Right Ventricular Function and PAP measurement

Brussels International Echo Course
September 2007

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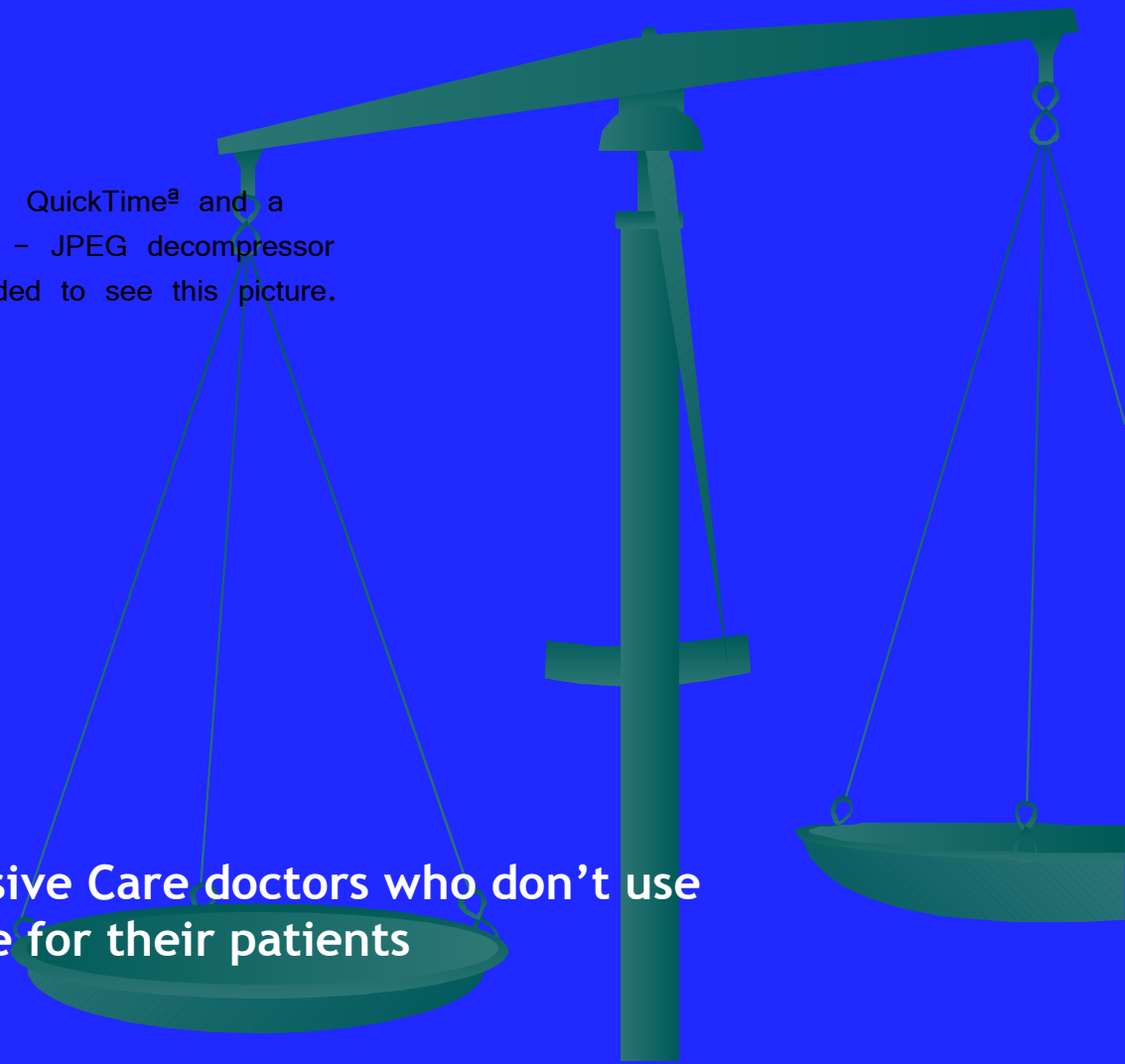
THE NEPEAN HOSPITAL PENRITH



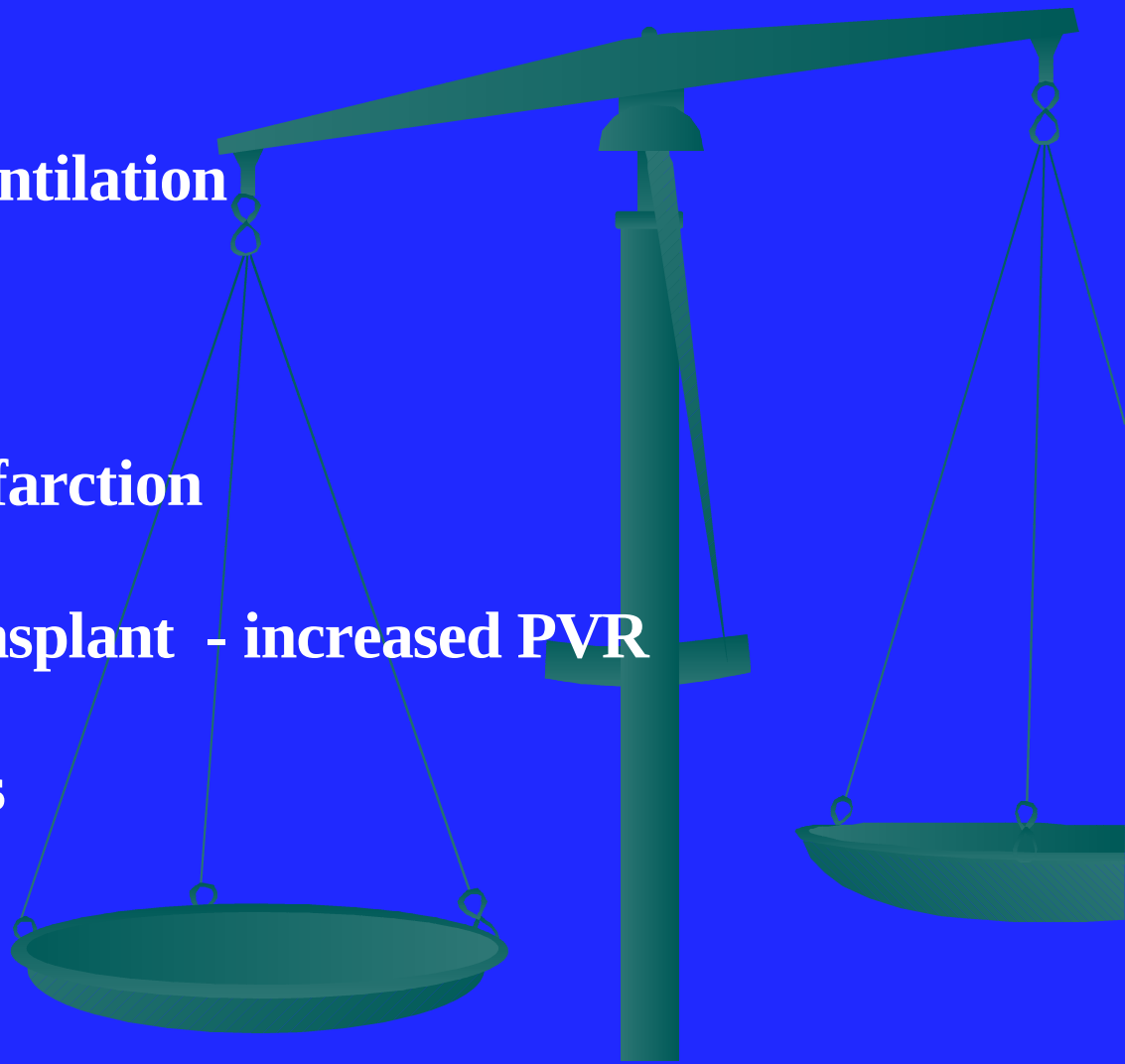
a future shared by Intensive Care doctors who don't use echocardiography to care for their patients

The right heart and …..

…. the critical care specialist

Factors precipitating RV Failure are common in ICU:

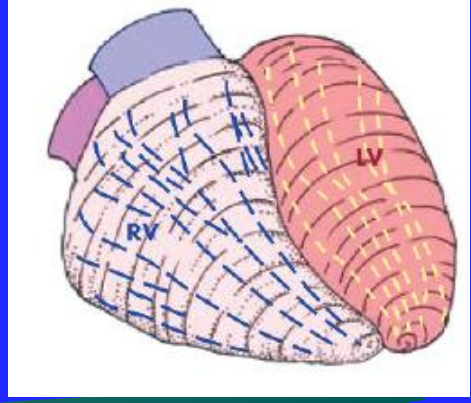
- ARDS
- positive pressure ventilation
- sepsis
- right ventricular infarction
- LVAD, cardiac transplant - increased PVR
- pulmonary embolus



Right Heart

- differences to left heart in anatomy and physiology
- therefore different responses to pathological forces
- diagnosis and evaluation of right heart function more complex
- management of right heart dysfunction - special considerations

RV-LV interaction

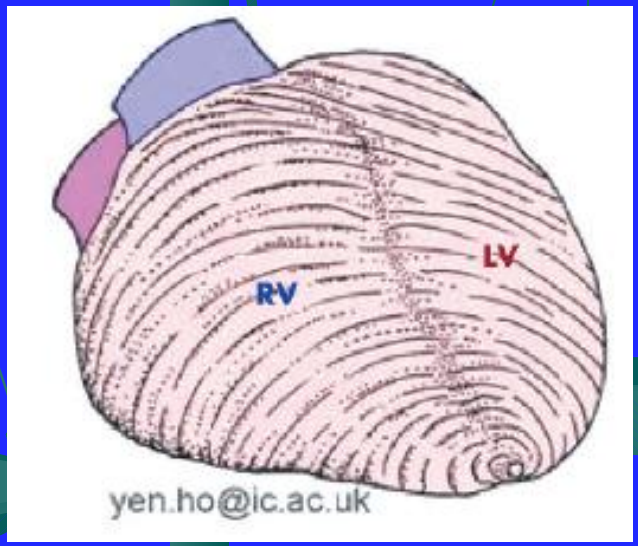


- ✓ some deeper layers of myocardial fibres are separate
- ✓ shared superficial fibres encircling normal RV and LV
- ✓ much of the RV work is done by LV contraction:

eg.

- electrically isolated LV contraction
  --> normal RV pressure trace

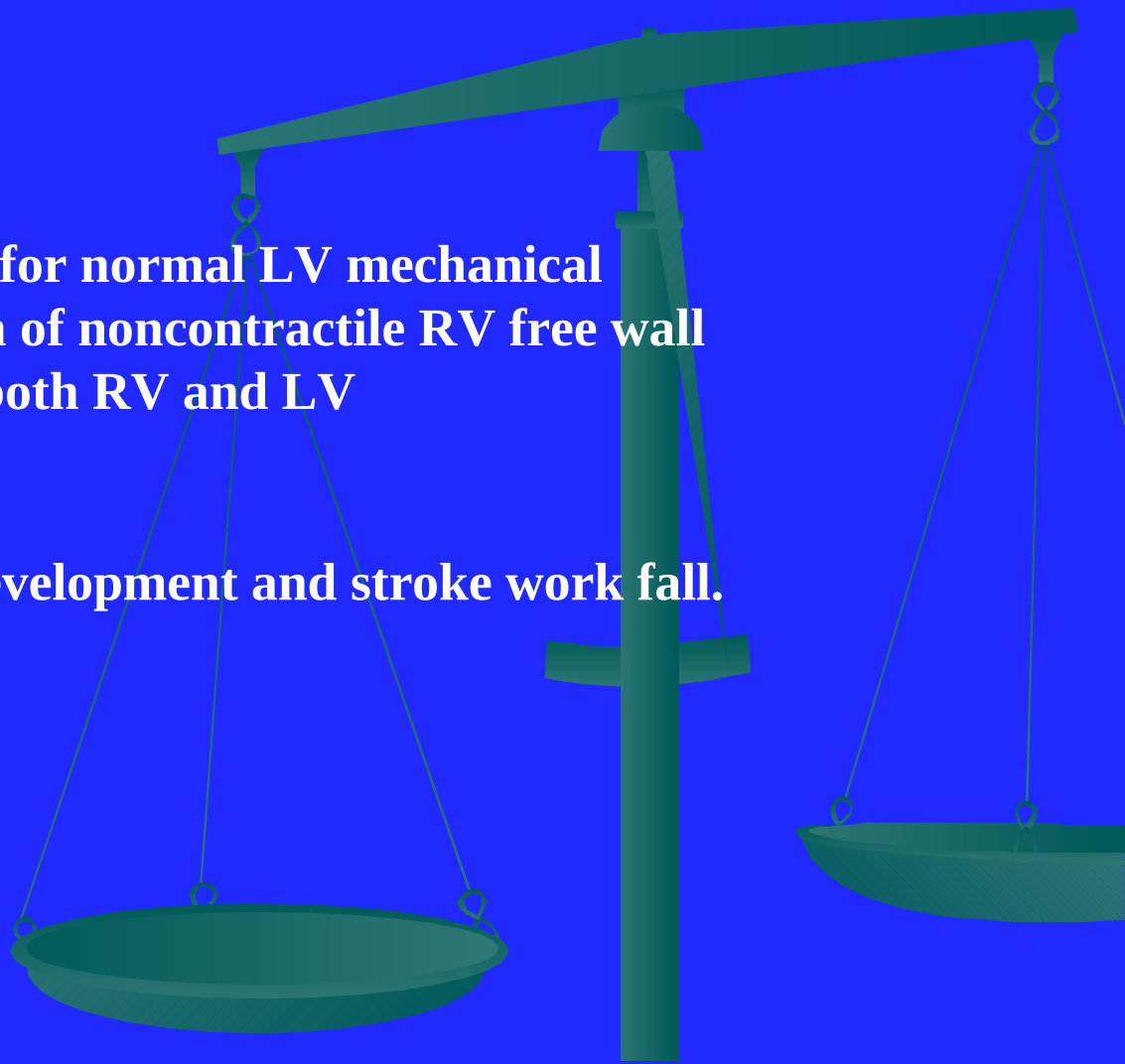
Damaino RJ AAMJ Physiol 1991:261:H1514-24



- replace RV myocardium with noncontractile prosthesis
  ---> normal RV pressure generation

ref: Hoffman D. J Thorac Cardiovasc Surg 1994;107:1496

RV-LV interaction

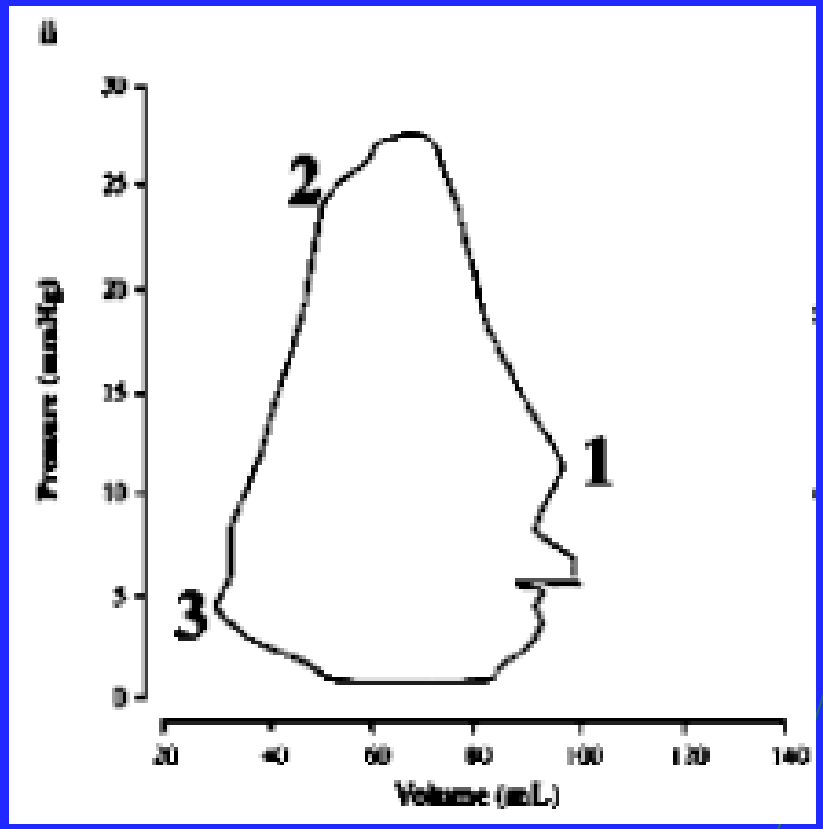


Conversely:

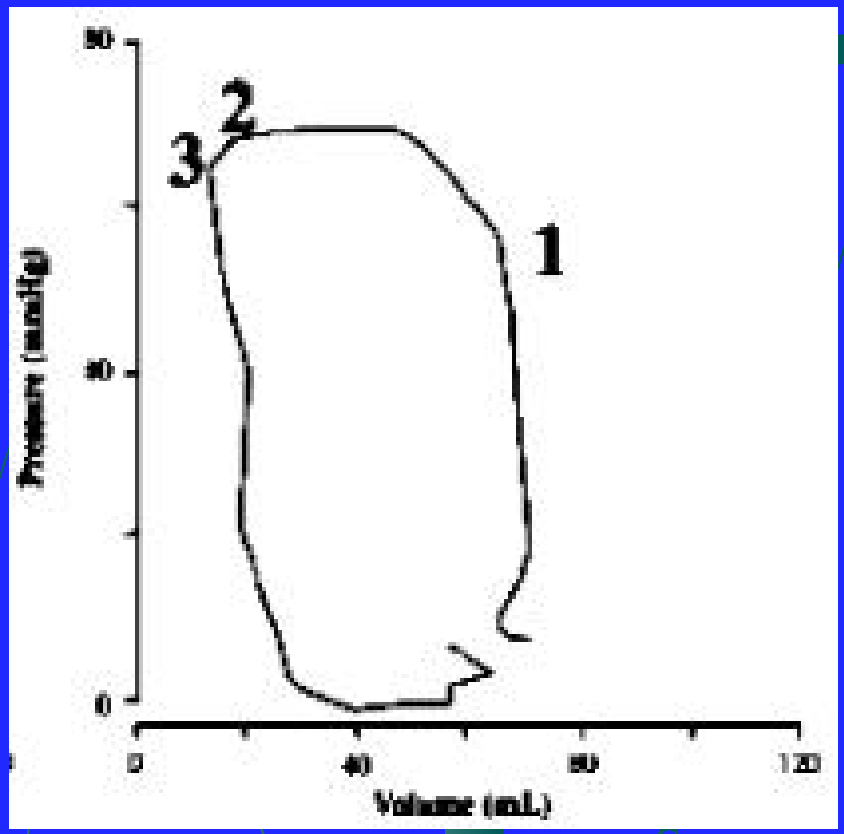
normal RV geometry is essential for normal LV mechanical performance. Gradual dilatation of noncontractile RV free wall leads to progessive reduction in both RV and LV mechanical work.

ie. as RV dilates, LV pressure development and stroke work fall.

RV pressure/ volume curve



Normal



Increased RV afterload

1. PV opening
2. Onset relaxation
3. PV closure

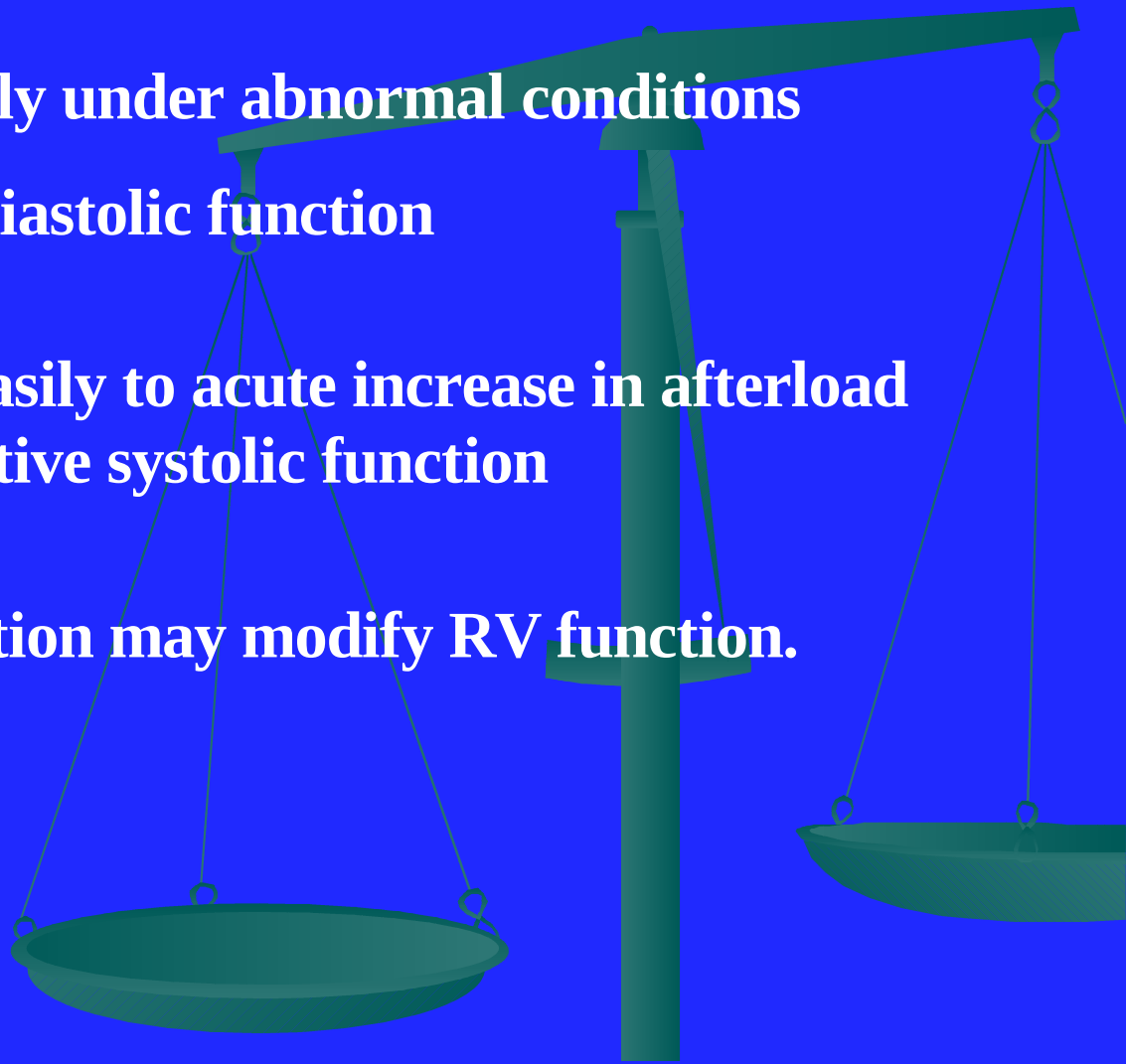
Practice Points:

1. RV can dilate acutely under abnormal conditions

   ie. tolerant diastolic function

1. RV cannot adapt easily to acute increase in afterload
   ie. insensitive systolic function

3. Mechanical ventilation may modify RV function.



***Assessment of Right Heart performance*:**

Symptoms
Physical examination
ECG;CXR

Serum Biomarkers
Echo Doppler
Cardiac catherisation

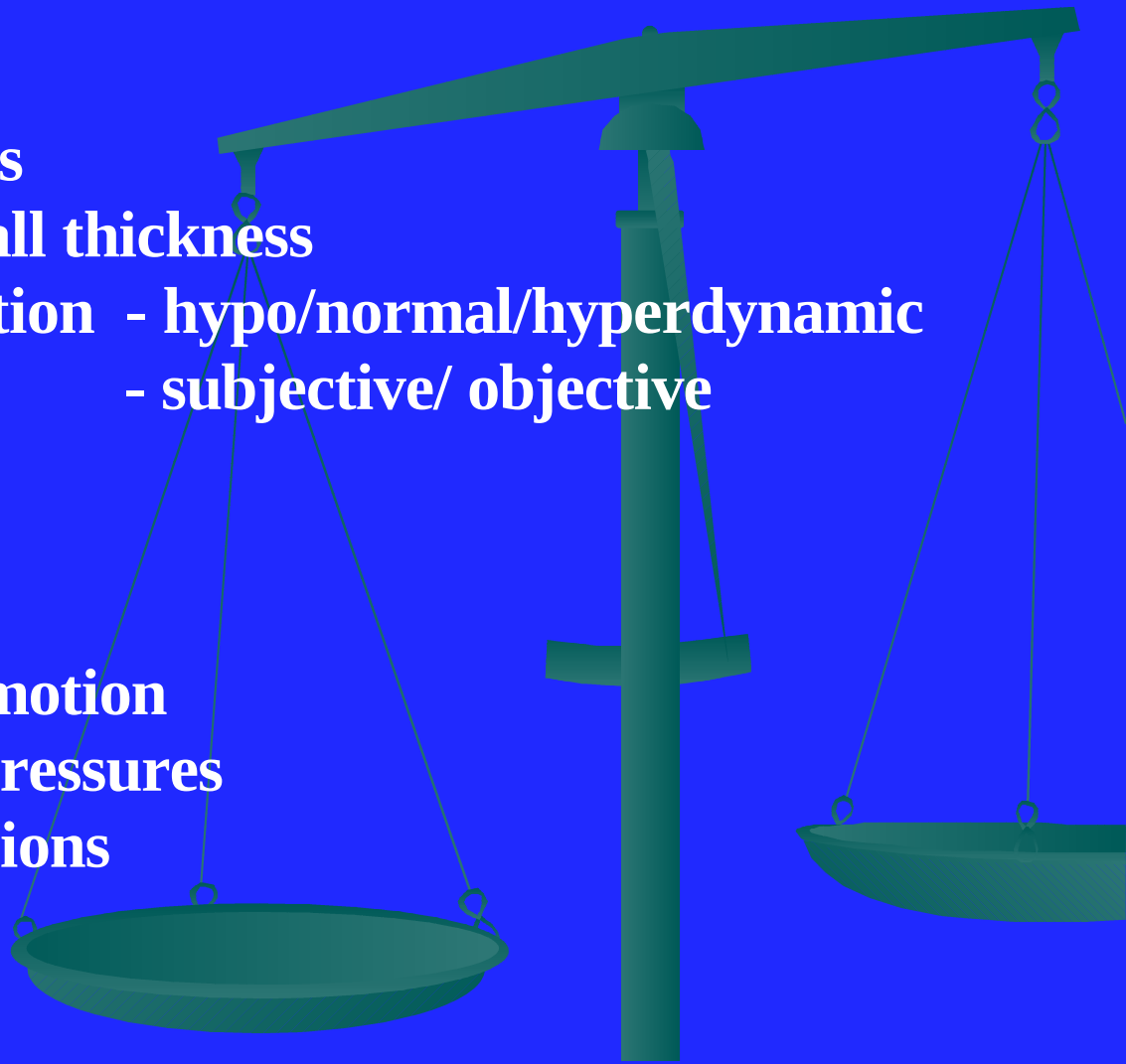
Radionuclide studies: superseded by echo and MRI
MRI

Echocardiographic Assessment of the Right Heart

" Bedside echo has supplanted invasive procedures as the best tool to evaluate right-sided function "

