Pulmonary Hypertension and the Role of Echocardiography

Linda D. Gillam, MD, MPH, FACC, FASE
Chair, Department of Cardiovascular Medicine
Director, Cardiovascular Service Line
Morristown Medical Center/Atlantic Health System
Professor of Medicine
Sidney Kimmel Medical College
Thomas Jefferson University

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No disclosures

Companion to RV presentation

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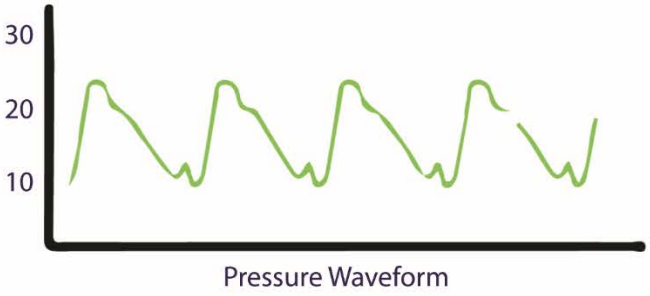
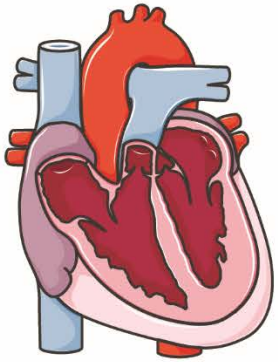
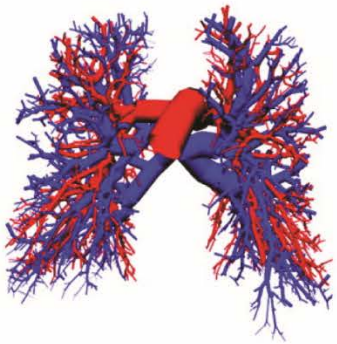


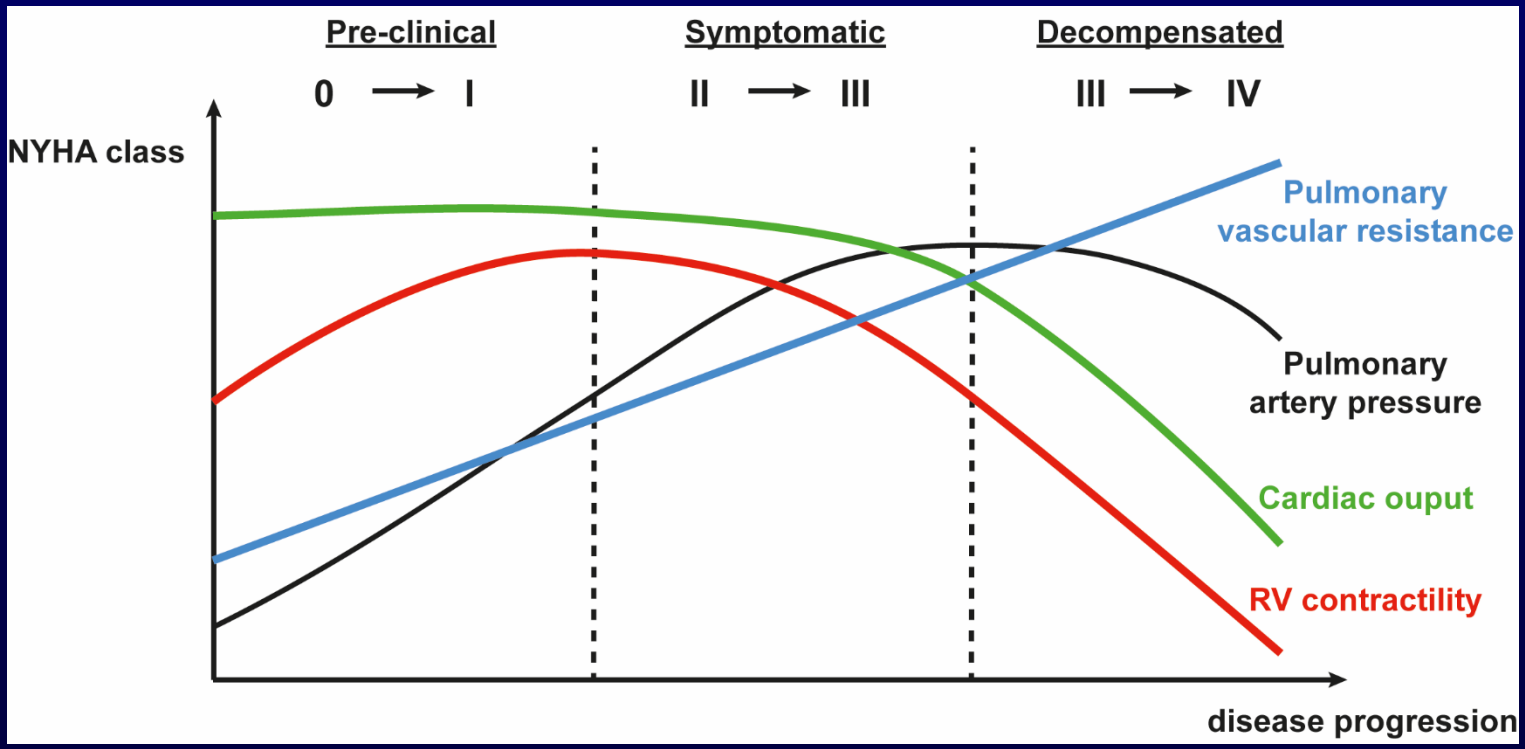




Pulmonary Artery Pressure = **Pump** x **Load**

Pump: RV function

Load: **Pulmonary** (Resistance & Compliance) + **Left heart** (Left atrial pressure)



The degree of pulmonary hypertension is best based on the degree of RV dysfunction not the PA pressure

Role of Echocardiography

- Assess pressures, PVR
- Assess RV function
- Assess the left heart

- Provide prognostic information
- Identify underlying causes
  - Distinguish pre- from post-capillary PHTN

Assessing PA pressures during stress

Definitions

Pulmonary Artery Pressures

	Normal	PHTN
Systolic	20-30	>30
Diastolic	5-12	>12
Mean	10-20	>25

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Updated Clinical Classification of Pulmonary Hypertension

Gerald Simonneau, MD,* Michael A. Gatzoulis, MD, PhD,† Ian Adatia, MD,‡ David Celermajer, MD, PhD,§ Chris Denton, MD, PhD,‖ Ardeschir Ghofrani, MD,¶ Miguel Angel Gomez Sanchez, MD,# R. Krishna Kumar, MD,** Michael Landzberg, MD,†† Roberto F. Machado, MD,‡‡ Horst Olschewski, MD,§§ Ivan M. Robbins, MD,‖‖ Rogiero Souza, MD, PhD¶¶

