Hemodynamic Assessment in Pulmonary Thromboembolism

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Pulmonary Thromboembolism

History

- 1819 Laennec
  - First clinically described venous thromboembolism and pulmonary embolism
- 1830 ~ 1842 Cruveilhier
  - Peripheral and central thrombi and pulmonary embolism
- 1858 Rudolph Virchow
  - Described peripheral thrombi and pulmonary embolism

Epidemiology of VTE

- Five million cases of VTE each year
- About 10% of these will have a PTE
- Up to 60% of autopsies will show some evidence of past PTE

Epidemiology of PTE

- Incidence: 600,000/ year in US, in excess of 50,000 deaths
- Overall 3-month mortality rate: ~15%
- Mortality rate in patients with shock: ~50%
- Correct diagnosis is made in only 10~30% of cases

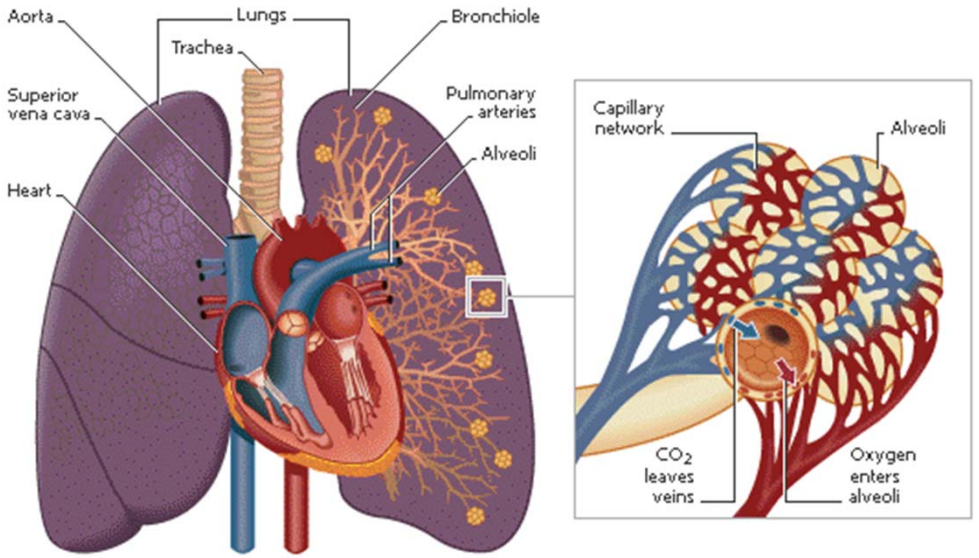
Wood KE, et al. Chest 2002;121:877
Stein PD, et al. Chest 1995;108:978
Bell WR, et al. Am Heart J 1982;103:239

Role of EchoCG in ER

- Differential diagnosis in critically ill or shocked patient
- Identify high possibility of PTE
- Assess right and left ventricular function
- Assist diagnosis of PTE if with characteristic hemodynamic pattern