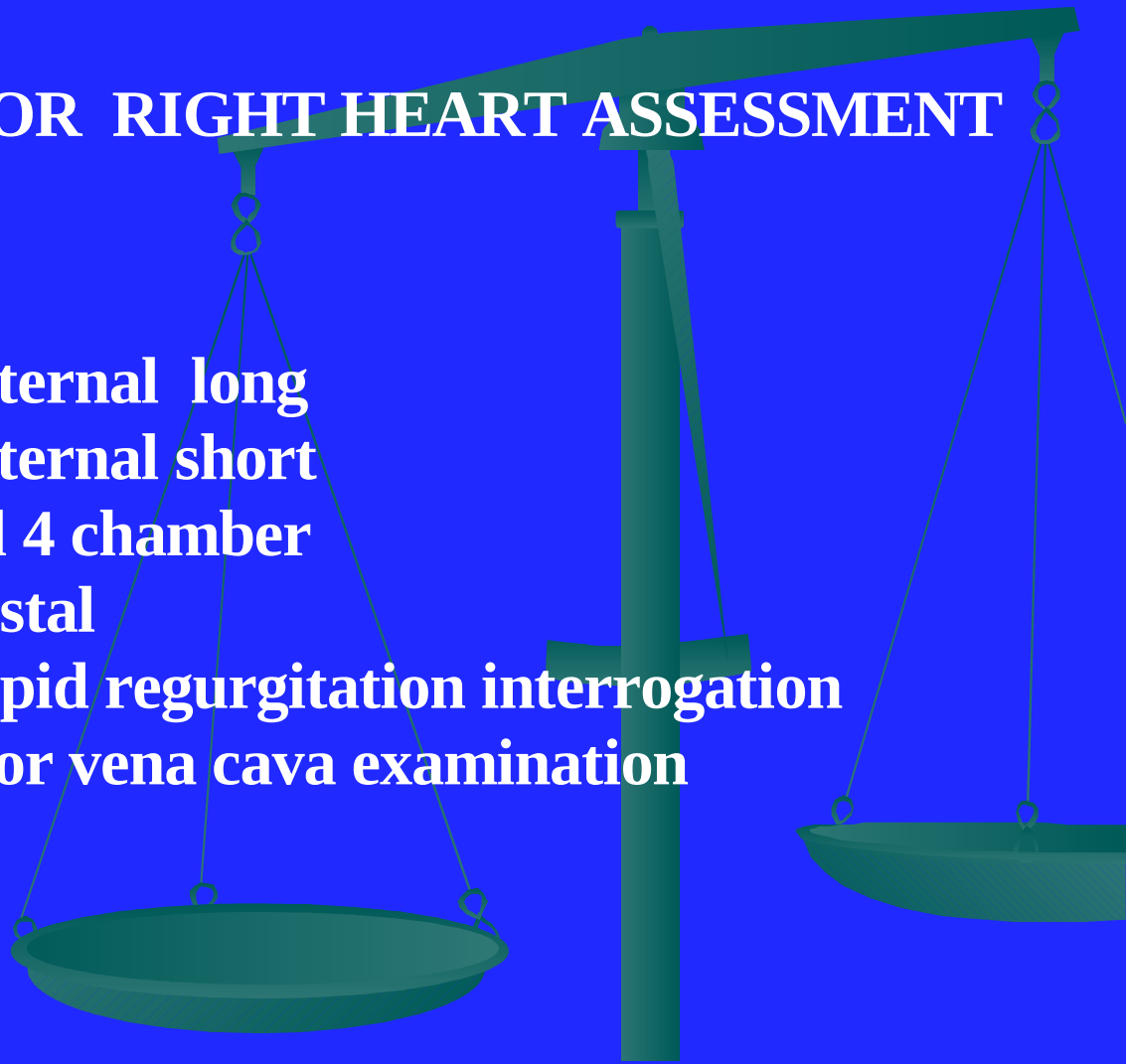
- Jardin F Current Opinion Crit Care 05

Echocardiographic Assessment of the right heart



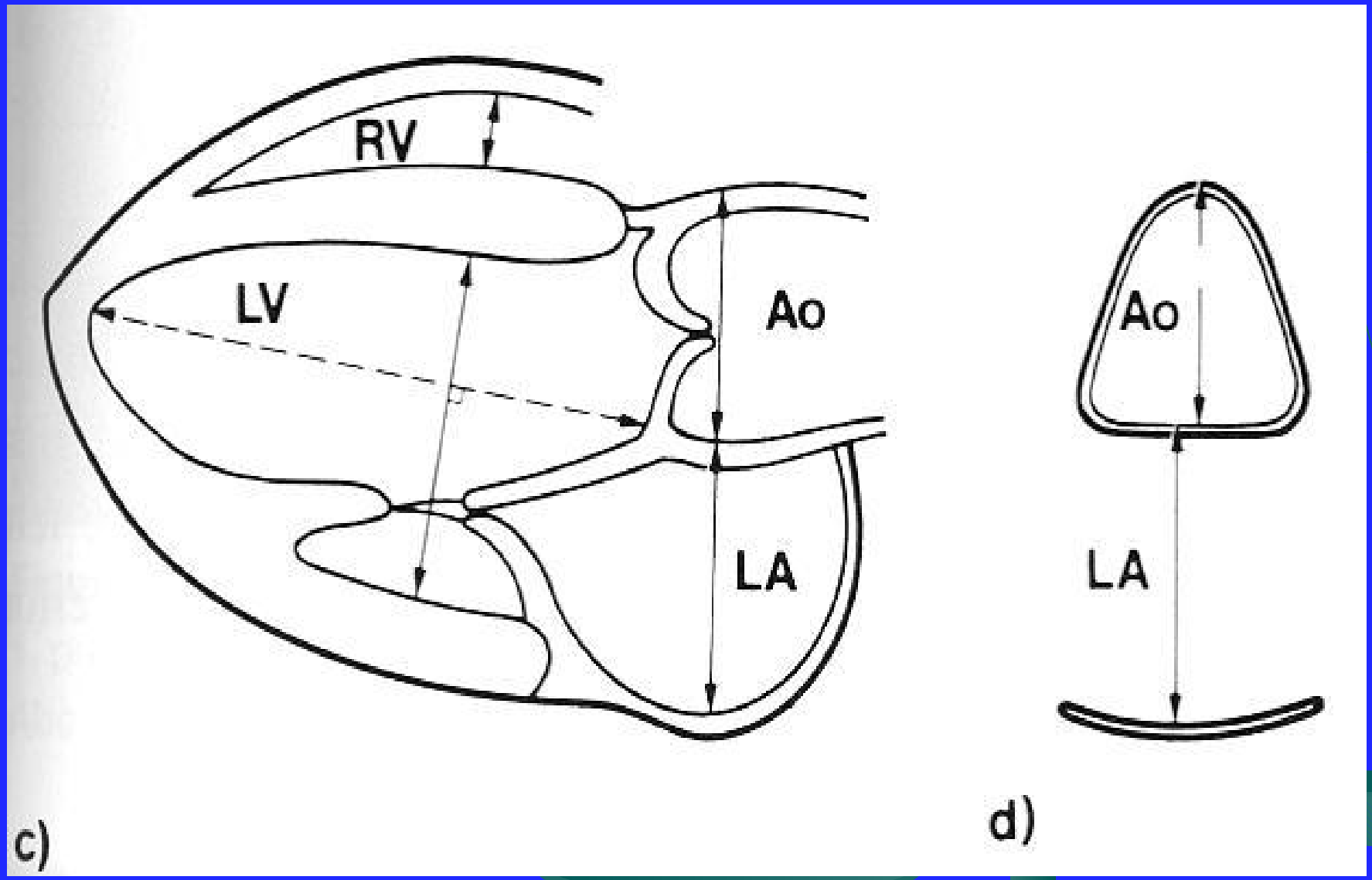
- chamber dimensions
- right ventricular wall thickness
- ventricular contraction - hypo/normal/hyperdynamic
  - subjective/ objective
- intracardiac shunts
- tricuspid valve
- pulmonary valve
- paradoxical septal motion
- pulmonary artery pressures
- hepatic vein dimensions
- left atrial pressure

SELECTED VIEWS FOR RIGHT HEART ASSESSMENT



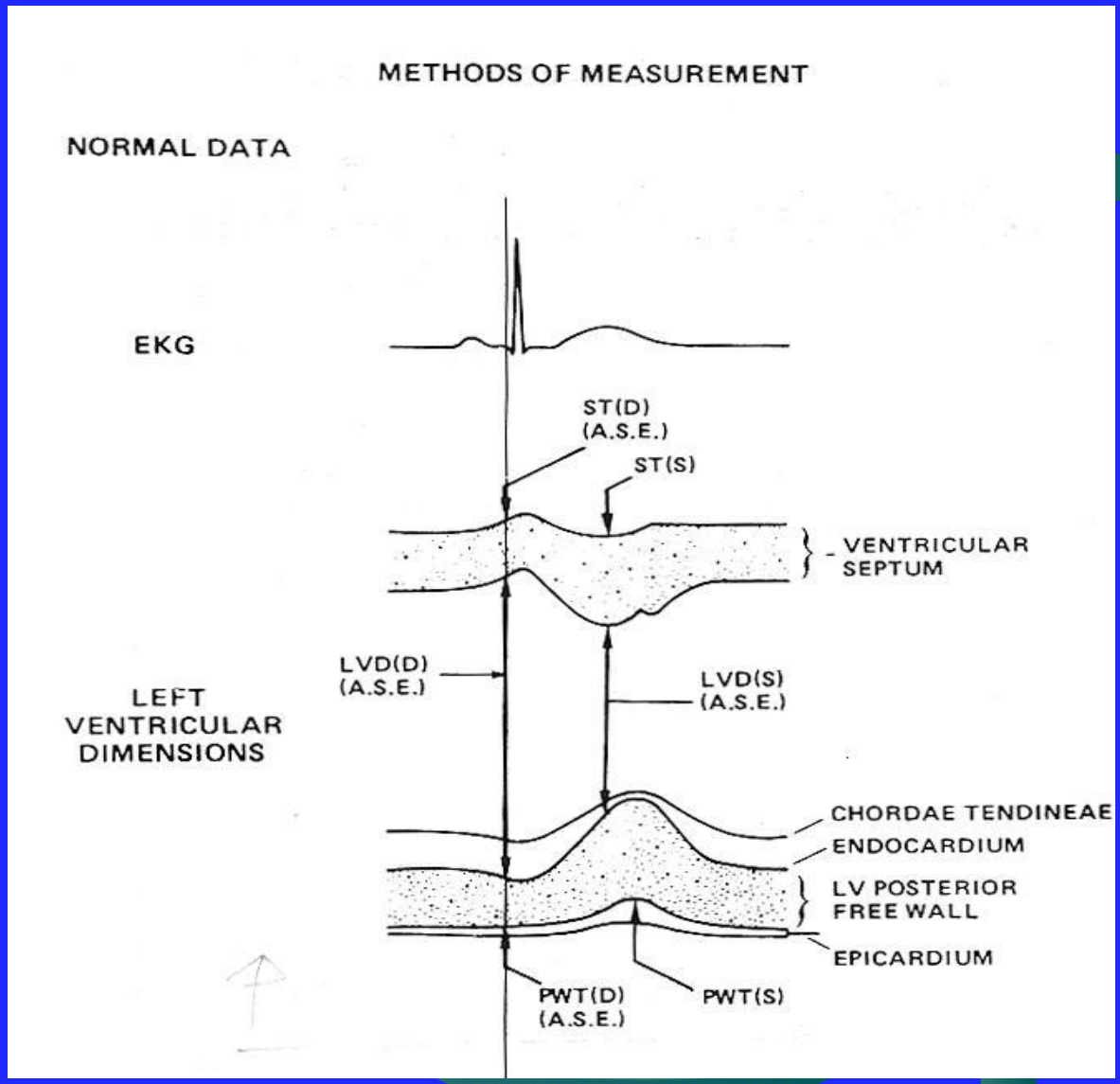
- parasternal long
- parasternal short
- apical 4 chamber
- subcostal
- tricuspid regurgitation interrogation
- inferior vena cava examination

PLAX

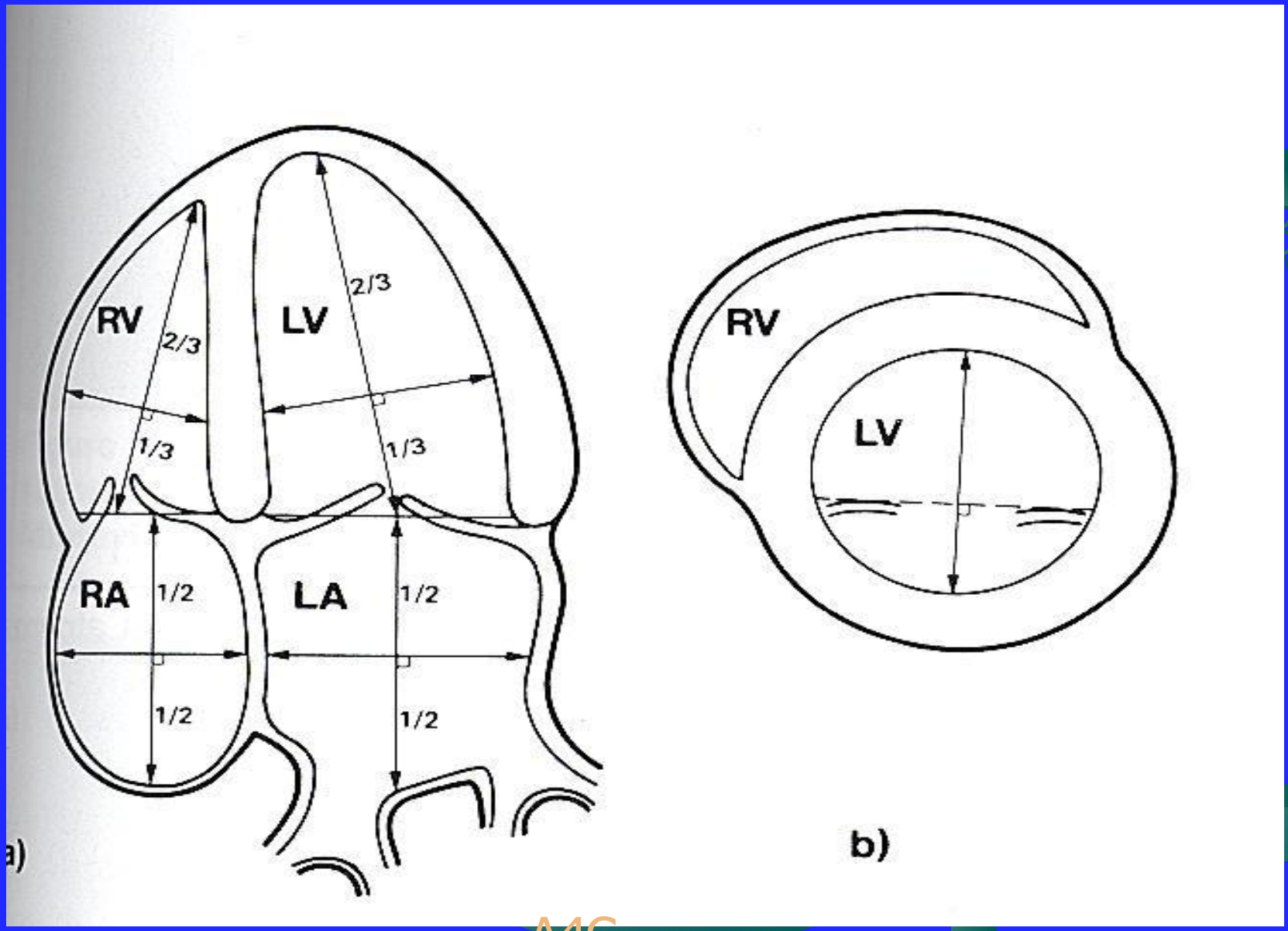


LPX

PLAX M-mode

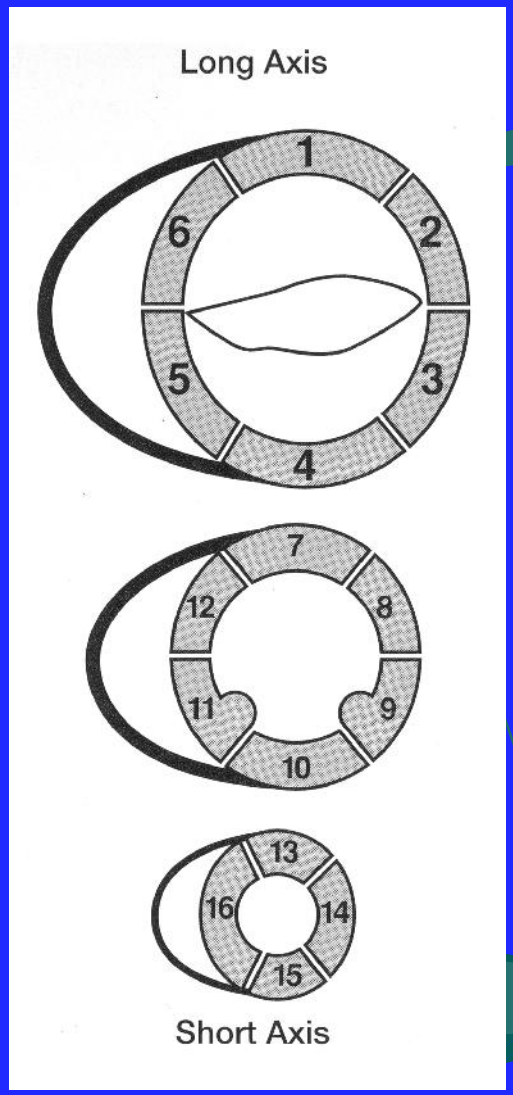

METHODS OF MEASUREMENT
NORMAL DATA
EKG
ST(D)
(A.S.E.)
ST(S)
VENTRICULAR
SEPTUM
LVD(D)
(A.S.E.)
LVD(S)
(A.S.E.)
LEFT
VENTRICULAR
DIMENSIONS
CHORDAE TENDINEAE
ENDOCARDIUM
LV POSTERIOR
FREE WALL
EPICARDIUM
PWT(D)
(A.S.E.)
PWT(S)

