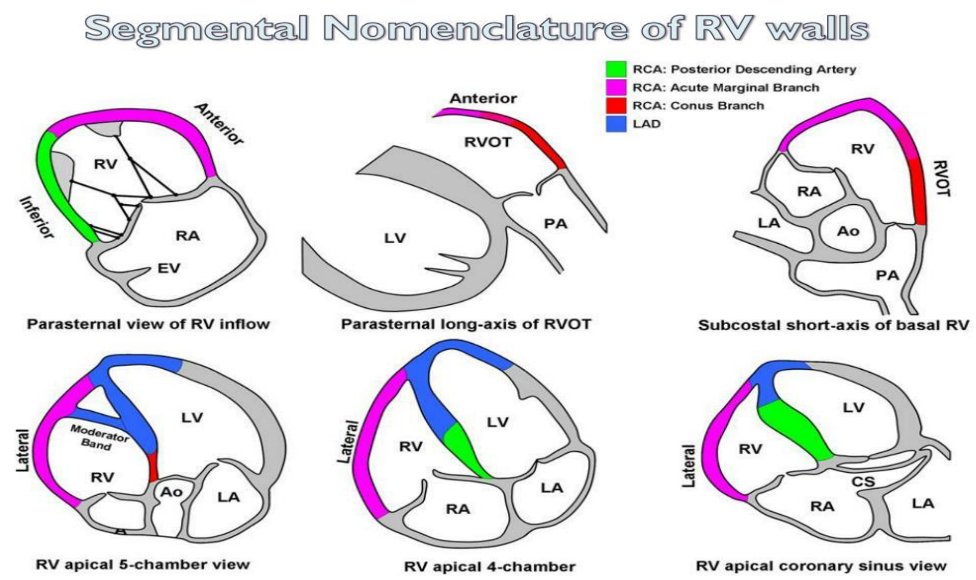
Right Ventricular Function

Anatomy & Physiology of the Right Ventricle

- The RV is a thin-walled pyramidal structure that "wraps around" the LV & it appears triangular when viewed in cross section. Shape of the RV is also influenced by the intraventricular septum.
- The RV has:
  - the inlet, with the TV, chordae tendineae, & papillary muscles,
  - the trabeculated apical myocardium
  - the infundibulum or conus which is the smooth myocardial outflow region & pulmonic valve

    Additional structures unique to the RV: crista supraventricularis, prominent trabeculations, three prominent muscular bands – the parietal band, the septomarginal band & the moderator band.
- In an adult, the volume of the RV is larger than the volume of the LV, whereas RV mass is about one sixth of the LV.
- **The RV contracts by three separate mechanisms:** <u>inward movements of the free wall to the interventricular septum </u>(i.e., is "bellows" motion, allowing for a larger volume shift with the little transverse motion), <u>contraction of longitudinal fibers</u>, and <u>traction on the free wall as a result of LV contraction</u>

  The main driving force of the LV contraction comes from a layer of circumferential constrictor fibers that act to reduce ventricular diameter. The RV lacks these fibers & thus must rely more heavily on longitudinal shortening than does the LV. In addition, although the RV does undergo torsion, this does not contribute substantially to RV contraction
- The systolic function is a reflection of contractility, afterload, & preload. RV performance is also influenced by heart rhythm, synchrony of ventricular contraction, and ventricular interdependence.



2D Echocardiographic Assessment of Right Ventricular Size

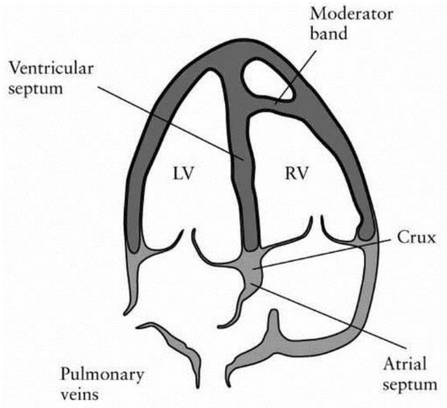
The RV is the complex 3D shape, and unlike the LV is difficult to model with a single 2D echocardiographic view. Therefore, **multiple** views should be assessed before determining that RV enlargement is present.