Pulmonary Circulation

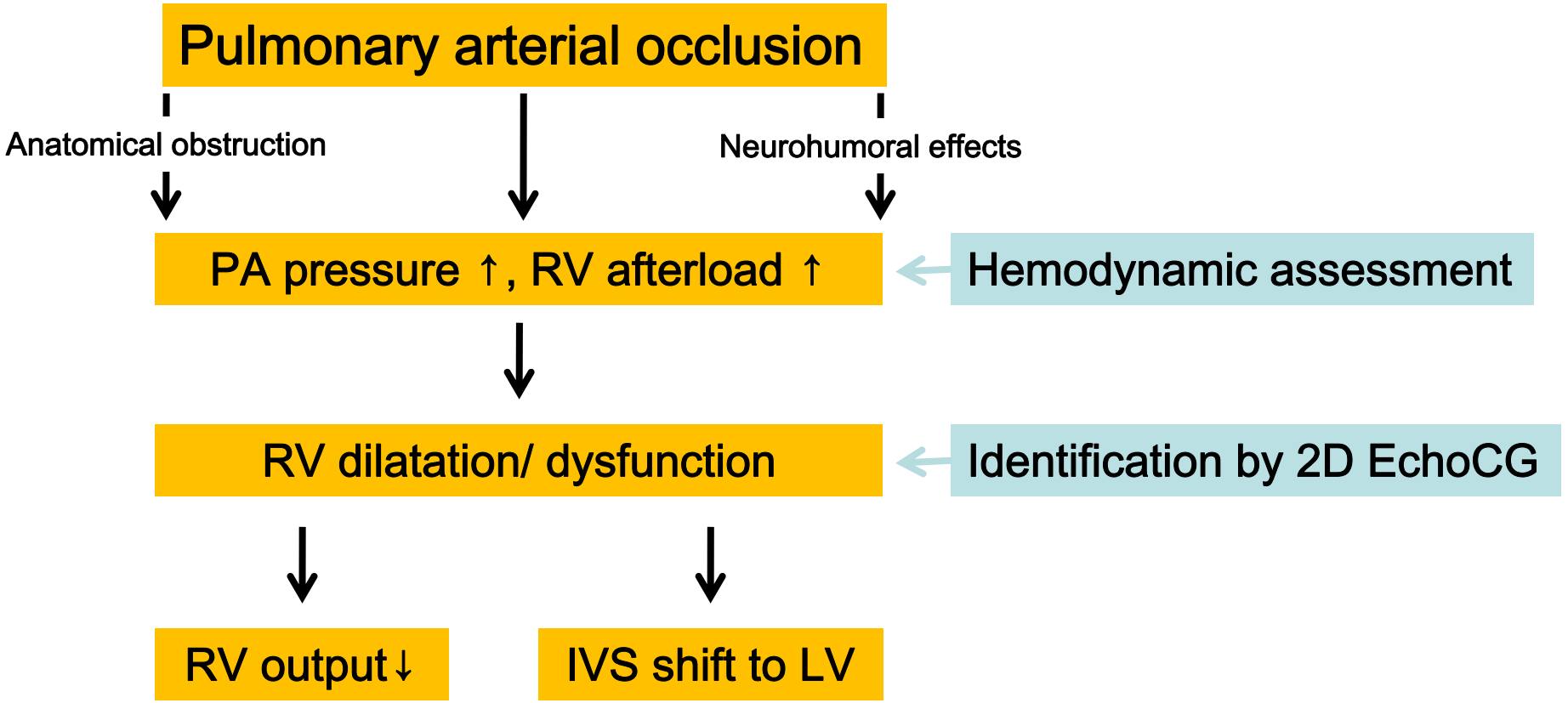
- **Characteristics of pulmonary circulation**
  - High capacity
  - Low resistance
  - Thin walled structure
  - Vasoconstriction to hypoxia