Le Kremlin-Bicêtre and Paris, France; London, United Kingdom; Edmonton, Alberta, Canada; Sydney, Australia; Marburg, Germany; Madrid, Spain; Kerala, India; Boston, Massachusetts; Chicago, Illinois; Graz, Austria; Nashville, Tennessee; and São Paulo, Brazil

Table 1 Updated Classification of Pulmonary Hypertension*

1. Pulmonary arterial hypertension
   - 1.1 Idiopathic PAH
   - 1.2 Heritable PAH
   - 1.2.1 BMPR2
   - 1.2.2 ALK-1, ENG, SMAD9, CAV1, KCNK3
   - 1.2.3 Unknown
   - 1.3 Drug and toxin induced
   - 1.4 Associated with:
   - 1.4.1 Connective tissue disease
   - 1.4.2 HIV infection
   - 1.4.3 Portal hypertension
   - 1.4.4 Congenital heart diseases
   - 1.4.5 Schistosomiasis

1′ Pulmonary veno-occlusive disease and/or pulmonary capillary hemangiomatosis

1′′. Persistent pulmonary hypertension of the newborn (PPHN)

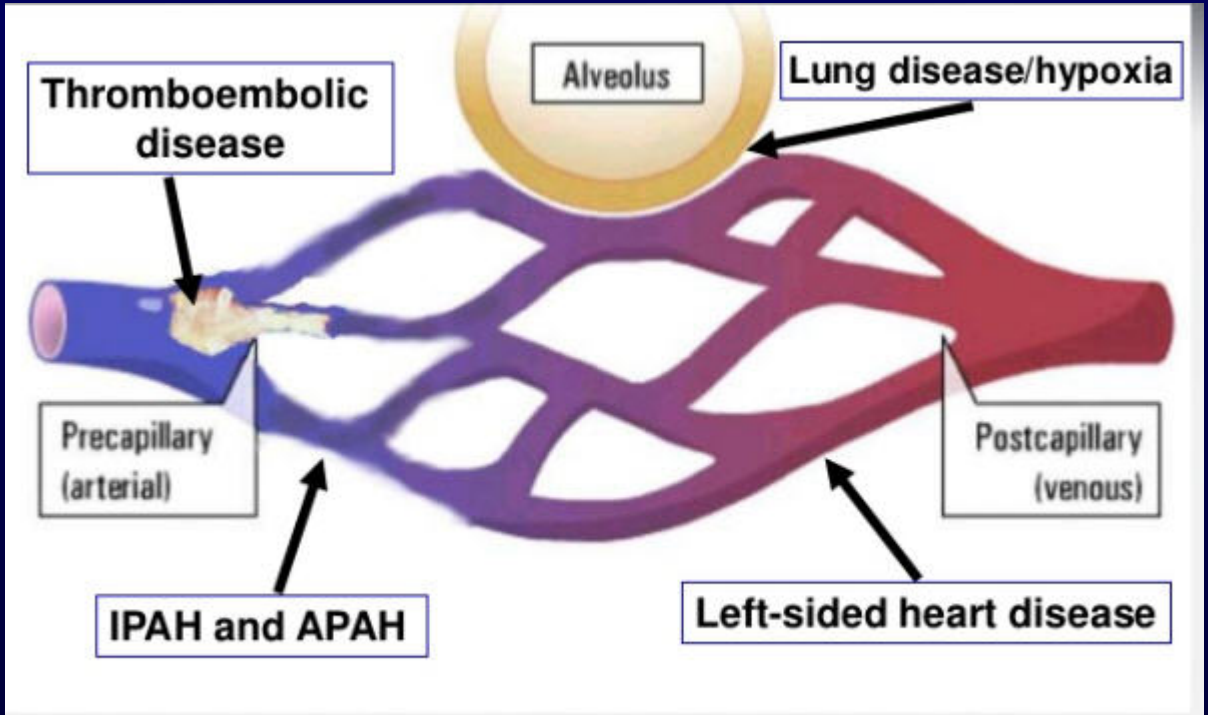
2. Pulmonary hypertension due to left heart disease
   - 2.1 Left ventricular systolic dysfunction
   - 2.2 Left ventricular diastolic dysfunction
   - 2.3 Valvular disease
   - 2.4 Congenital/acquired left heart inflow/outflow tract obstruction and congenital cardiomyopathies

3. Pulmonary hypertension due to lung diseases and/or hypoxia
   - 3.1 Chronic obstructive pulmonary disease
   - 3.2 Interstitial lung disease
   - 3.3 Other pulmonary diseases with mixed restrictive and obstructive pattern
   - 3.4 Sleep-disordered breathing
   - 3.5 Alveolar hypoventilation disorders
   - 3.6 Chronic exposure to high altitude
   - 3.7 Developmental lung diseases

4. Chronic thromboembolic pulmonary hypertension (CTEPH)

5. Pulmonary hypertension with unclear multifactorial mechanisms
   - 5.1 Hematologic disorders: chronic hemolytic anemia, myeloproliferative disorders, splenectomy
   - 5.2 Systemic disorders: sarcoidosis, pulmonary histiocytosis, lymphangioleiomyomatosis
   - 5.3 Metabolic disorders: glycogen storage disease, Gaucher disease, thyroid disorders
   - 5.4 Others: tumoral obstruction, fibrosing mediastinitis, chronic renal failure, segmental PH

*5th WSPH Nice 2013. Main modifications to the previous Dana Point classification are in **bold**.
BMPR = bone morphogenic protein receptor type II; CAV1 = caveolin-1; ENG = endoglin; HIV = human immunodeficiency virus; PAH = pulmonary arterial hypertension.



IPAH = idiopathic pulmonary artery hypertension; APAH = associated pulmonary artery hypertension.

Pulmonary arterial hypertension (pre-capillary PHTN)

- PHTN in which PCWP ≤ 15 mmHg and PVR > 3 WU

Back to echo….