Qualitative RV Size

- A standard A4C view is best to assess RV size compared with that of the LV
  - Mildly enlarged: RV is enlarged but < LV
  - Moderately enlarged: RV = LV
  - Severely enlarged: RV > LV, apex of the heart is comprised of RV

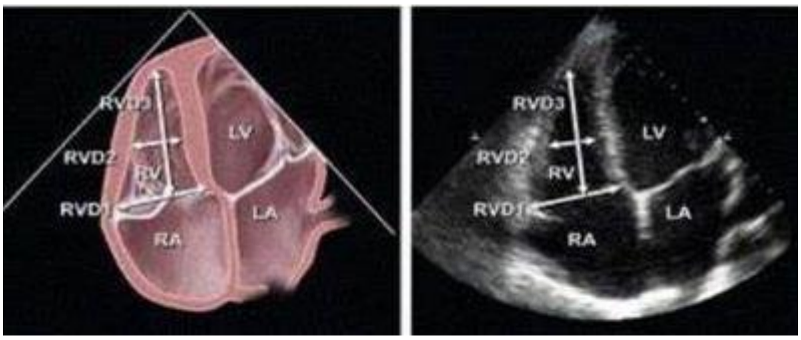
Quantitative RV Size

RV dimension is estimated at end-diastole from an RV focused A4C view with the goal of demonstrating the maximum diameter of the RV without foreshortening. This is accomplished by ensuring the crux *(The crux is located on the lower back side of the heart where the coronary sulcus (the groove separating the atria from the ventricles) and the posterior interventricular sulcus (the groove separating the left from the right ventricle) meet)* & apex are in view.



Taken at 3 levels:

- Diameter above the tricuspid valve annulus/Basal RV diameter (RVD1)
- Mid RV cavity (RVD2)
- Distance from the TV annulus to the apex (RVD3)



RV dilation: (Diameter in diastole)

- Basal: >4.2 cm
- Mid-level: >3.5 cm
- Longitudinal: >8.6

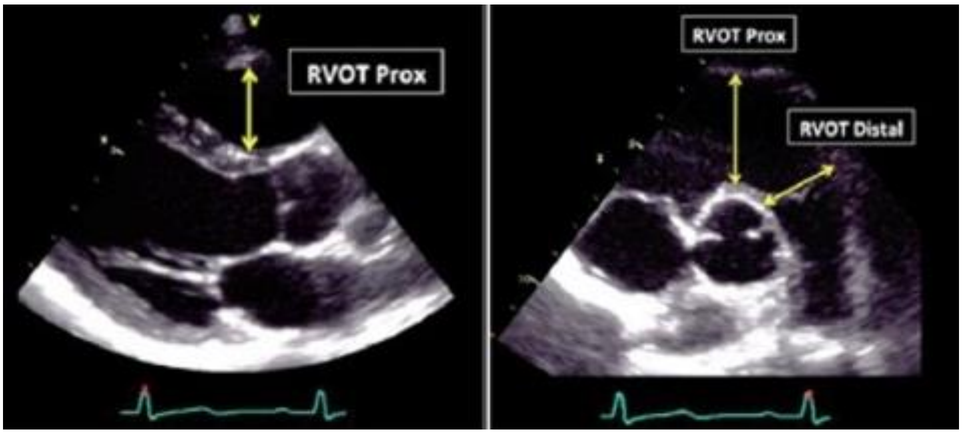
Note: as RV enlarges, it assumes more of a spherical shape and can impair LV output.

Quantitative RVOT Size

Best viewed from the left parasternal and subcostal windows

Size of the RVOT measured at the end-diastole on the QRS deflection

- Measured in PSAX view with focus on the RVOT and pulmonic valve
- PLAX RVOT proximal diameter >3.3 cm indicated enlargement
- RSAX RVOT distal (just proximal to the pulmonary valve) diameter >2.7 cm indicated enlargement



Quantitative RV Thickness

RV wall thickness measured at peak of R wave on ECG at the level of TV chordae in subcostal view (normal ≤5 mm or 0.5 cm, if >0.5 cm indicates RV wall thickness)

RVH may suggest RV pressure overload in the absence of other pathologies

Assessment of Right Ventricular Systolic Function

Right Ventricular Function Assessed by following methods –

- Fractional Area Change (FAC)
- Tricuspid Annular Plane Systolic Excursion (TAPSE)
- TEI Index or Right index of myocardial performance (RIMP) or myocardial performance index (MPI)
- S' (Tissue doppler systolic signal velocity of TV lateral annulus)