A4C and PSAX

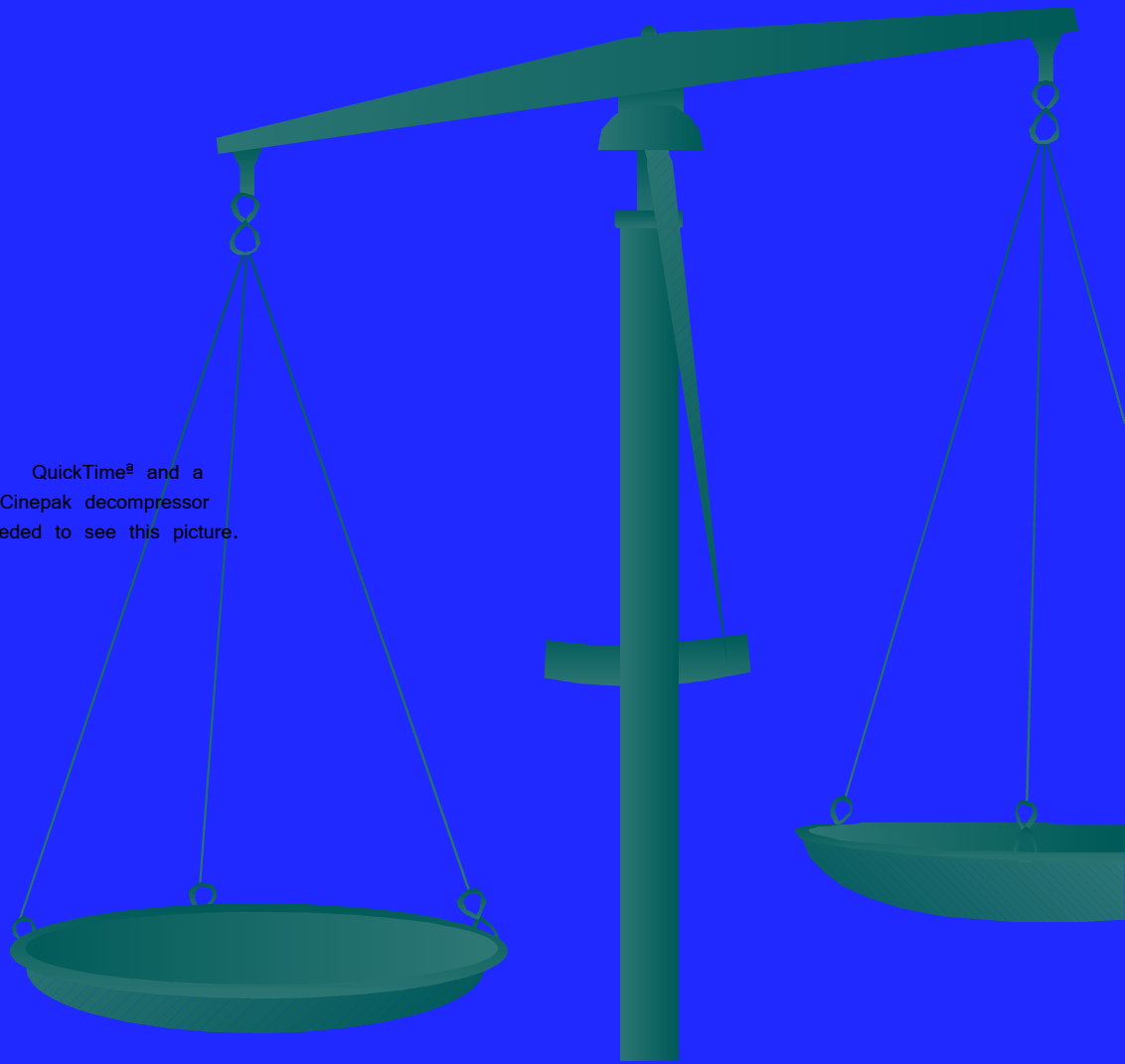


A4C

PSAX



SUBCOSTAL


QuickTime™ and a
Cinepak decompressor
are needed to see this picture.

Tricuspid Regurgitation - Colour Flow Doppler

Mild

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Cinepak decompressor
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Severe

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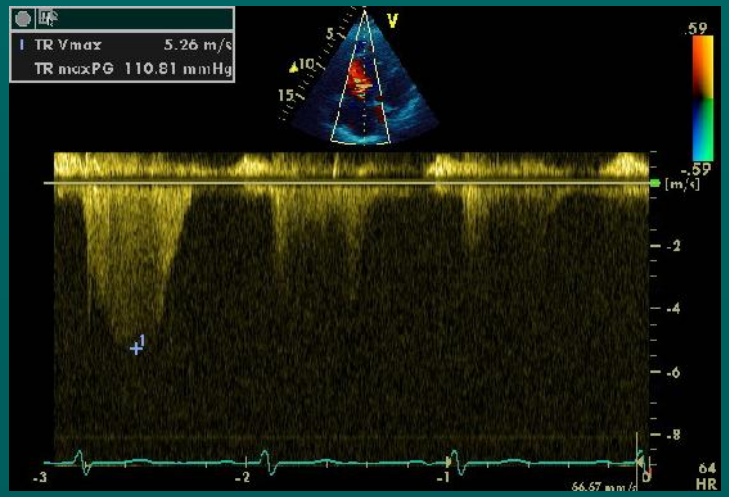

TR CW Doppler

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IVC inspiration

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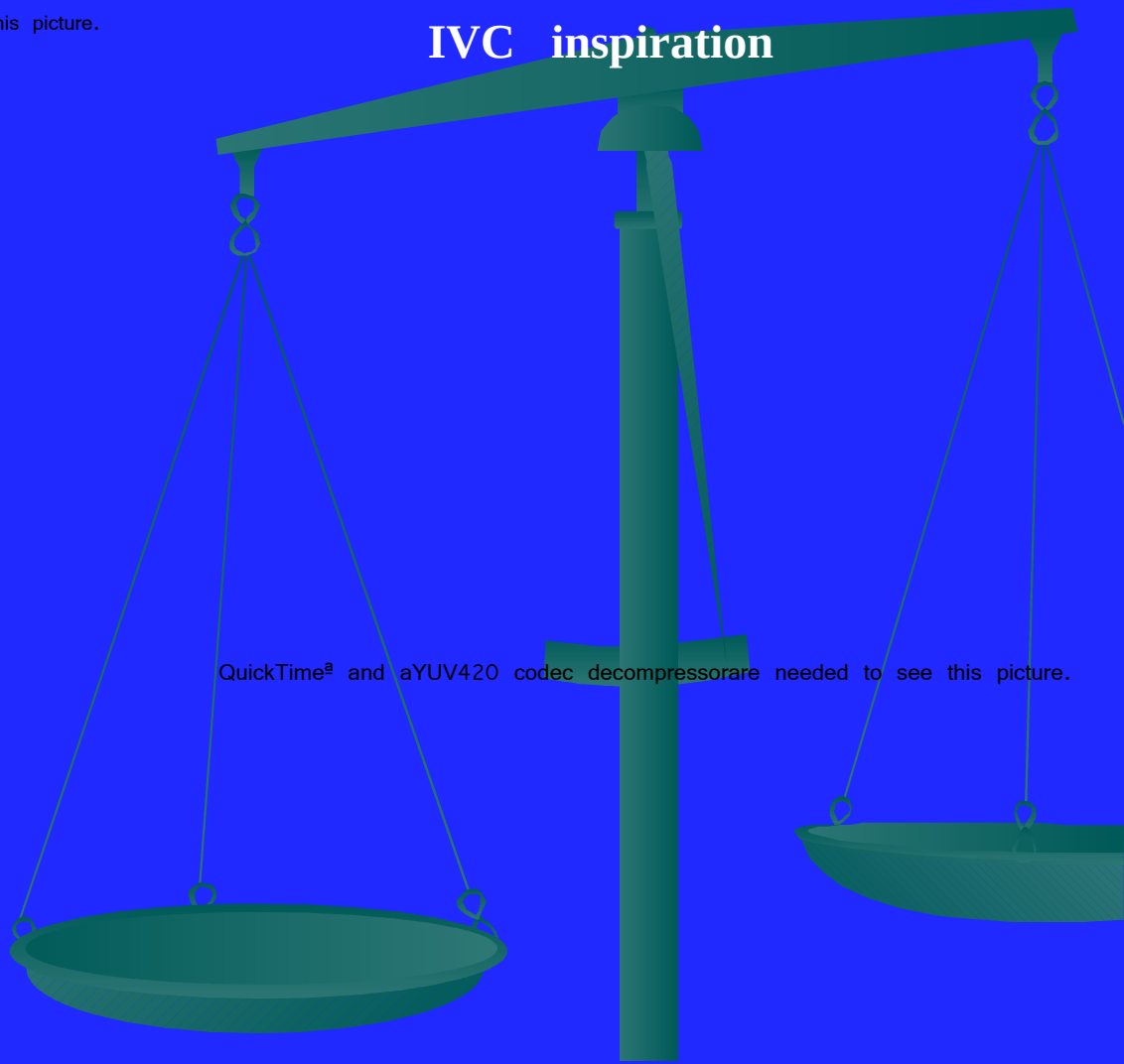
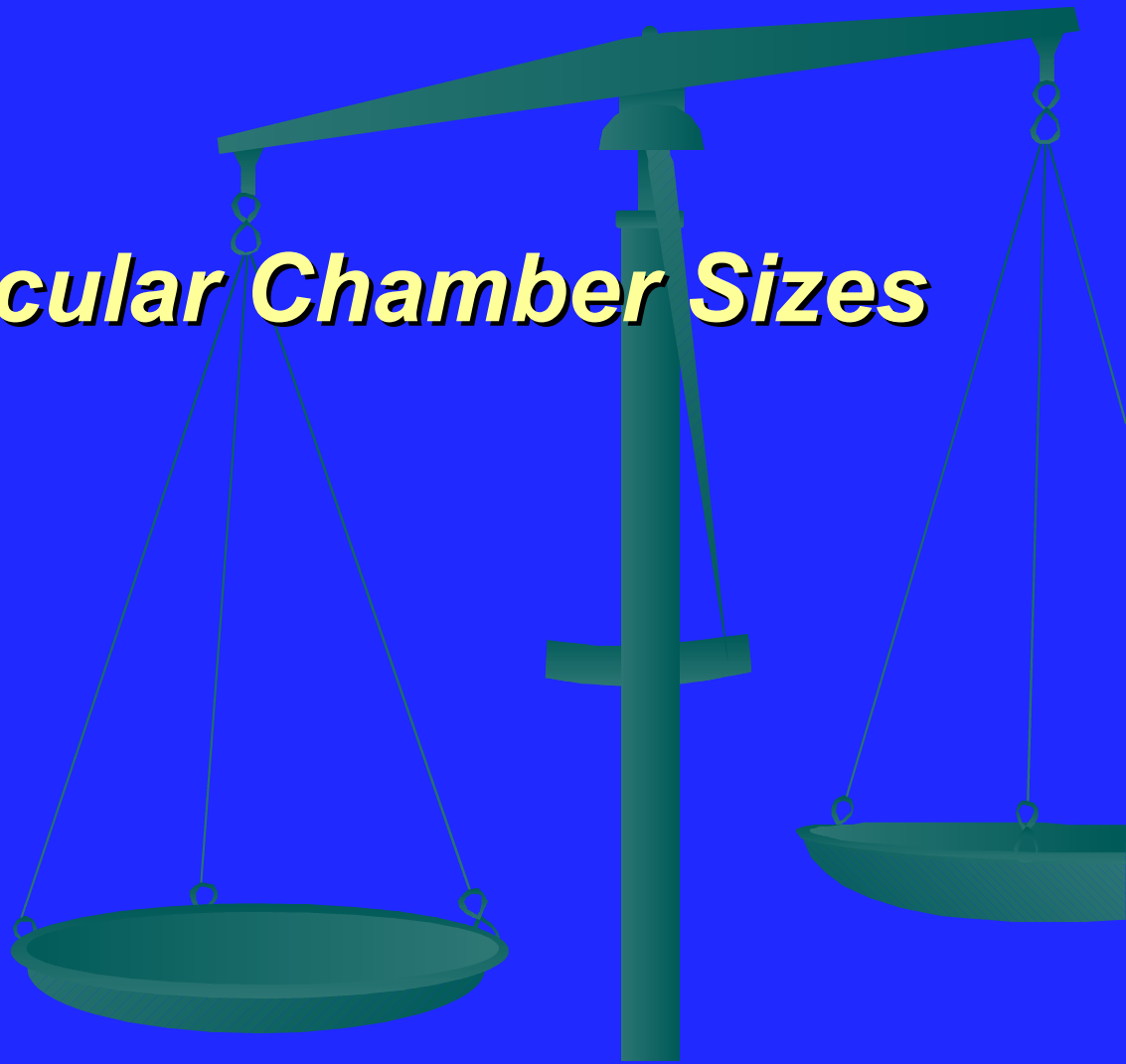
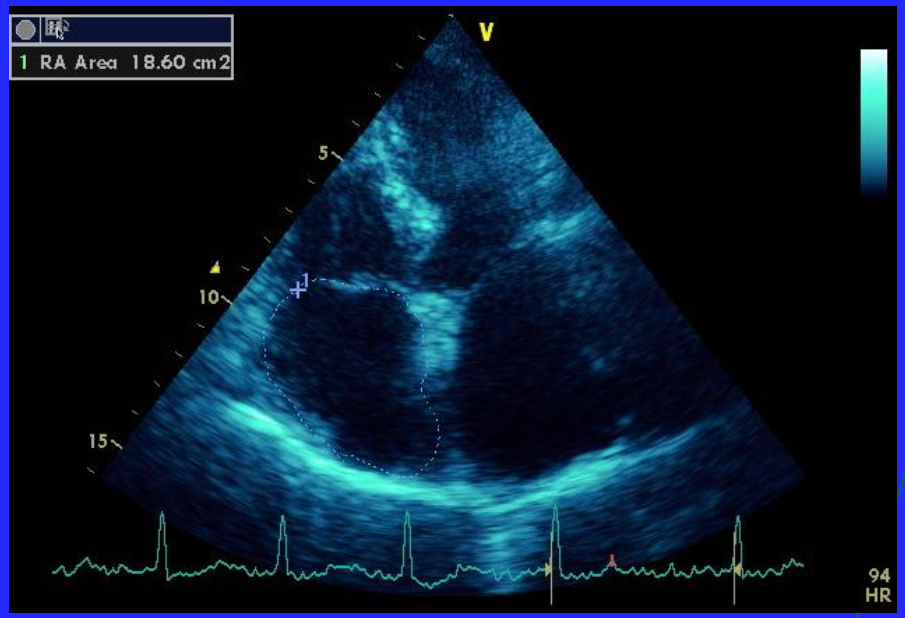
IVC expiration