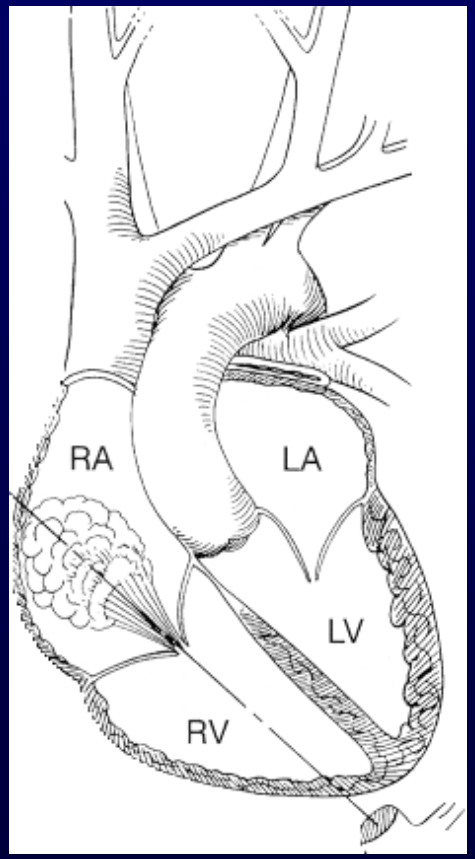
Calculating PA pressure

PA systolic pressure

Assume PASP = RVSP

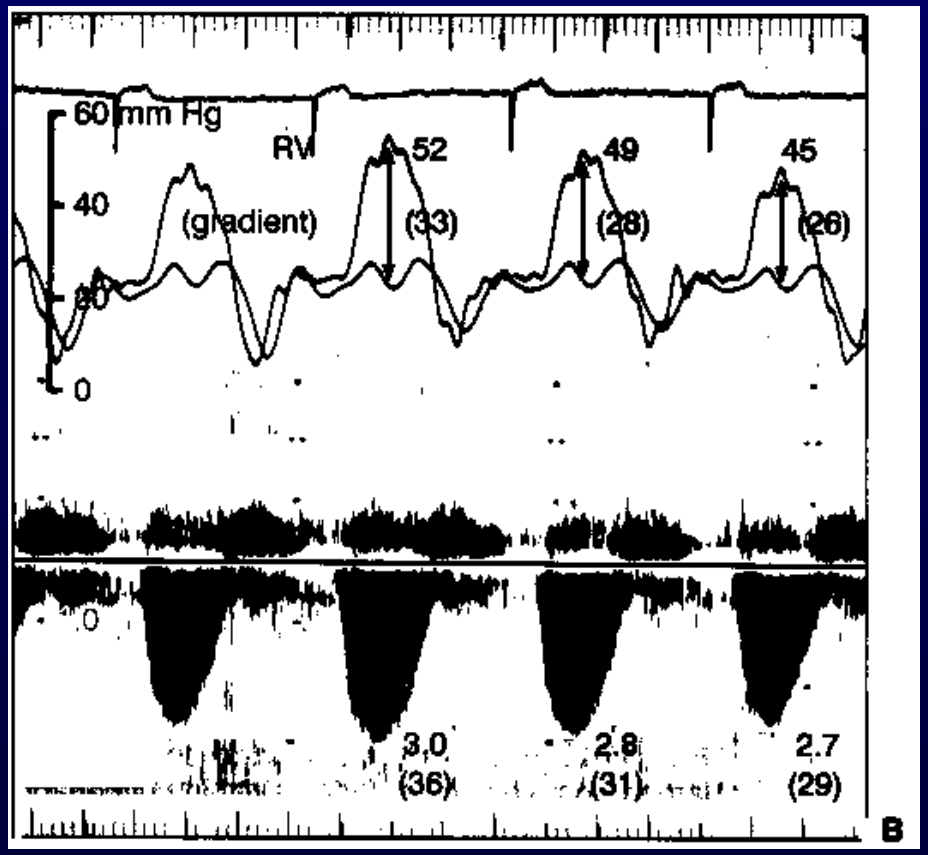
Calculating RV pressure

Yock PG Circulation 1984;70:657 and Currie PJ et al JACC 1985;6:750



RA and RV pressure readings →

tricuspid regurgitation velocity recordings →



4 x (TR velocity)^2 = RVP-RAP

4 x (TR velocity)^2 + RAP = RVSP

Contrast can help….

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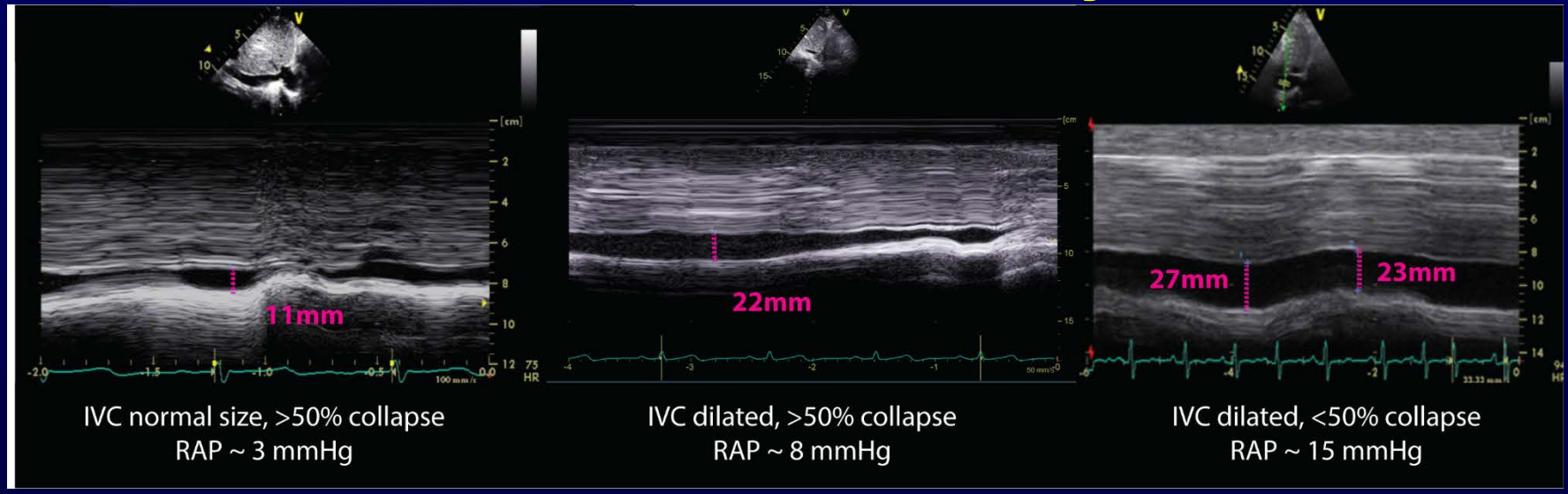
Right atrial pressure

What is the right atrial pressure?