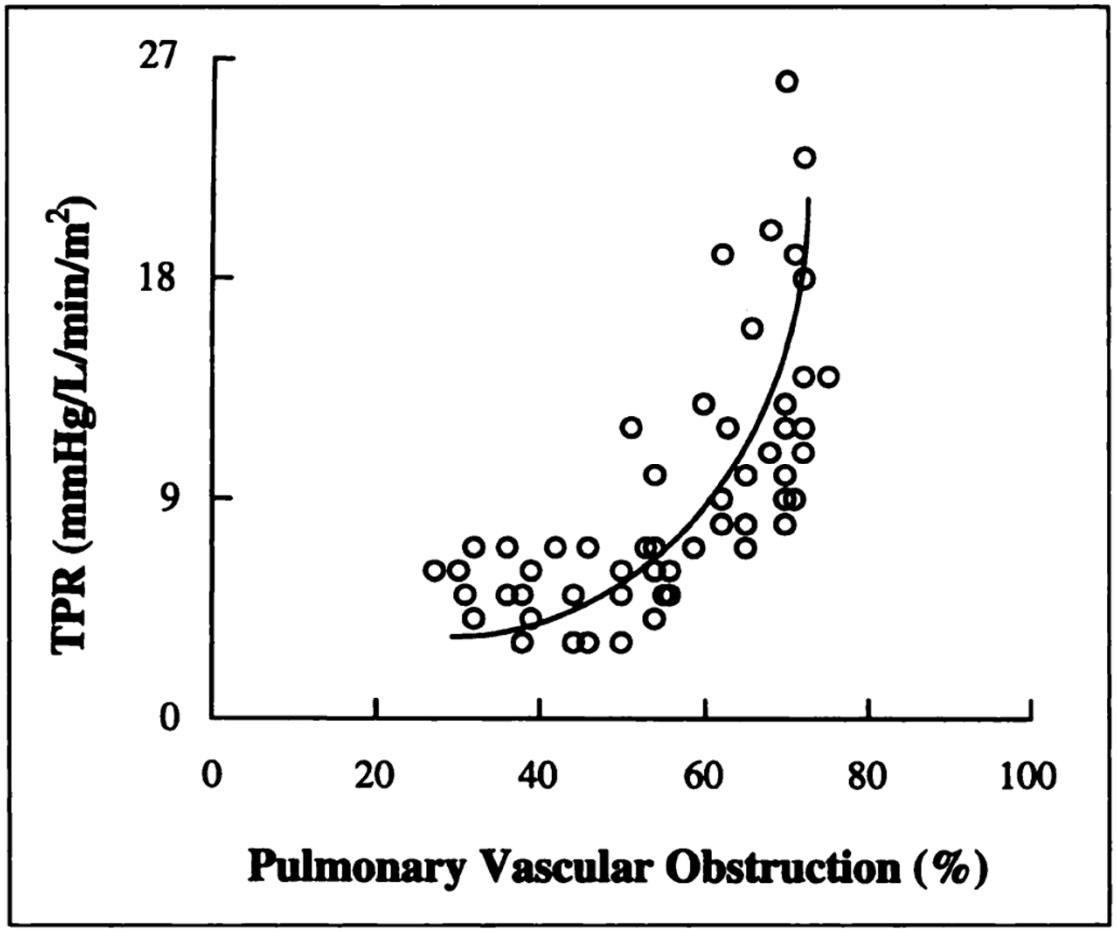
Pulmonary Circulation

- **Normal pulmonary arterial pressure**
  - Systolic pressure: 20~25mmHg
  - Diastolic pressure: 10mmHg
  - Mean pressure: 15mmHg