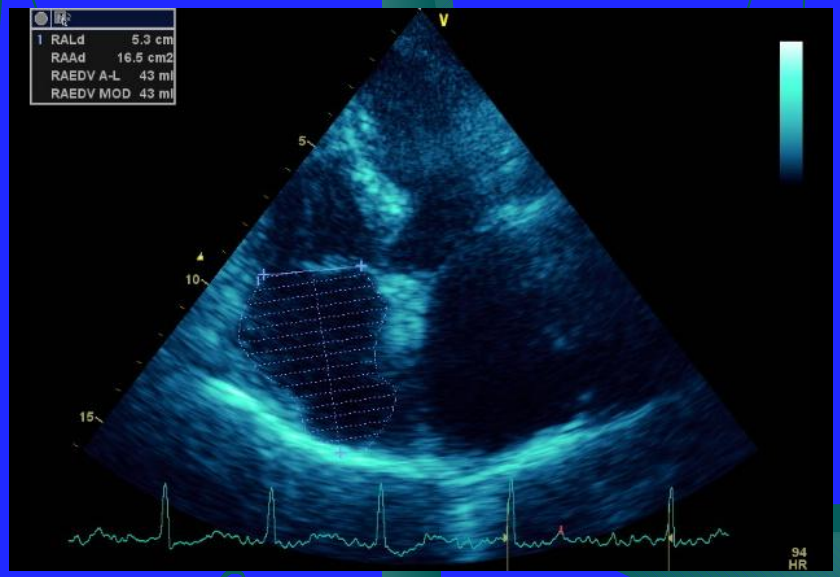
Right Ventricular Chamber Sizes



Right atrial size



RAA



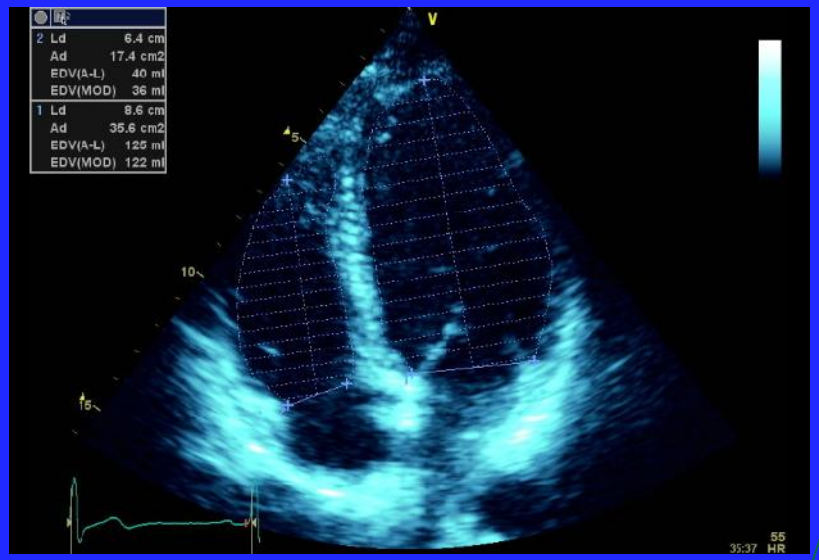
RAV

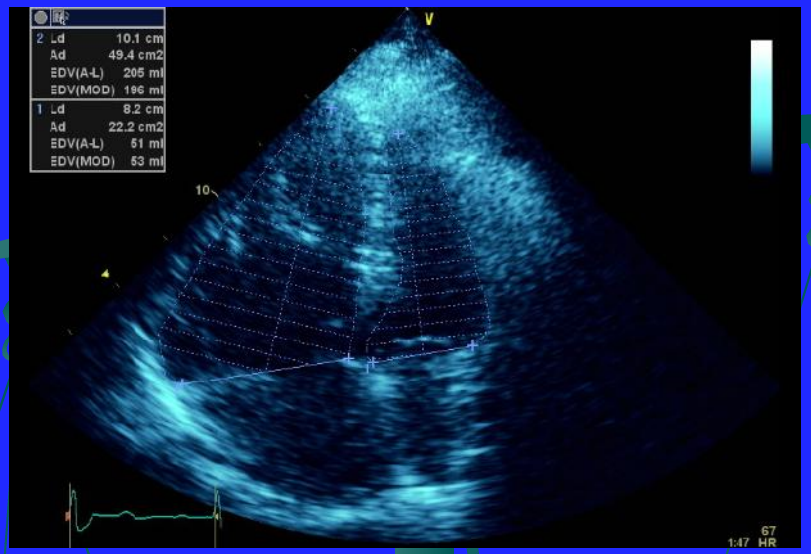
Right ventricular size - 2D

normal

dilated RV

Comparative RV SIZE





0.25 **4.0**

No dilatation: RVEDA/LVEDA < 0.6

Moderate dilatation: RVEDA/LVEDA 0.6 - 1

Major dilatation: RVEDA/LVEDA > 1

Jardin Chest 1997

Right Ventricular Contraction

Amniotic fluid embolus - 26 year primigravida

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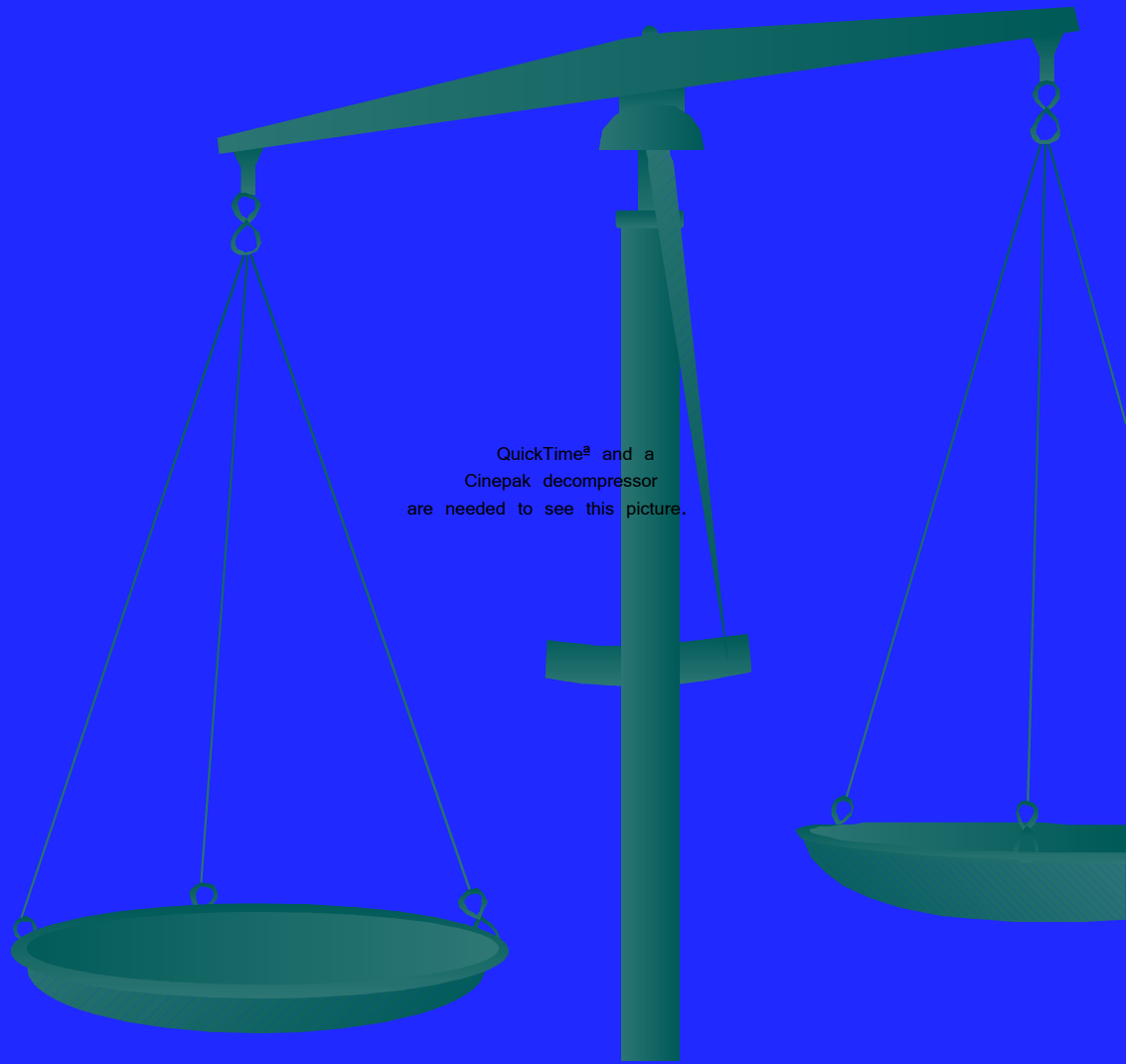
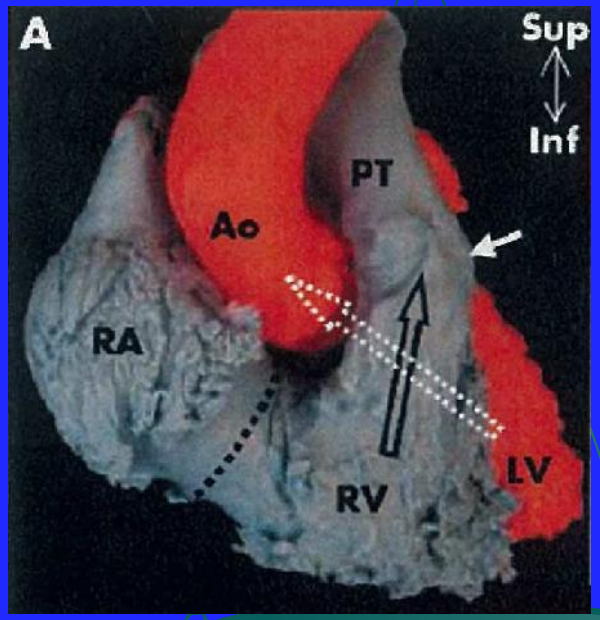


eyeball contraction

Right ventricular systolic function evaluation based on RVEDV and RVESV =

Ejection fraction ? ? ?



TAPSE

Right heart

Tricuspid annulus displacement is a good tool for assessing right ventricular contraction

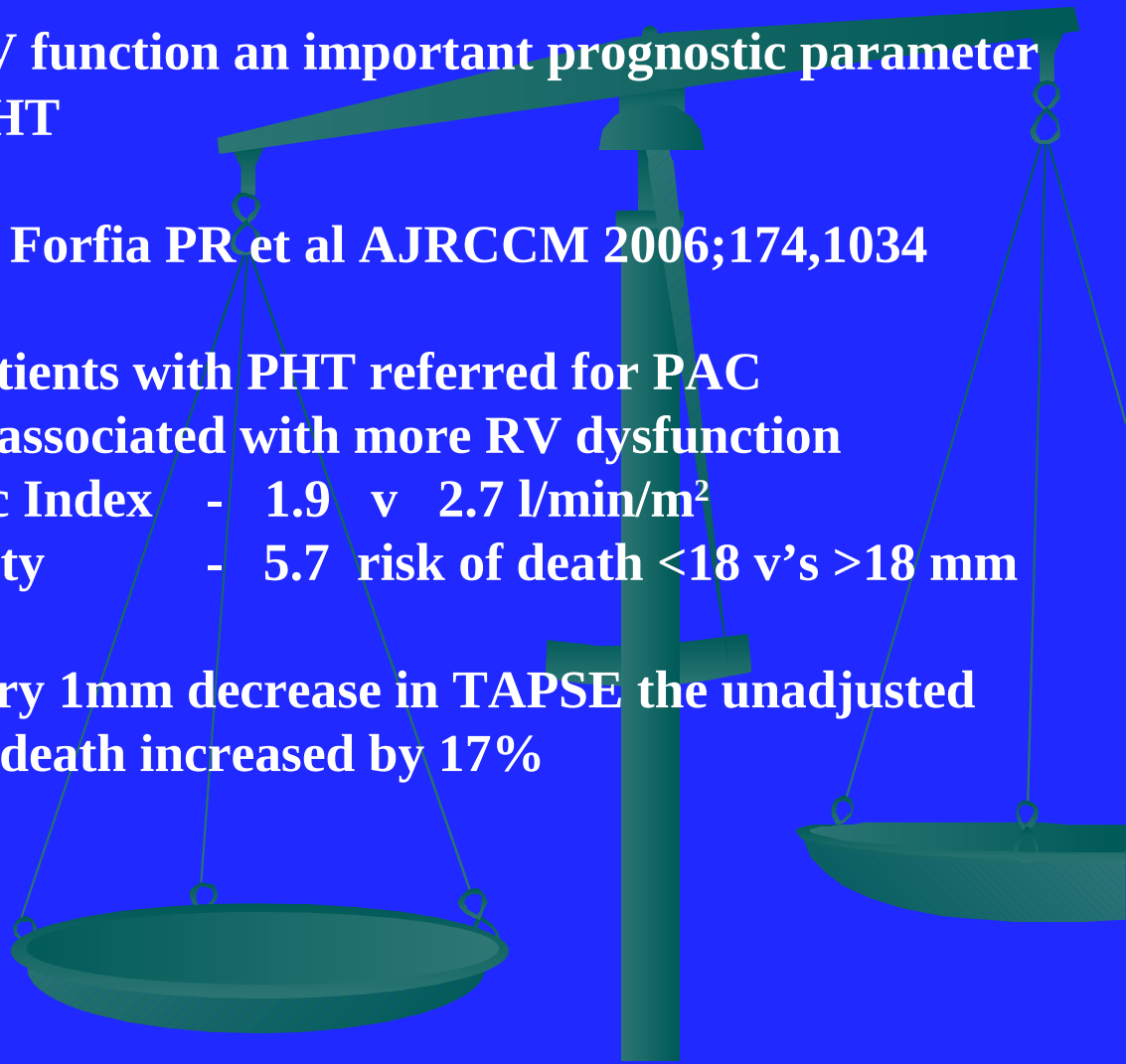
Value of TAPSE:

Prognosis: **Rationale - RV function an important prognostic parameter in PHT**

In chronic PHT. Forfia PR et al AJRCCM 2006;174,1034

63 consecutive patients with PHT referred for PAC
TAPSE < 18 mm associated with more RV dysfunction
Cardiac Index - 1.9 v 2.7 l/min/m²
Mortality - 5.7 risk of death <18 v's >18 mm