IVC	Δ with resp	RAP(mmHg)
<2.1 cm	collapse>50%	0-5 (3)
>2.1 cm	Dec<50%	10-20 (15)
<2.1 cm	Dec<50%	5-10 (8)
>2.1 cm	Dec> 50%	5-10 (8)

ASE Guidelines

1-2 cm from IVC-RA junction



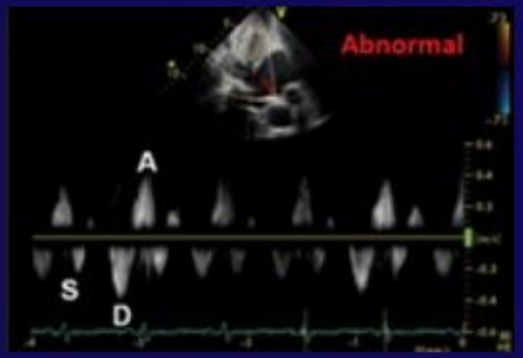
- Limitations:
  - inadequate inspiratory effort
  - “losing” the image

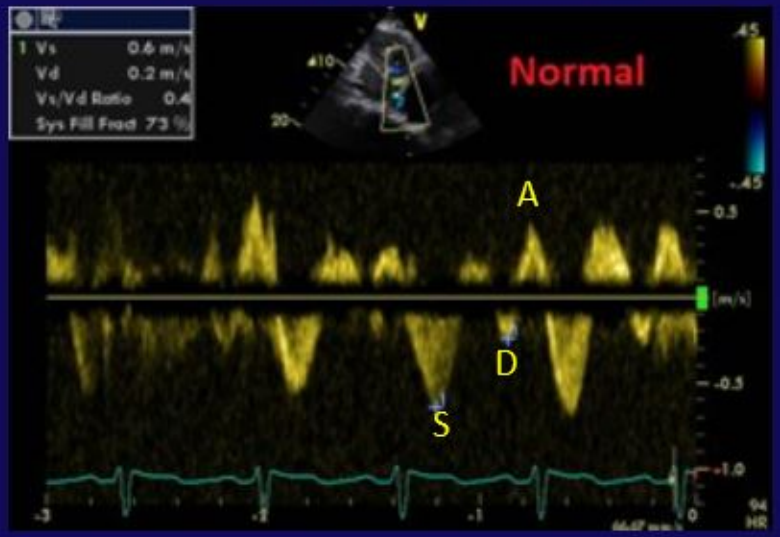
Circulation. 1996 Mar 15;93(6):1160-9.

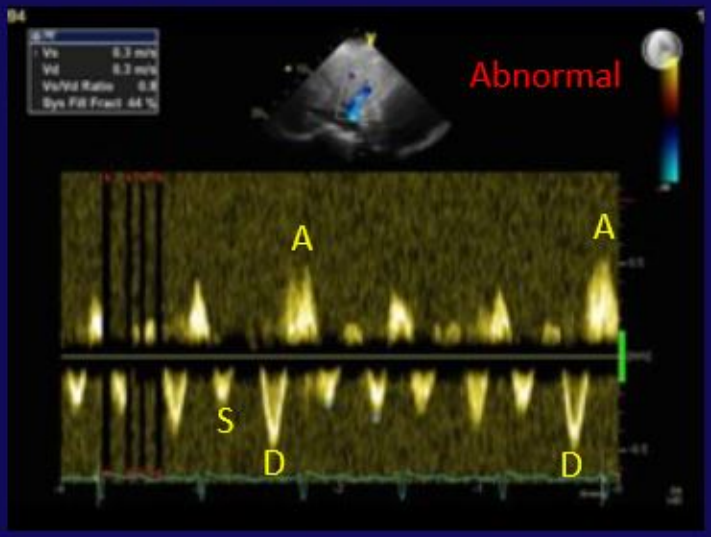
Relation of mean right atrial pressure to echocardiographic and Doppler parameters of right atrial and right ventricular function.

Nagueh SF[1], Kopelen HA, Zoghbi WA.

- *Systolic filling fraction:* **Vs/ (Vs + Vd)** < 55% sensitive and specific for increased RA pressure
- Abnormal: A wave is larger than systolic S wave







Normal: Systolic predominance in hep. vein flow

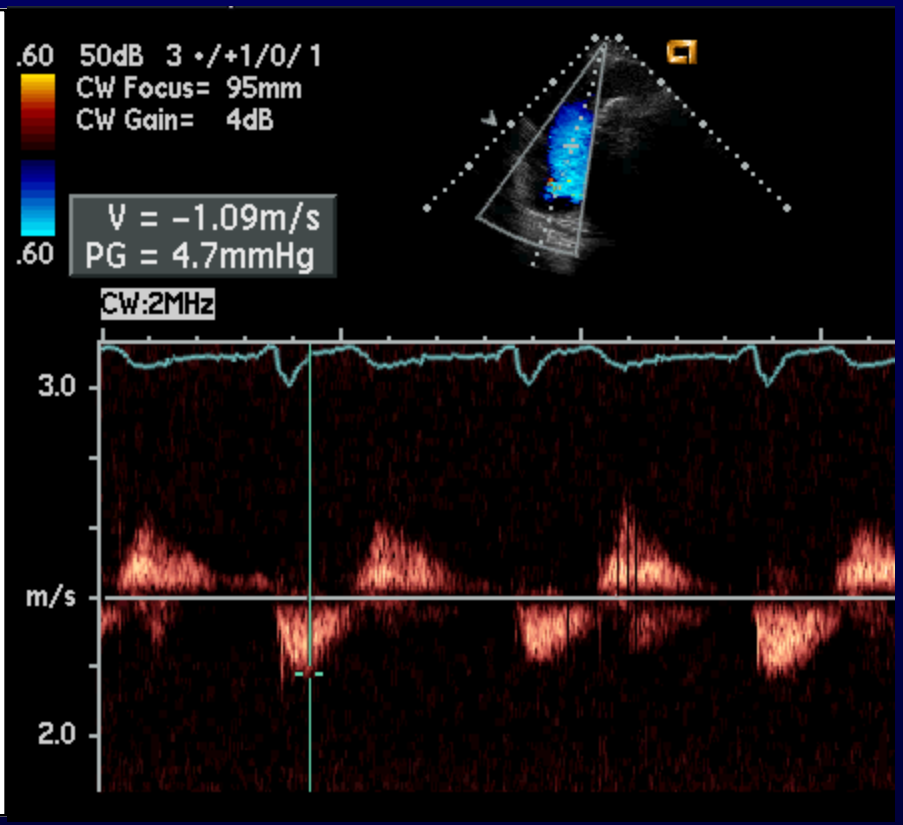
Abnormal: Vs/Vd< 1 (eg; High RA pressure)

Normal values

Peak TR velocity	**≤ 2.8 – 2.9 m/s**
Peak systolic pressure (assuming an RA pressure of 3 to 5 mm Hg)	**35 or 36 mm Hg***

•You can’t calculate the RV pressure….