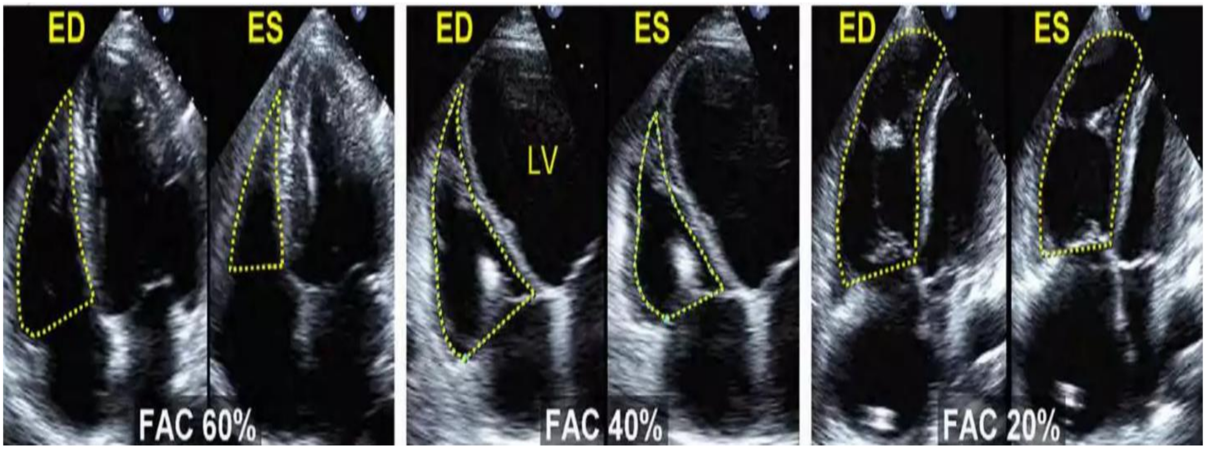
- Visual estimation of RV free wall & TV annular motion

Fractional area change (FAC)

- **Fractional area change (FAC)** is calculated by tracing the endocardial border (RV area) from tricuspid annulus along the free wall to the apex, then back to the annulus, along the IVS at end diastole (ED) & end systole (ES) in A4C view
- Trabeculations should be excluded while tracing the area.

End diastolic area – End systolic area/ End diastolic area x 100

- Normal Fraction area: >35%



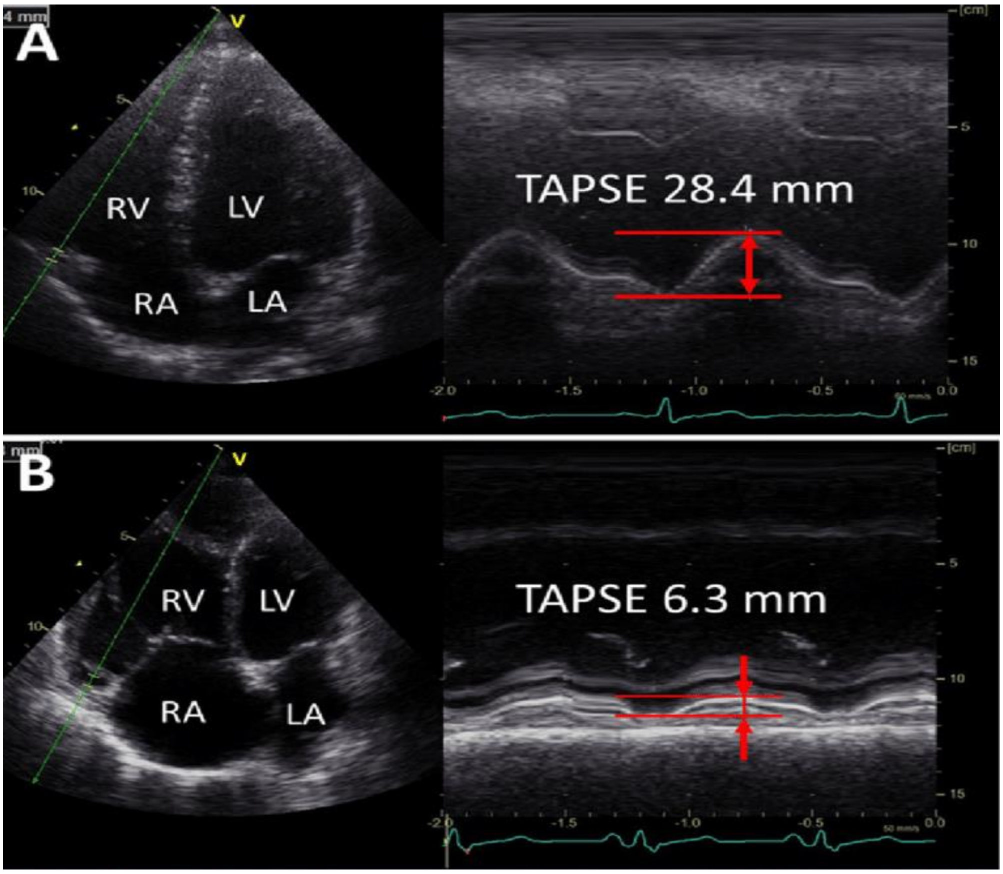
Tricuspid Annular Plane Systolic Excursion (TAPSE) or Tricuspid Annular Motion (TAM)