for every 1mm decrease in TAPSE the unadjusted risk of death increased by 17%



Chronic pulmonary hypertension - echo diagnosis

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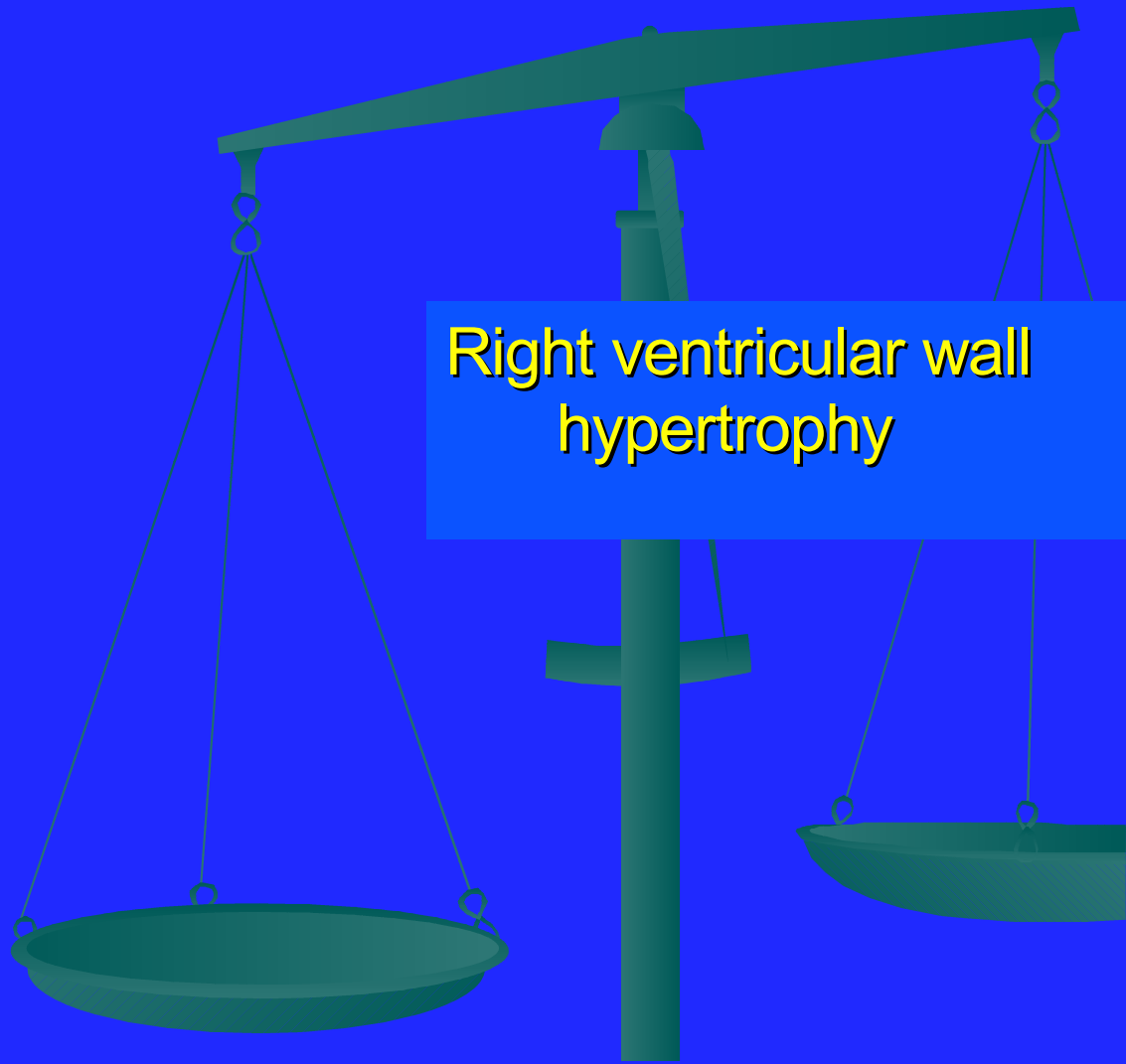
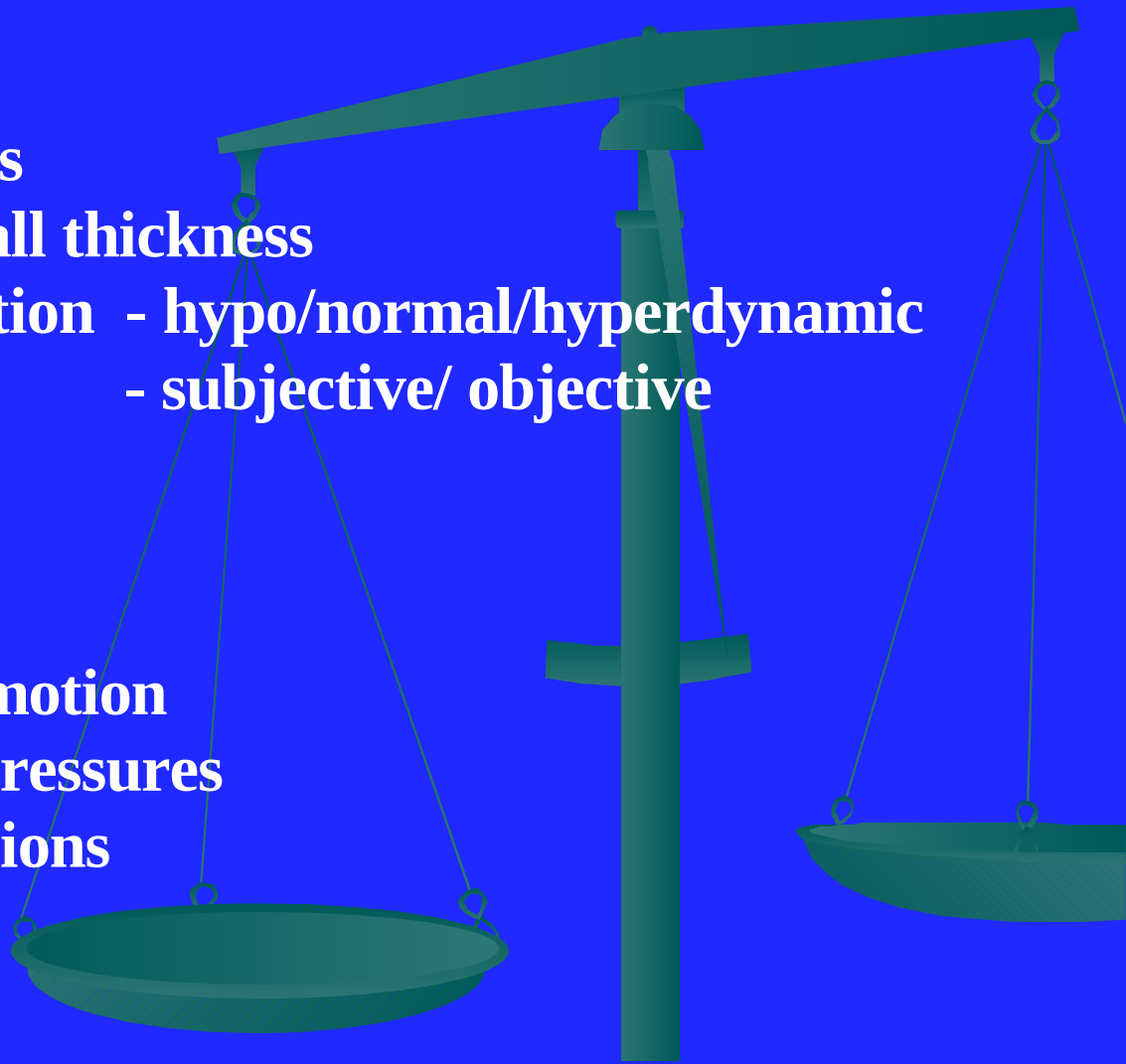


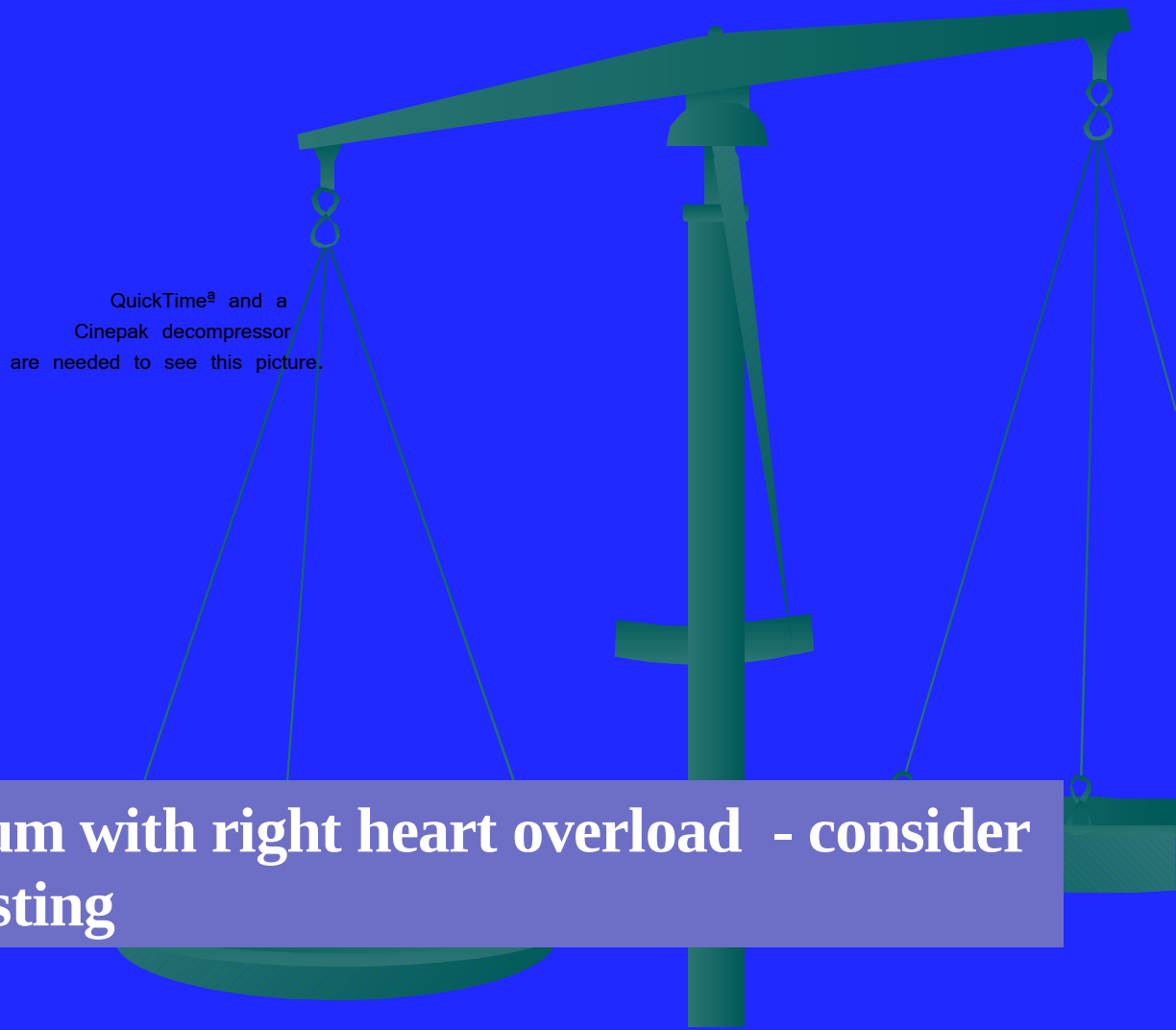
Echocardiographic Assessment of the right heart



- chamber dimensions
- right ventricular wall thickness
- ventricular contraction - hypo/normal/hyperdynamic
  - subjective/ objective
- intracardiac shunts
- tricuspid valve
- pulmonary valve
- paradoxical septal motion
- pulmonary artery pressures
- hepatic vein dimensions
- left atrial pressure

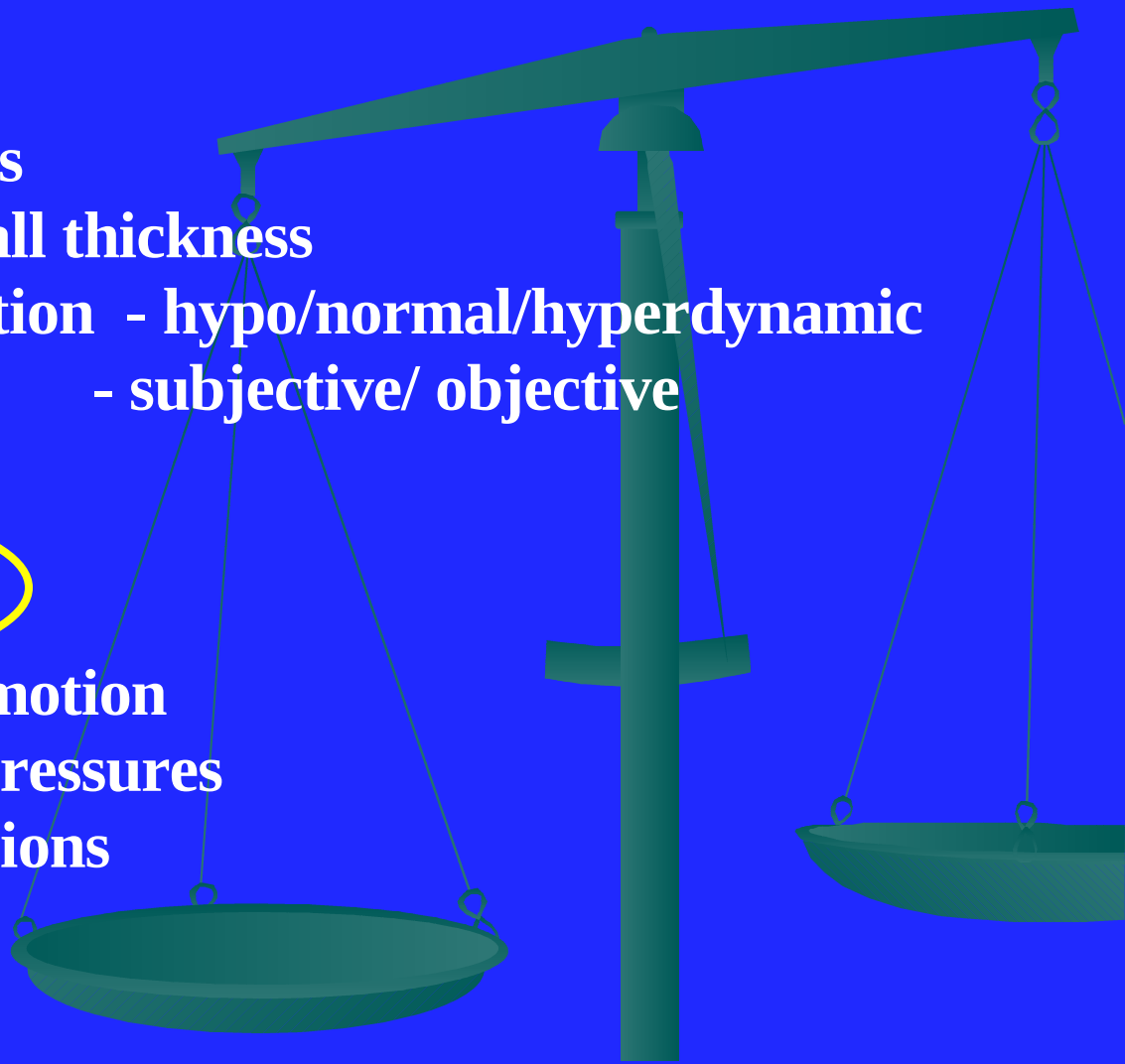
Intracardiac shunts - usually affect the right heart

Secundum Atrial Septal Defect



Ostium Secundum with right heart overload - consider saline bubble testing

Echocardiographic Assessment of the right heart



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- *pulmonary valve*
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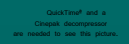
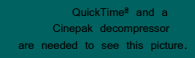
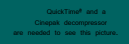
Tricuspid - Stenosis
Regurgitation

Tricuspid Regurgitation - Aetiology

- Small physiological degrees of tricuspid regurgitation are often encountered in the normal individual
- Rheumatic heart disease
- Carcinoid heart disease
- Endocarditis
- Ebstein anomaly
- Tricuspid valve prolapse
- Right ventricular infarct



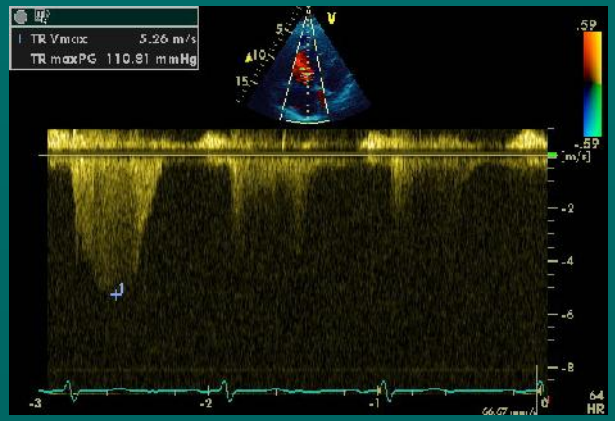




Tricuspid Regurgitation - Aetiology
Secondary causes

- Pulmonary hypertension
- Cor pulmonale
- Ischaemic heart disease
- Cardiomyopathies
- Volume overload
  (e.g. ASD, VSD)
- Interference with normal valve closure

e.g. pacing wire,
central line



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Evaluation of tricuspid valve