- When TR is unrestricted:
  - Large color flow jet dimension
  - Failure of leaflet coaptation
  - When TR jet is laminar or shows little mosaic



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When is the RV systolic pressure≠PA pressure?

- When there is:

A gradient across the RVOT

When there is PS

- Calculate RVSP in the usual fashion

  $RVSP = 4\ TRvel^2 + RAP$

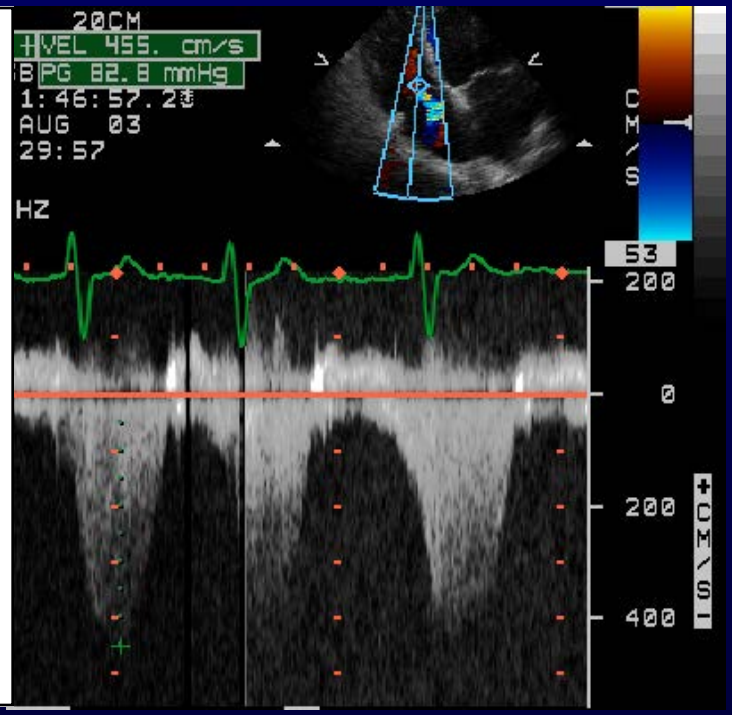
- Calculate RV-PA gradient

  $gradient = 4V^2$

- Subtract gradient from RVSP

  $PASP = RVSP - gradient$

You must evaluate the RVOT!



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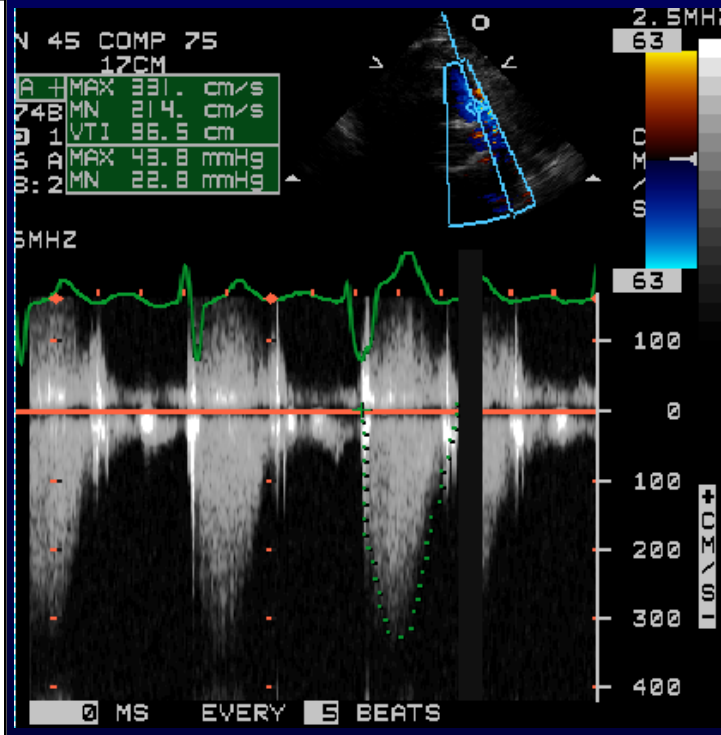


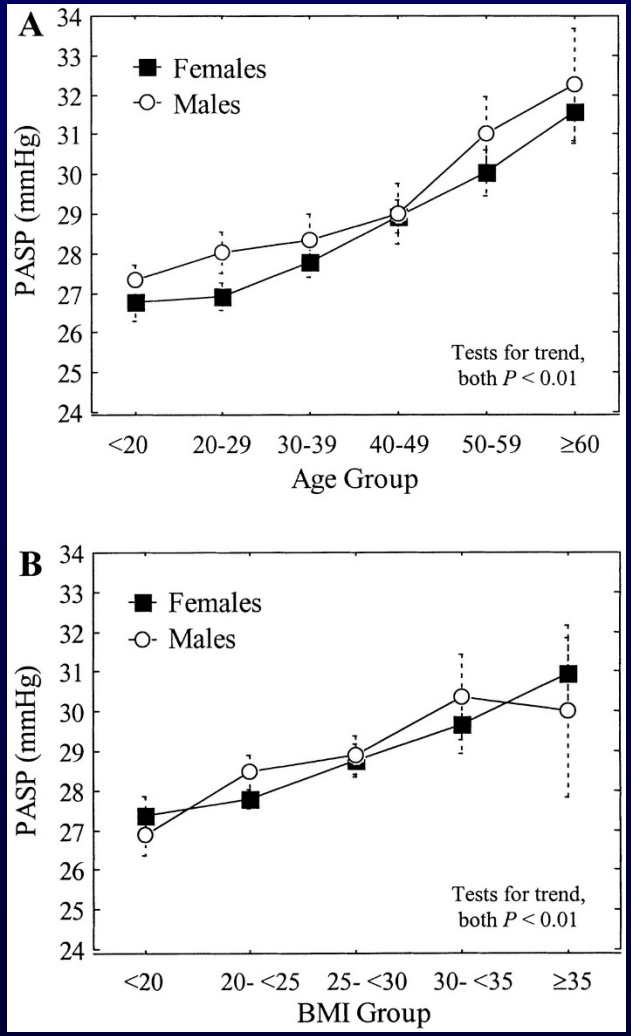
- PASP= 83-44 = 39mmHg

•Clinical Correlates and Reference Intervals for Pulmonary Artery Systolic Pressure Among Echocardiographically Normal Subjects

•*by Brendan M. McQuillan, Michael H. Picard, Marcia Leavitt, and Arthur E. Weyman*