As RV systolic function primarily relies on longitudinal myocardial shortening, measurement of TAPSE can be used.

TAPSE is a method to measure the distance of systolic excursion of the RV annular segment along its longitudinal plane. TAPSE is the difference in the displacement of the RV base during diastole & systole.

In the A4C view, an M-mode cursor is oriented to the junction of the TV plane with the RV free wall

TAPSE <1.6 cm – Abnormal excursion (low sensitivity but high specificity)



Advantages of TAPSE:

- Simple, less dependent on optimal image quality and reproducible
- Does not require sophisticated equipment or prolonged image analysis

Disadvantages of TAPSE:

- Assumes that the displacement of a single segment represents the function of a complex 3D structure
- It is angle dependent, and there are no large-scale validation studies
- Finally, TAPSE may be load dependent

RIMP/MPI/Tei Index

It is global estimation of both systolic & diastolic function of the right ventricle. RIMP is a ratio of isovolumic time (contraction and relaxation) to ventricular ejection time (ET).

Obtained by two methods: the pulse Doppler method & the tissue Doppler method

- **2D Doppler:** TR jet duration (CW Doppler) and RVOT jet duration (PW Doppler) are recorded.

The duration of TR is holosystolic & includes both isovolumic relaxation & contraction, RVOT ET only includes active ejection

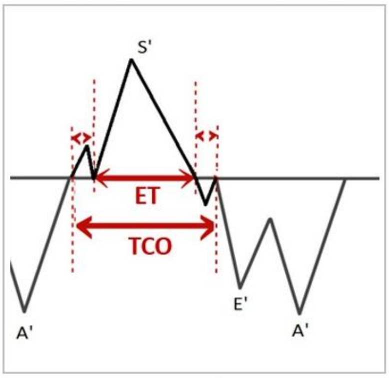
MPI = IVCT + IVRT/ET

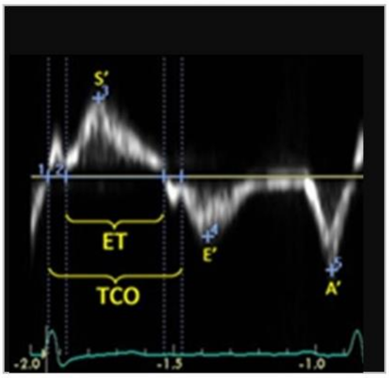
However, IVCT + IVRT = TR time – RVOT ET

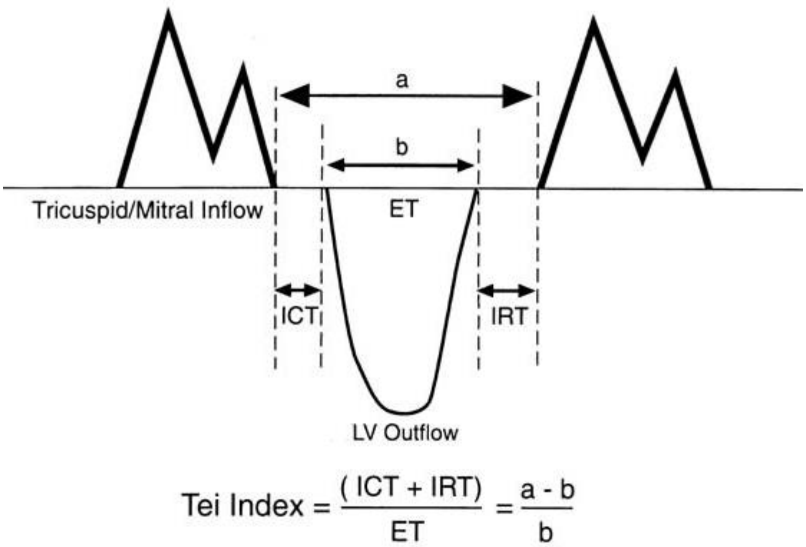
Thus, MPI is also given as:

MPI = (TR time – RVOT ET)/RVOT ET

- **Tissue Doppler:** IVCT, IVRT and ET are measured from tissue Doppler velocity of the lateral tricuspid annulus. This technique avoid error related to heart rate variability.