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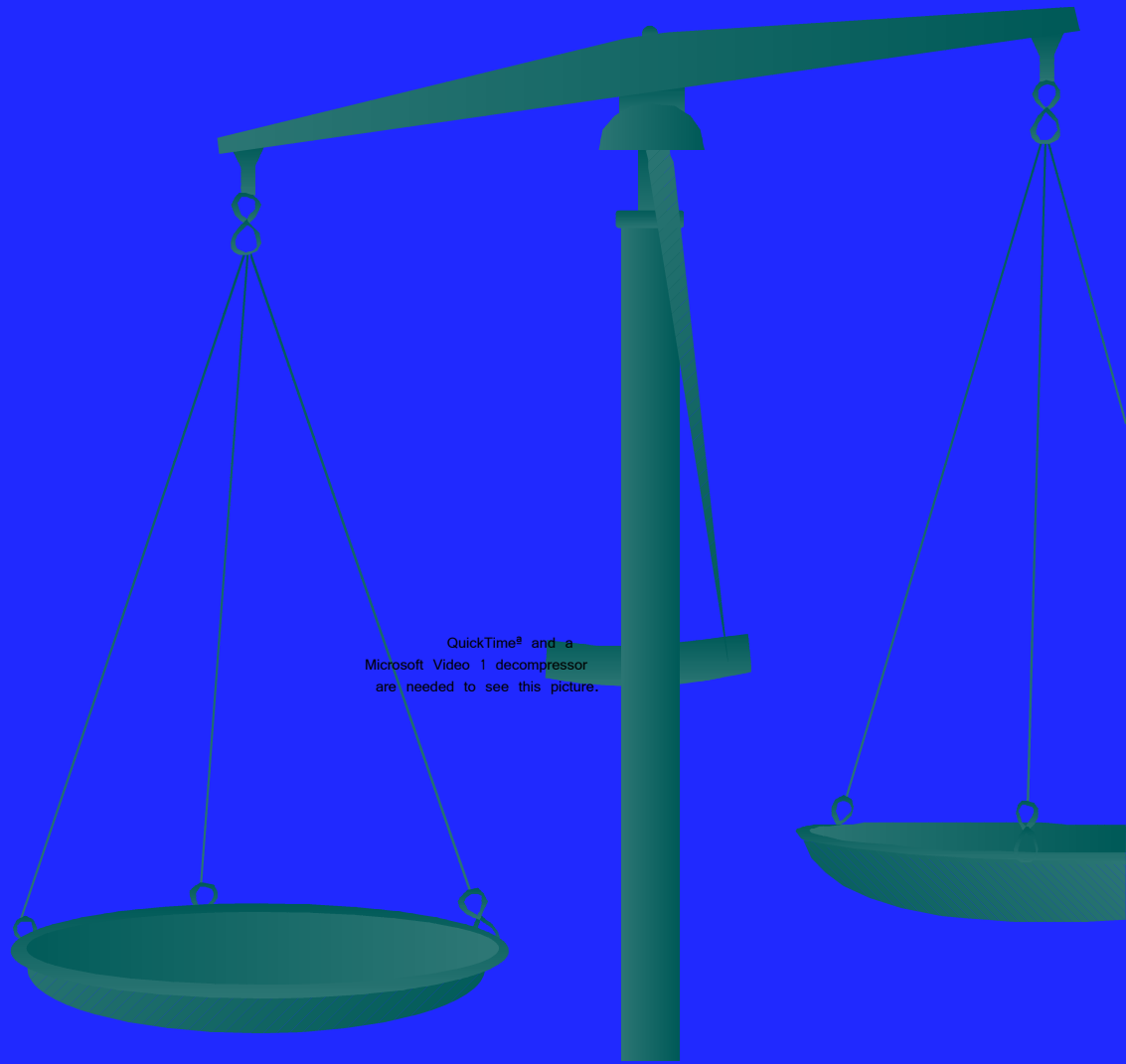

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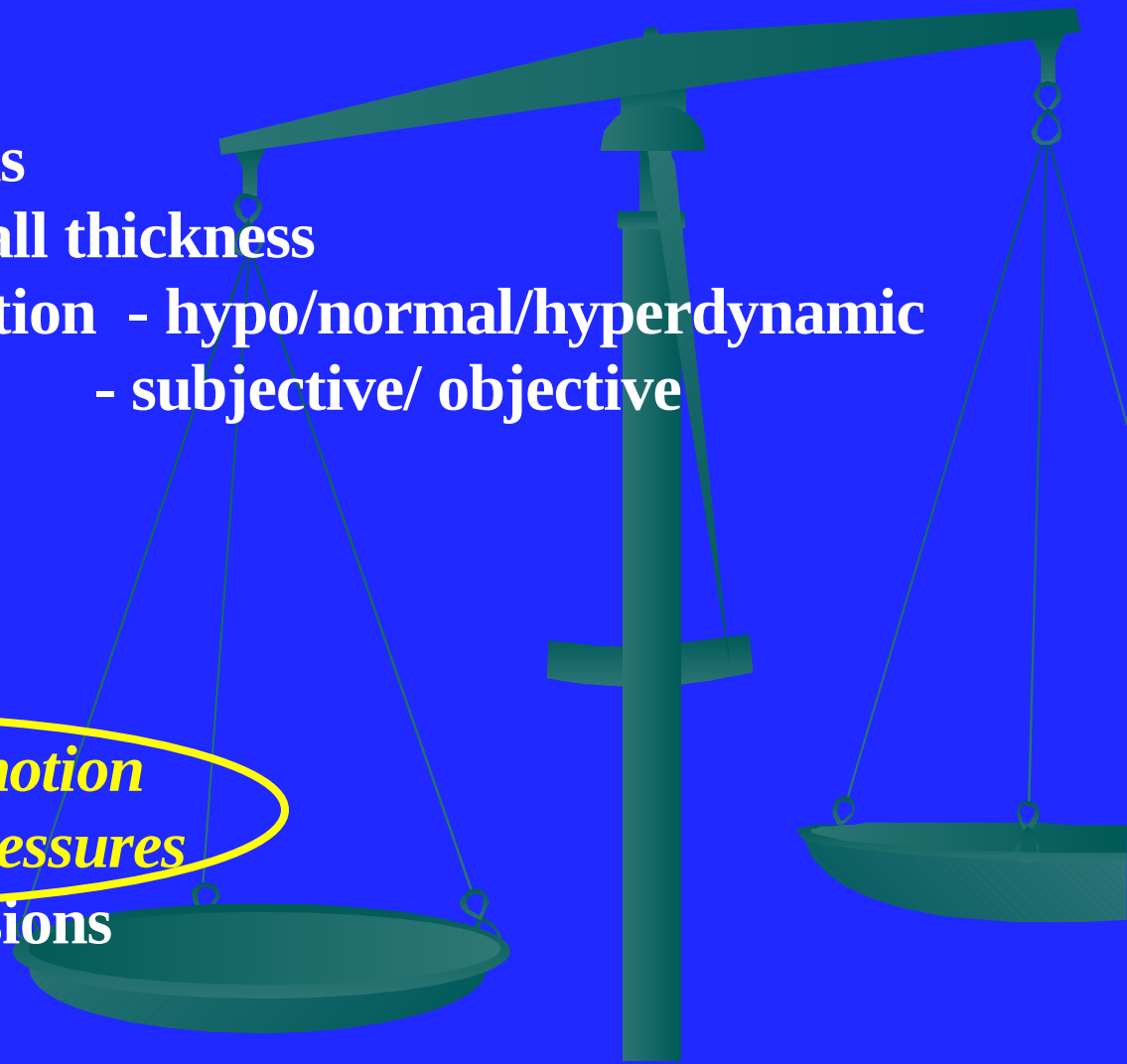

- chamber dimensions
- right ventricular wall thickness
- ventricular contraction - hypo/normal/hyperdynamic
  - subjective/ objective
- intracardiac shunts
- tricuspid valve
- pulmonary valve
- right atrial size
- *paradoxical septal motion*
- *pulmonary artery pressures*
- hepatic vein dimensions
- left atrial pressure

Pulmonary arterial pressures (afterload): Systolic pressure

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PSAX

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Microsoft Video 1 decompressor
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Right ventricular pressure overload -paradoxical septal motion

Tricuspid Regurgitation - Colour Flow Doppler

Mild

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Severe

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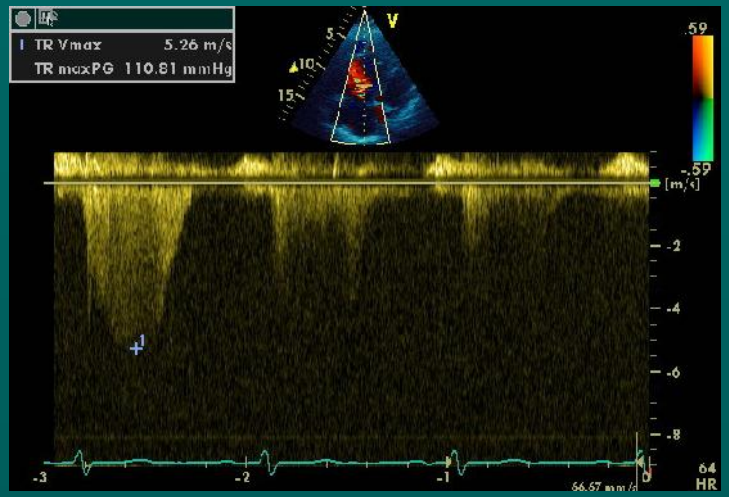
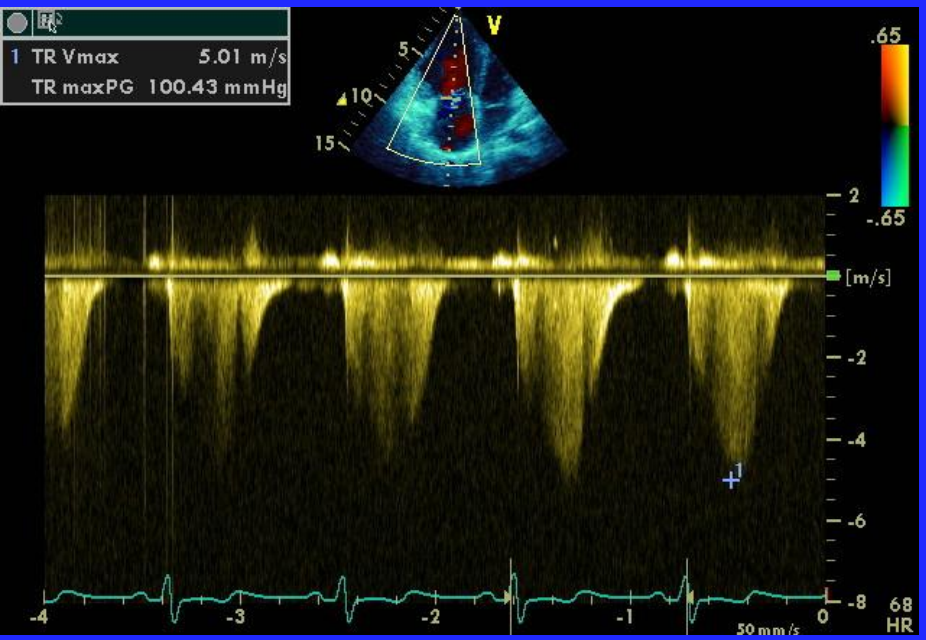


TR CW Doppler

Calculation of PAP using tricuspid regurgitation



Gradient across Tricuspid valve
= RV - RA pressure

(Bernoulli Equation: $P = 4 V^2$)

PAP = peak RV + RAP

- ***0 to 5 mm Hg*** *if the IVC is normal in dimension (1.2 to 2.3 cm) and collapses at least 50% upon inspiration*
- ***5 to 10 mm Hg*** *if the ICV is normal in dimension but does not collapse upon inspiration*
- ***10 to 15 mm Hg*** *if the IVC is dilated but collapses upon inspiration*
- ***15 to 20 mm Hg*** *if the IVC is dilated and does not collapse upon inspiration*

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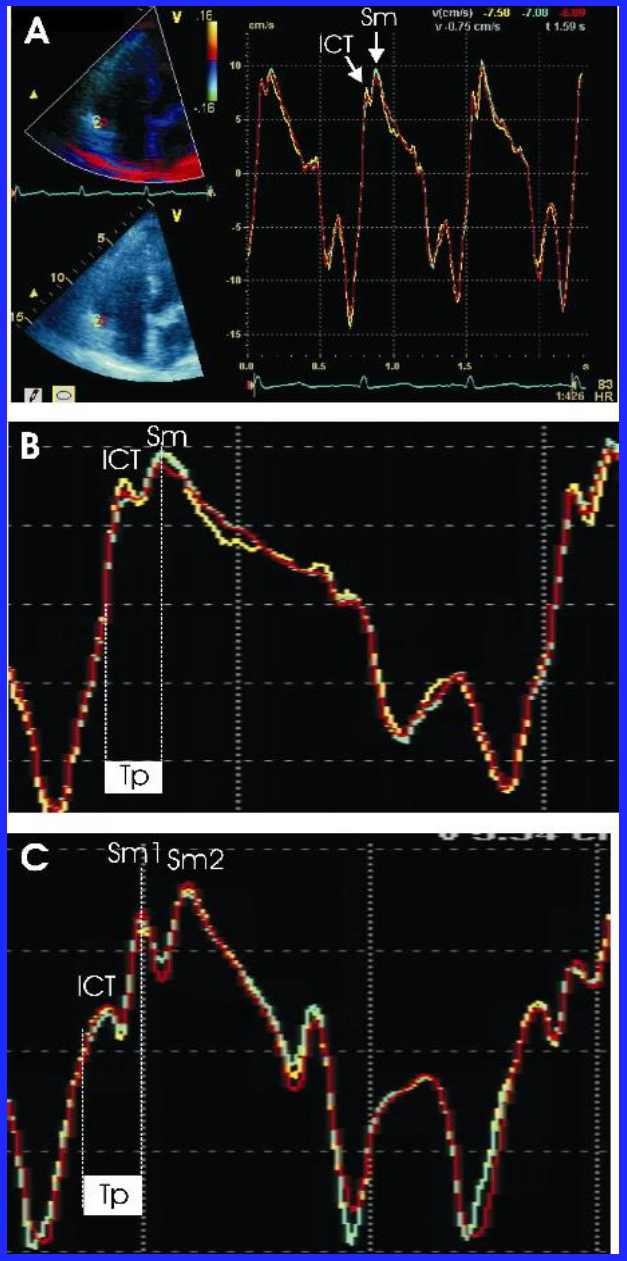
inspiration **expiration**



Calculating Pulmonary Artery Systolic Pressure in the absence of a TR signal.