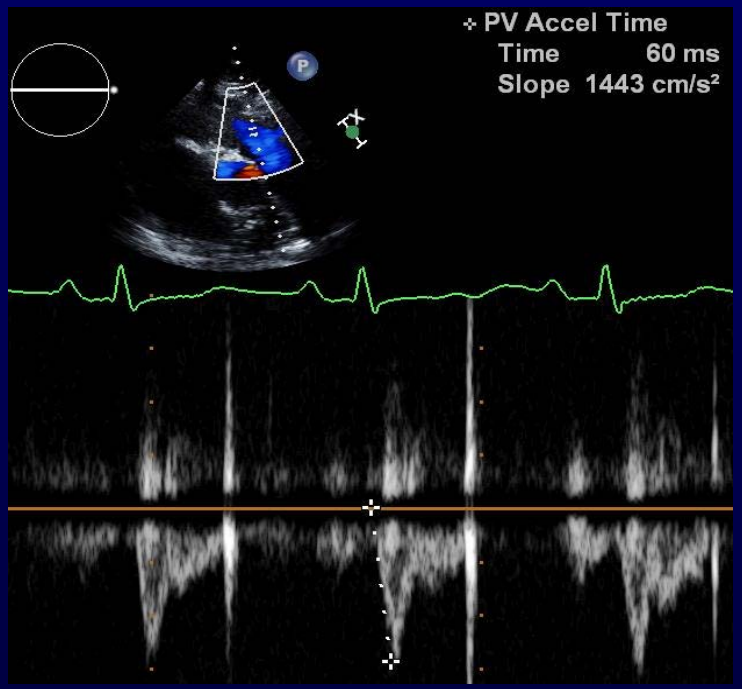
•*Circulation*
•*Volume 104(23):2797-2802*
•*December 4, 2001*

Relation between PASP and age (A) and BMI (B).



Brendan M. McQuillan et al. Circulation. 2001;104:2797-2802

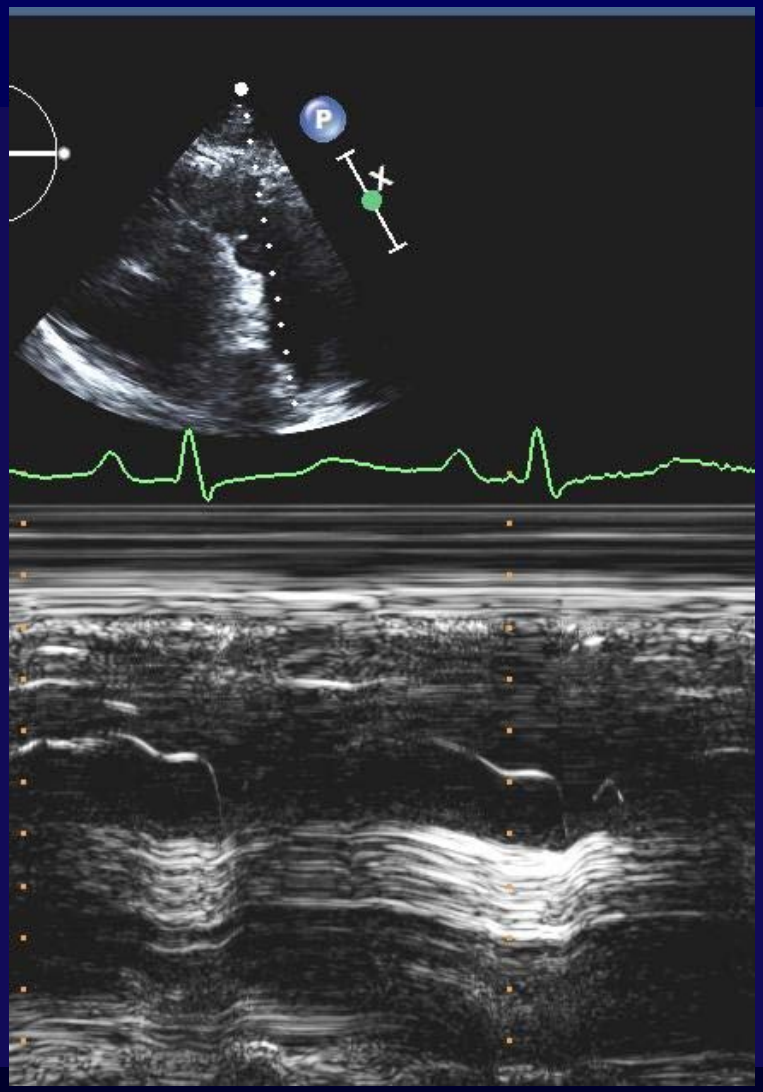
Pulmonary Artery Acceleration Time



Normal	120 - 140 ms
Borderline	100 ms
Usually PHTN	<80 - 90 ms
Severe PHTN	< 60 ms

- Modal velocity
- Level of leaflets
- Inversely related to HR (consider only for 60-100 bpm)
- Highly variable!
  - Beat to beat
  - Location
  - RV function