As a Consequence of



Pulmonary Vascular Obstruction

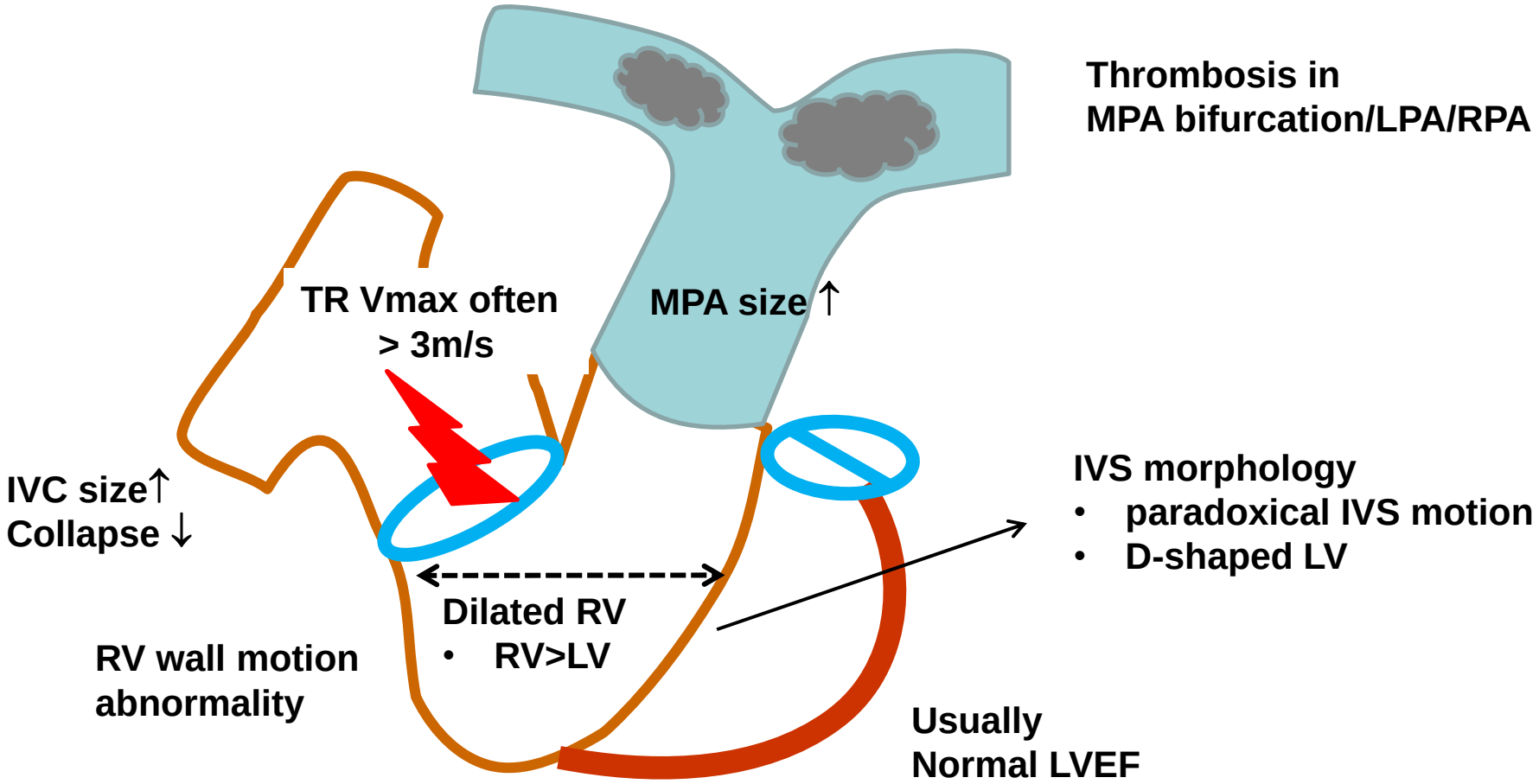


Azarian R, et al. J Nucl Med 1997;38:980

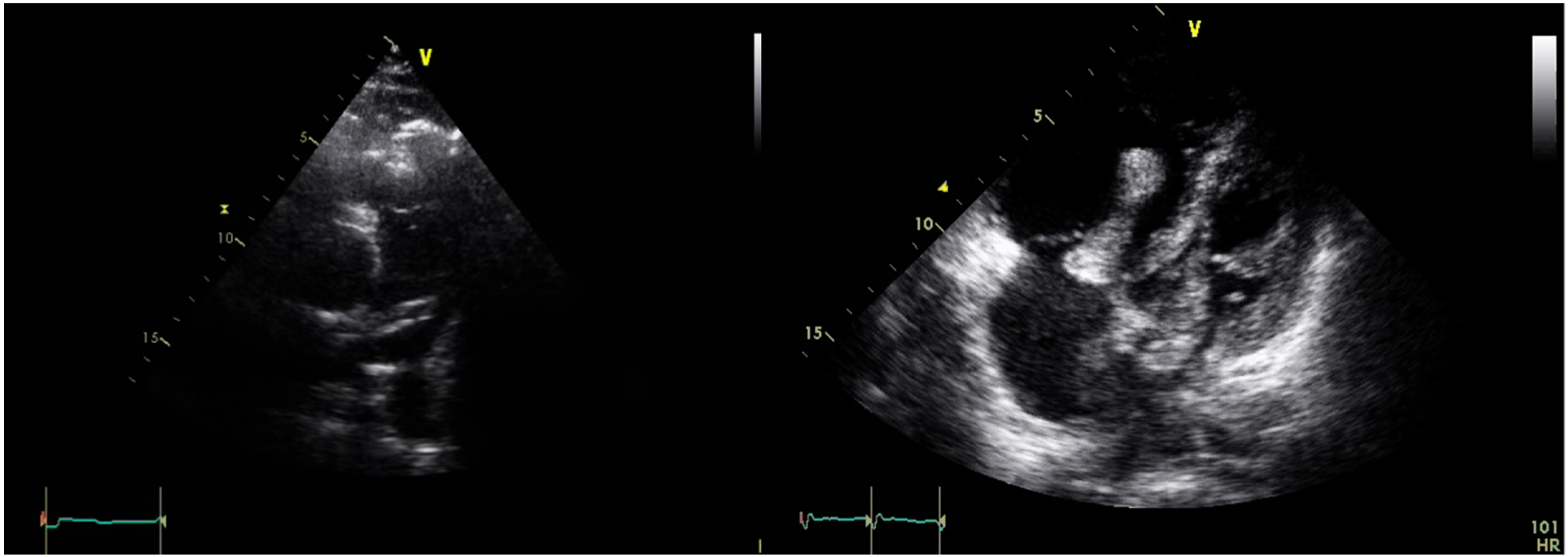
EchoCG Findings in PTE

- Direct visualization of thrombus
- Right ventricular dilatation & hypokinesis
- Abnormal interventricular septal motion
- Lack of decreased inspiratory collapse of inferior vena cava
- Increased TR Vmax (>3.0 m/s)