$$\text{Index} = \frac{\text{RVD}}{T_{peak}}$$

Nepean < 22 cm/sec PASP <35 mmHg

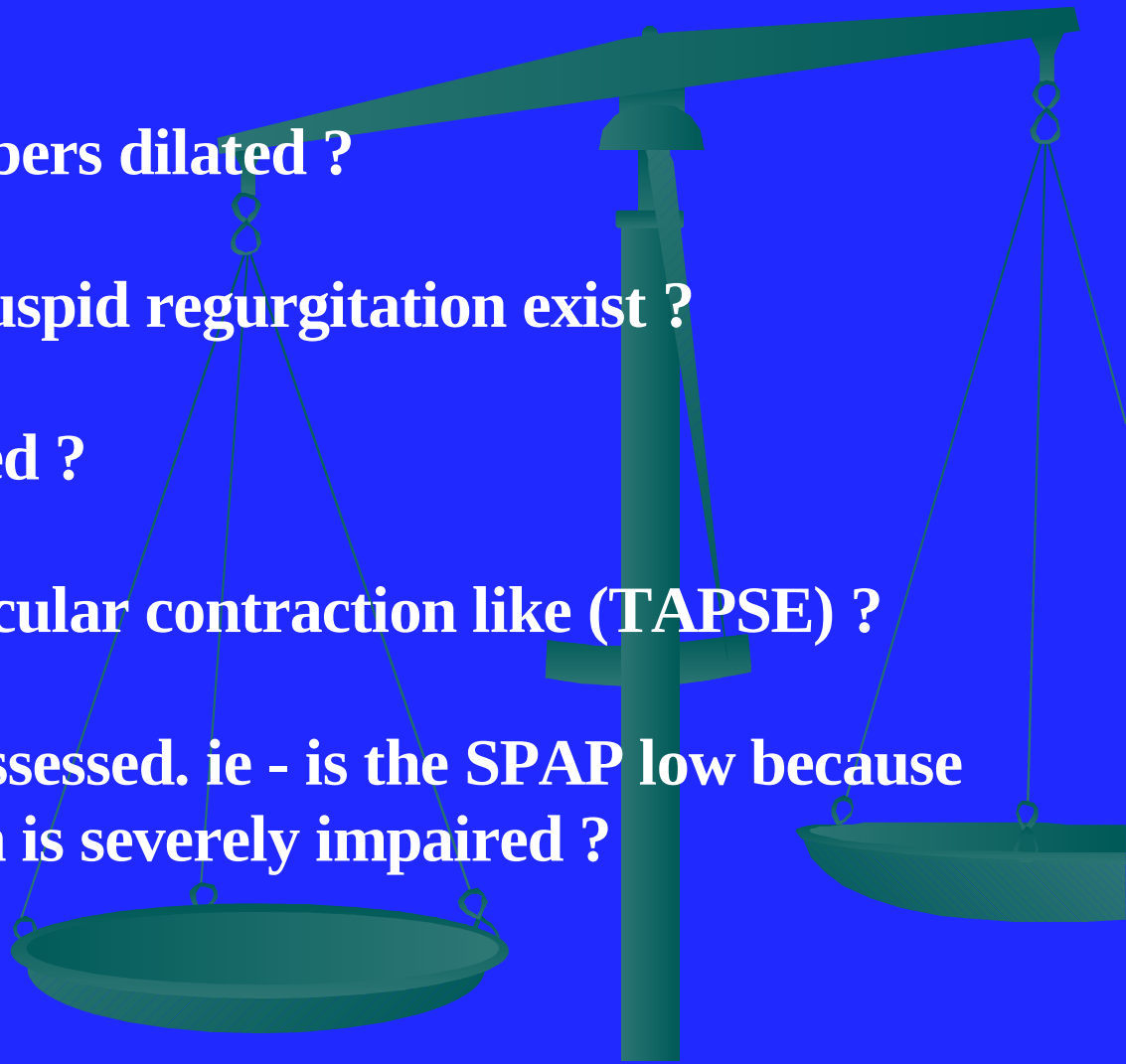
Index > 22 cm/sec PASP >35 mmHg

Ref: Mclean A,Ting I, Huang S, Wesley S Eur J Echo 2007;8(2):128-136

Right ventricular function:

- are the right chambers dilated ?
- does significant tricuspid regurgitation exist ?
- is the SPAP elevated ?
- what is right ventricular contraction like (TAPSE) ?

Note : all have to be assessed. ie - is the SPAP low because RV contraction is severely impaired ?



Example : - dilated RA and RV on background of tricuspid regurgitation does not always indicate marked pulmonary hypertension.

AD - 76 year woman.

Essentially asymptomatic regards heart

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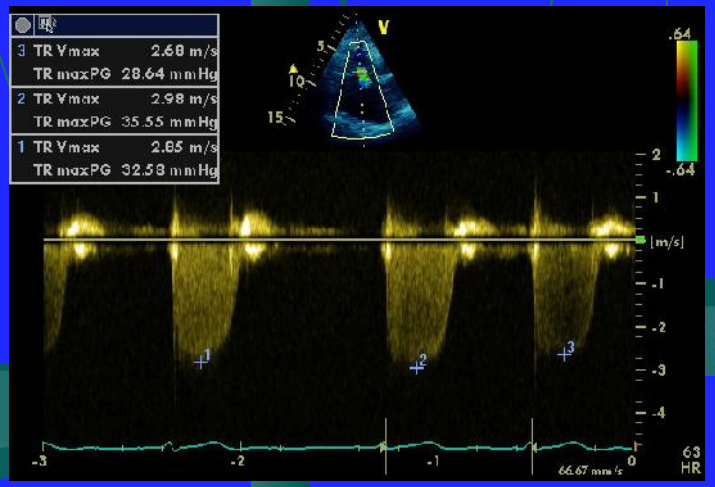

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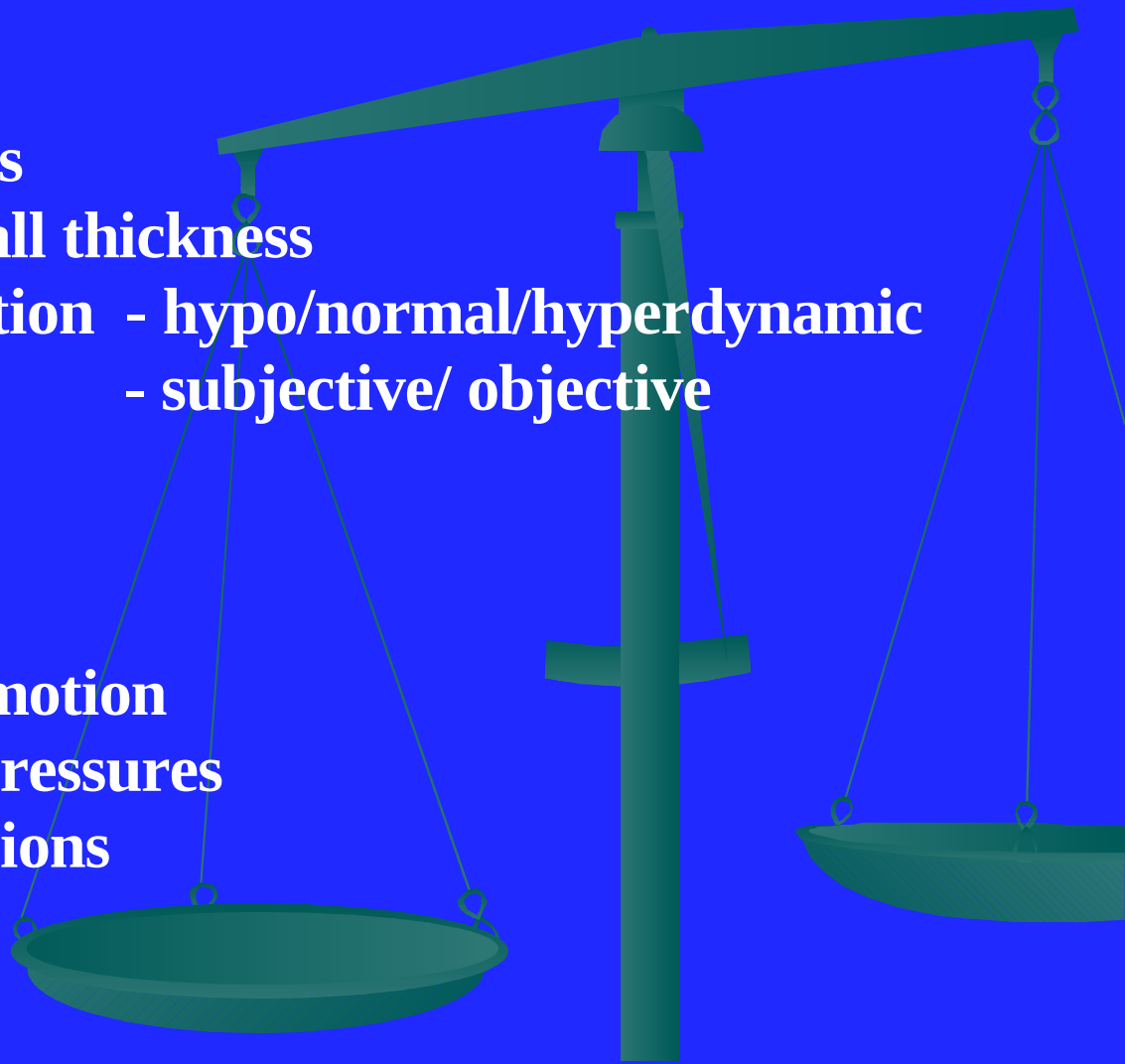

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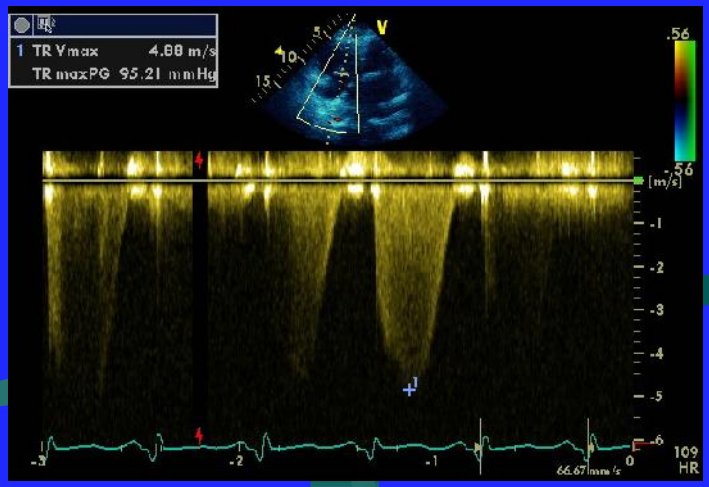
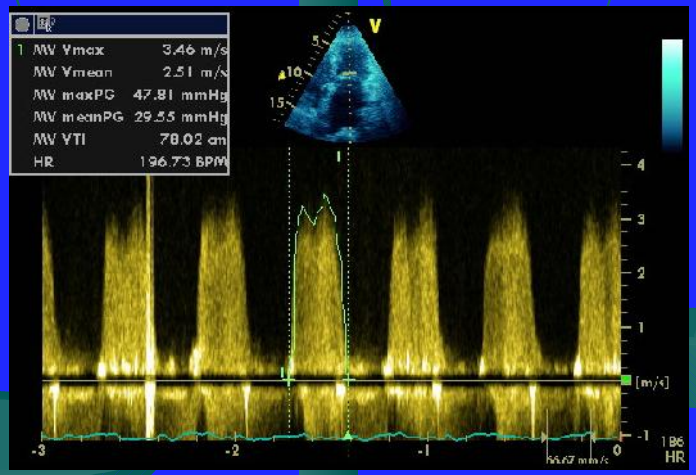
- **left atrial pressure**

48 year woman

- asthma since 20s
- admitted to ICU - ? intubation
- August 2007.
- trainee performs echo- Sunday

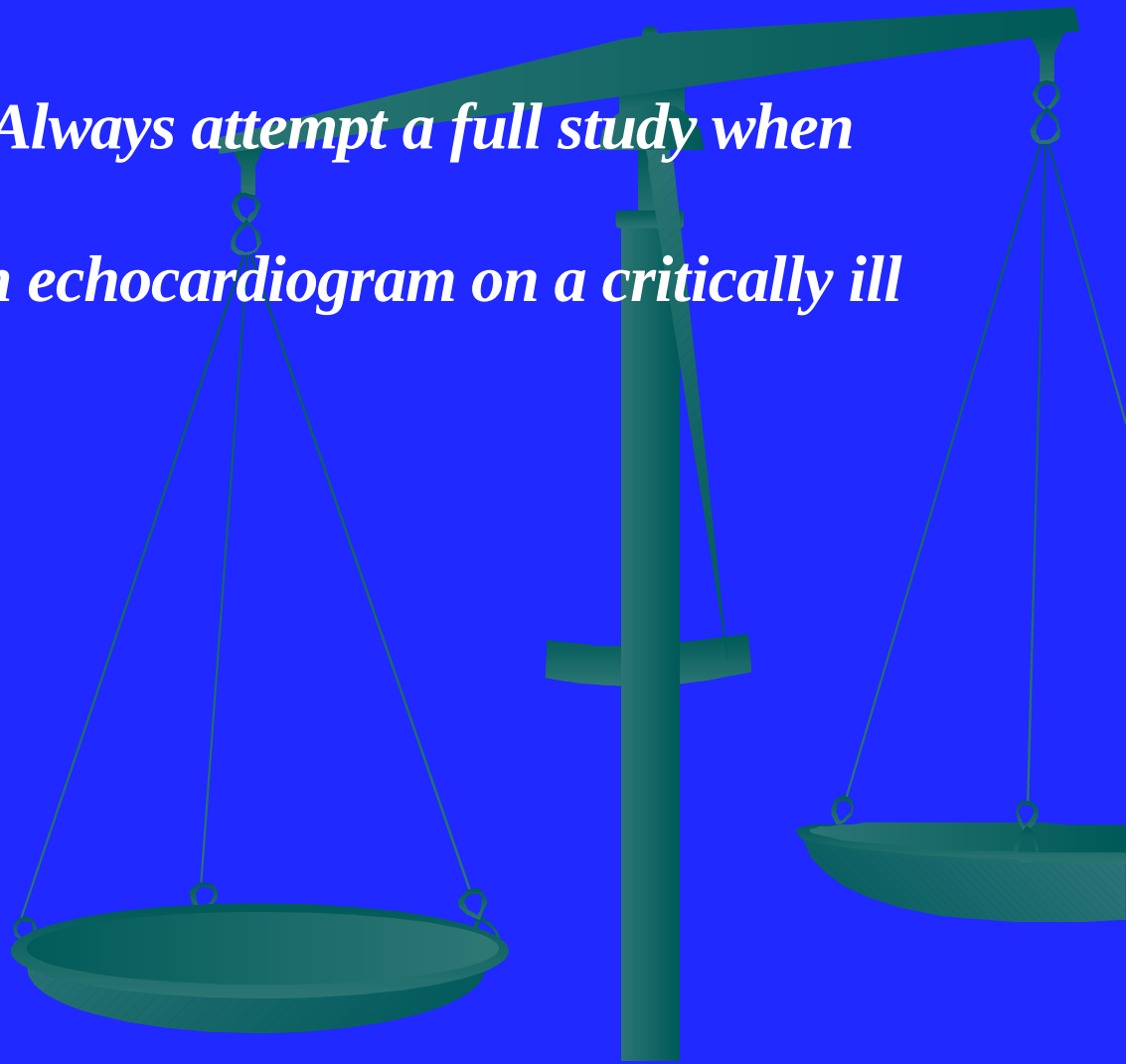


QuickTime® and a
Microsoft Video 1 decompressor
are needed to see this picture.



Severe mitral stenosis !!

Basic Rule : ***Always attempt a full study when performing an echocardiogram on a critically ill patient.***



The End