Flying W

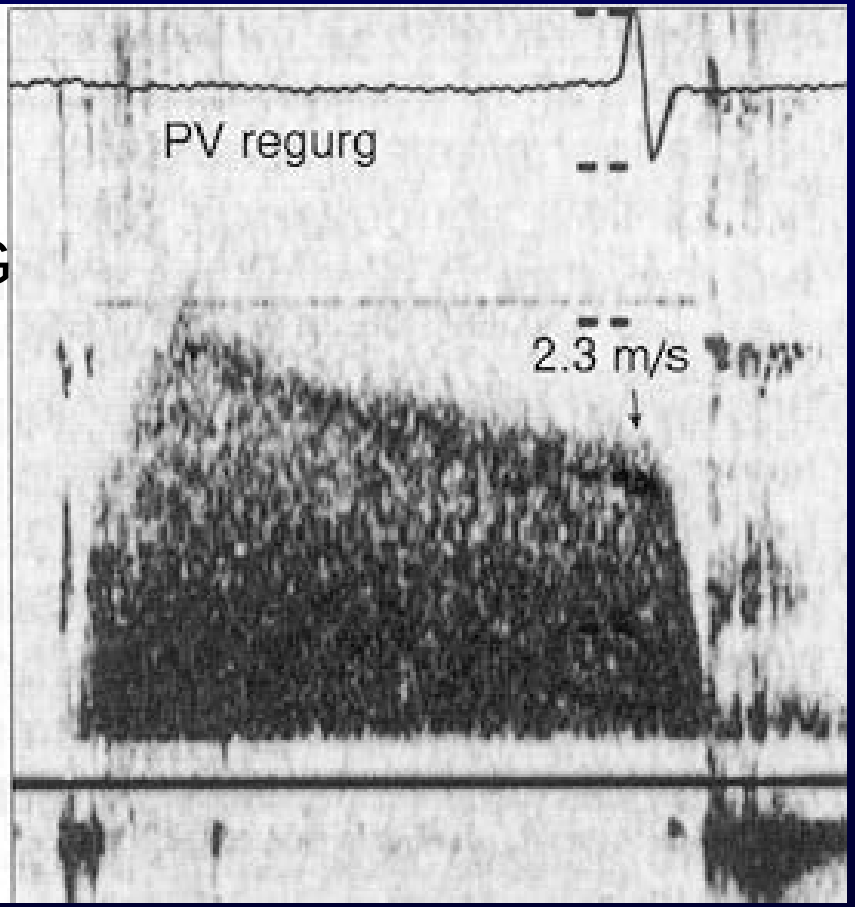


- Timing may reflect location of “obstruction”

PA diastolic pressure

PA Diastolic Pressure

- PA - RV= 22mmHG
- RAP = 3 mmHG
- PAD = 25 mmHG



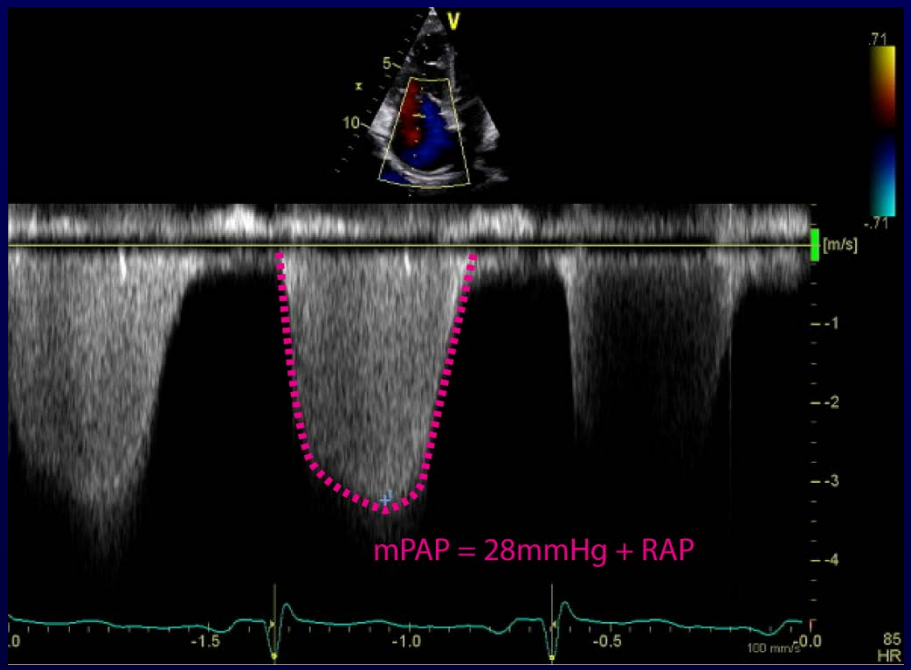
Mean PA pressure

Mean PAP
Method 1

$$PA_{mean} = 0.6 \times PA_{SP} + 2 \text{ mm Hg}$$

Chest 2004;126:1313-17

Mean PAP
Method 2



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Mean PAP
Method 3

$$PA_{mean} = \frac{PA_s + 2 \times PA_d}{3}$$

Mean PAP
Method 4
Not recommended

$$PA_{mean} = 79 - 0.45 \times PAcT$$

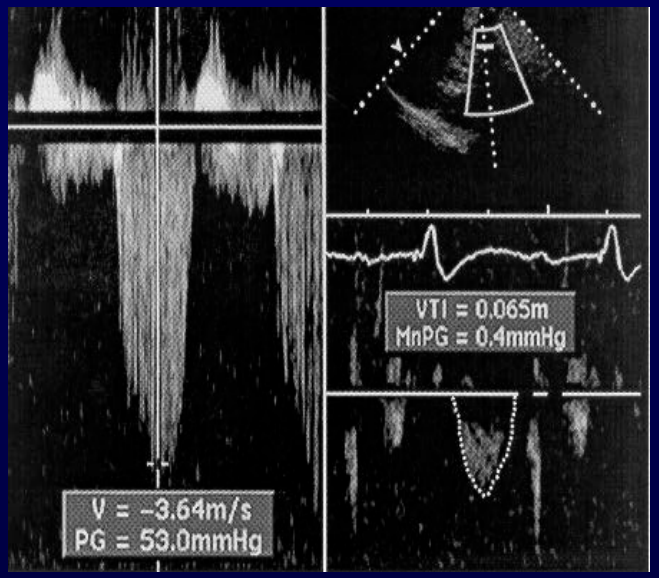
Pulmonary Vascular Resistance

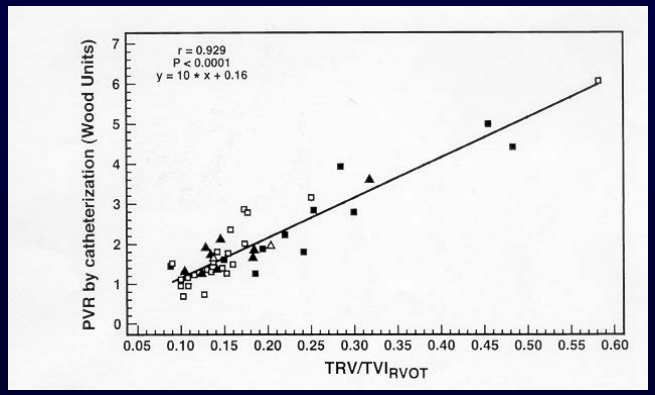
Pulmonary Vascular Resistance

- PVR = PA-LA /CO
  normal= 0.5-1.5
  (Wood units)