RIMP >0.40 by pulsed Doppler & >0.55 by tissue Doppler indicated RV dysfunction

Advantages of RIMP

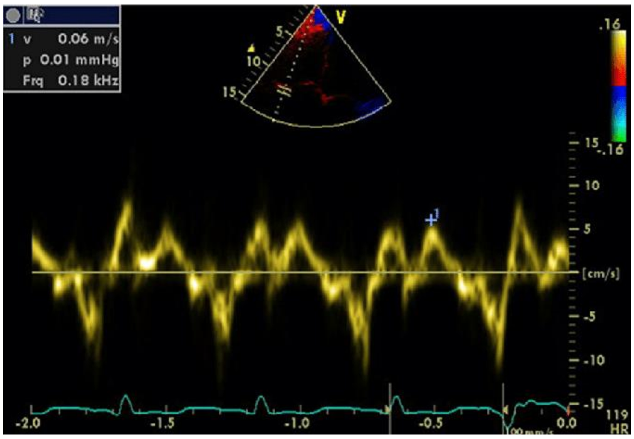
- Feasible in a large majority of subjects both with & without TR
- Reproducible
- Avoids geometric assumptions & limitations of complex RV geometry

Disadvantages of RIMP

- Unreliable when RV ET & TR time are measure with differing RR intervals, such as in atrial fibrillation
- It is load dependent & unreliable when RA pressure is elevated.

Tissue Doppler (S'):

S' is a measured of RV systolic function& is measured by tissue Doppler at the lateral tricuspid annulus. S' <10 cm/sec indicates RV dysfunction. (Normal >10 cm/sec)



Advantages of TDI

- A simple, reproducible technique with good discriminatory ability to detect normal versus abnormal RV function
- Pulsed Doppler is available on all modern systems

Disadvantages of TDI

- Is angle dependent
- Limited normative data in all ranges and in both sexes
- It assumes that the function of a single segment represents the function of the entire right ventricle.

Assessment of Right Ventricular Diastolic Function

- From the A4C view, the PW Doppler beam should be aligned parallel to RV inflow, where sample volume (sample gate) is paced at the tips of the tricuspid valve leaflets
- Measure at the end-expiration and/or take the average of ≥5 consecutive beats

Grading of RV Diastolic Dysfunction should be done as follows:	
Impaired relaxation	E/A ratio <0.8
Pseudonormal filling	E/A ratio 0.8 - <2.0 with an E/e' ratio >6 including a diastolic prominence in the hepatic veins
Restrictive	E/A ratio >2.1 with deceleration time <120 ms

Tissue Doppler of the lateral TA (tricuspid annulus), PW Doppler of hepatic veins, & IVC should be measured.

Right Atrial Assessment

RA Size Assessment

- Measured in A4C view at end-diastole: Tracing of the RA is performed from the plane of the Tricuspid annulus along the interatrial septum, superior, and anterolateral wall of the RA.
- Estimation of Right atrial area by planimetry

RA Enlargement:

- Area >18 cm^2
- Length (major dimension) >53 mm, Diameter (minor dimension) >44 mm
    - *RA major dimension is the distance from the superior wall to the TA.*
    - *RA minor dimension is the distance from interatrial septum to the anterolateral wall.*

Estimating Mean RA Pressure

RA pressure is estimated by the size & compressibility of the IVC.

Diameter of the IVC is measured in subcostal view just proximal to the entrance of hepatic veins during quiet respiration & after "sniff" maneuver.

Variable	**Normal RA Pressure ranges from 0-5mmHg**	**Intermediate RA Pressure ranges from 5-10 mmHg**	**High RA Pressure ranges from 10-20mmHg**
IVC diameter	≤2.1 cm	-	>2.1 cm
Collapse with sniff	collapsing	-	<50%
Secondary indices of RA pressure			– Restrictive filling – Tricuspid E/e' >6 – Diastolic flow – Predominance in hepatic veins (systolic filling fraction <55%)

Note:

- In normal young athletes, the IVC may be dilated with normal RA pressure
- Ventilated patients may have dilated and non-collapsible IVC

RV Pathology

RV Volume or pressure overload< RV Infarction, ARVD, Pulmonary embolism etc.