PVR =10(TRV/VTI)+0.16

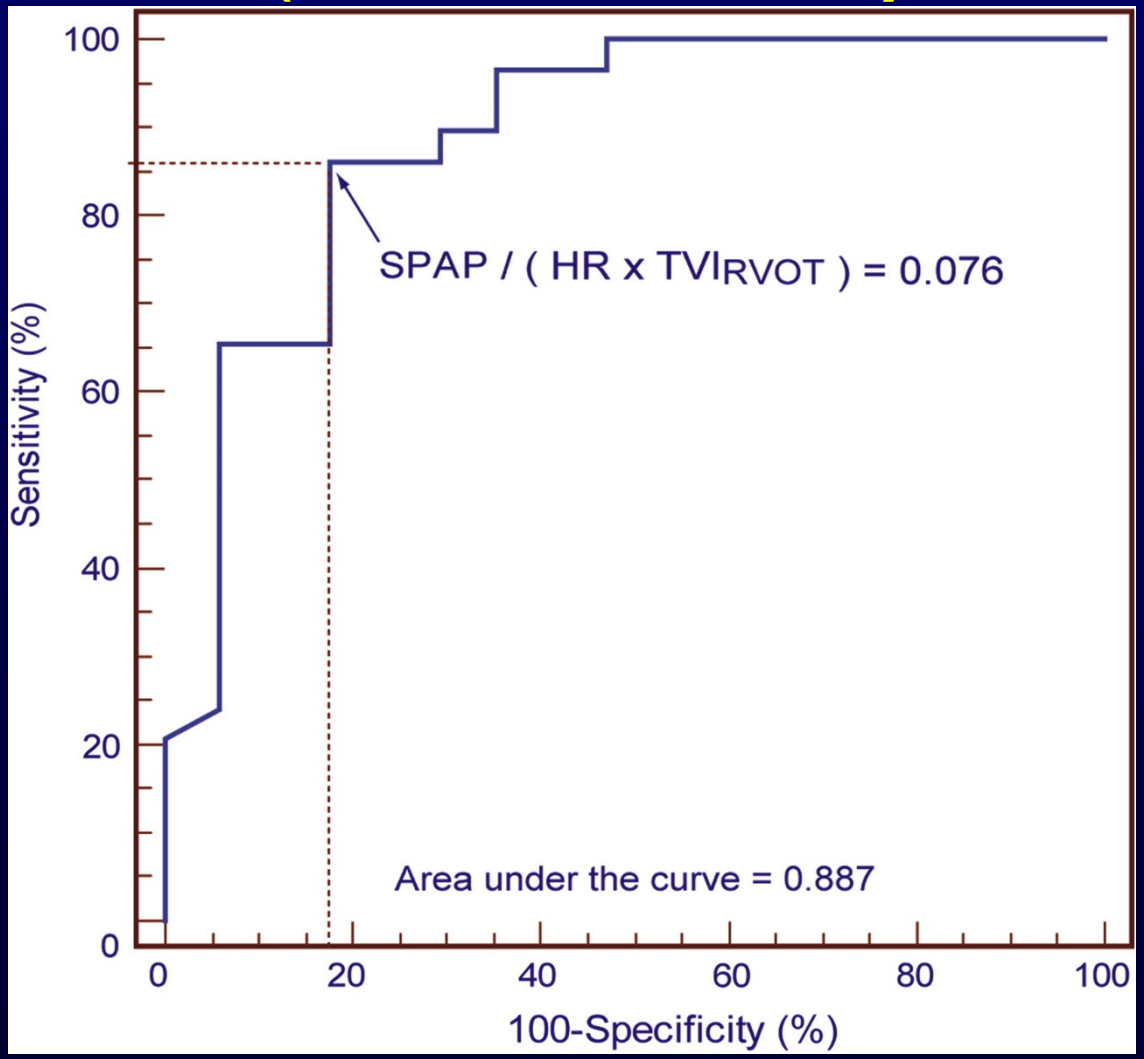
Note: does not consider HR





•Abbas et al JACC 2003; 41:1021

Haddad et al (PVRI >15 WU/m2)



•*Journal of the American Society of Echocardiography* 2009 22, 523-529DOI: (10.1016/j.echo.2009.01.021)

Consider calculating when..

- Calculated PASP unexpectedly high
- Known or suspected increased PV flow
  - ASD, VSD, post valvotomy severe PR, high output state (exercise)

- Note: neither method addresses LA pressure, will overestimate PVR if LA pressure is high

The RV in PHTN

- Multiple views
- Multiple techniques
  - Qualitative
  - Quantitative

- Multiple views
- Multiple techniques
  - Qualitative
  - Quantitative

Echocardiographic Markers of Prognosis

- TAPSE <15
- RV Tei Index >0.88
- RV FAC decreasing
- Pericardial effusion
- LV eccentricity index

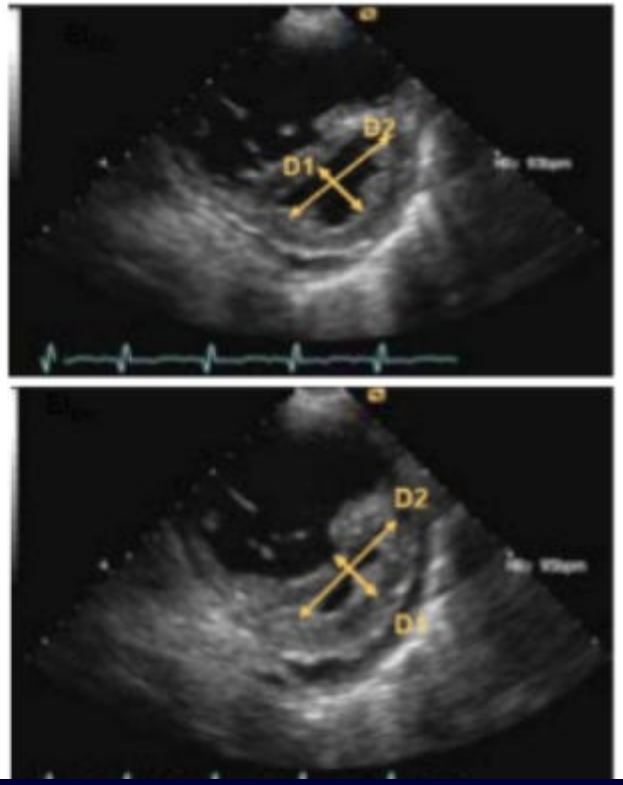
Eccentricity Index

A measure of septal displacement in systole or diastole

- Eccentricity Index
  EI = D2/D1

D1= minor axis diameter perpendicular to IVS

D2= minor axis diameter parallel to IVS



Ryan, T. et al. J Am Coll Cardiol 1985;5: 918-24

Stress Echocardiography in Pulmonary Hypertension

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Normal response to exercise

Limited normative data

Indications for Testing

- Elucidating symptoms
- High risk groups
  - Family members/Genotype positive
  - CT disease
  - HIV
- ?High altitude
- Treadmill vs. bicycle
- Role of assessing RV contractile reserve is uncertain

Summary

- The echo assessment of pulmonary hypertension is more than the peak TR jet
- Must consider pressures and ventricular function
- Echo is an excellent tool to do both

Thank you!

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