EchoCG in Acute PTE



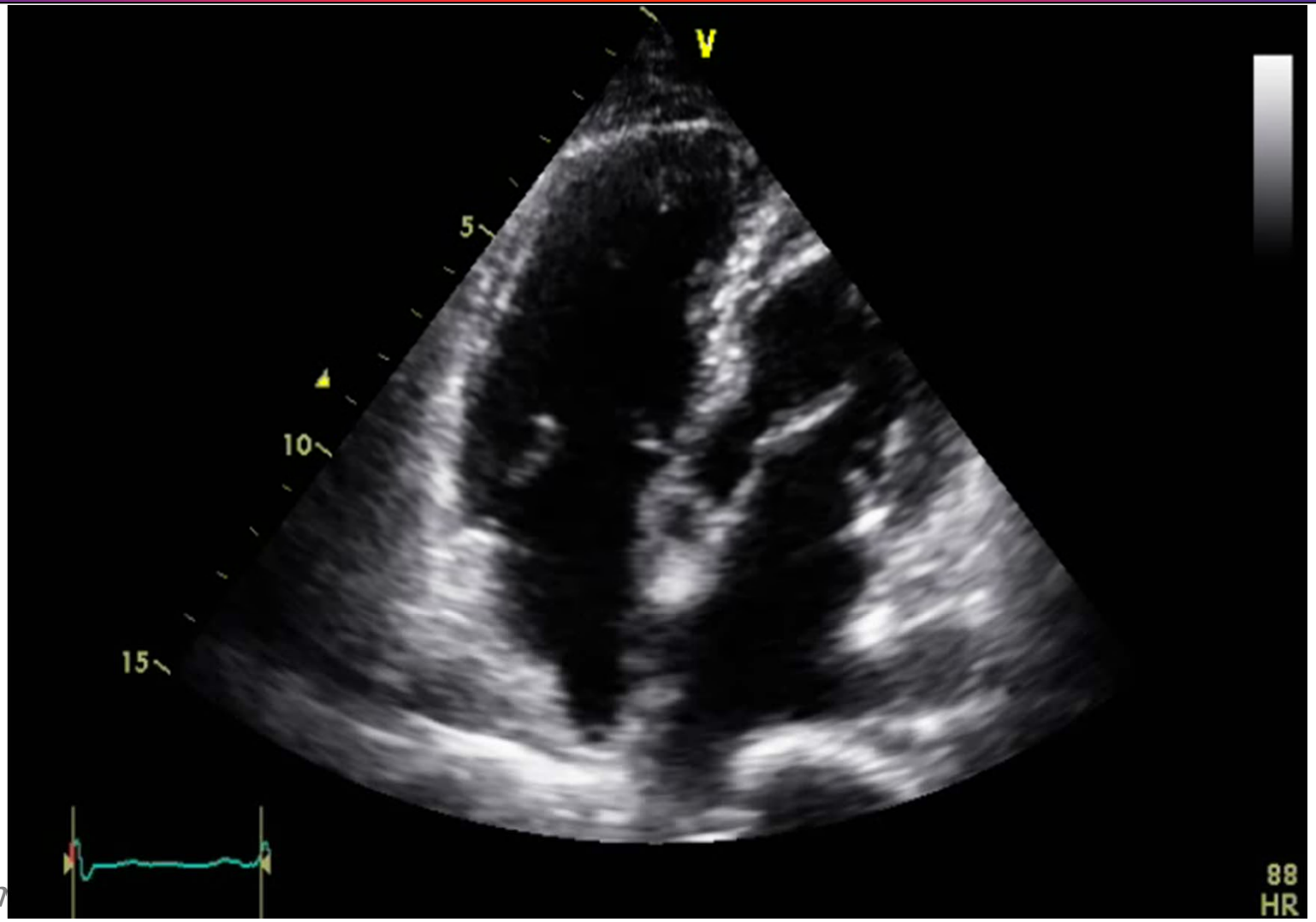
Direct Visualization of Thrombus



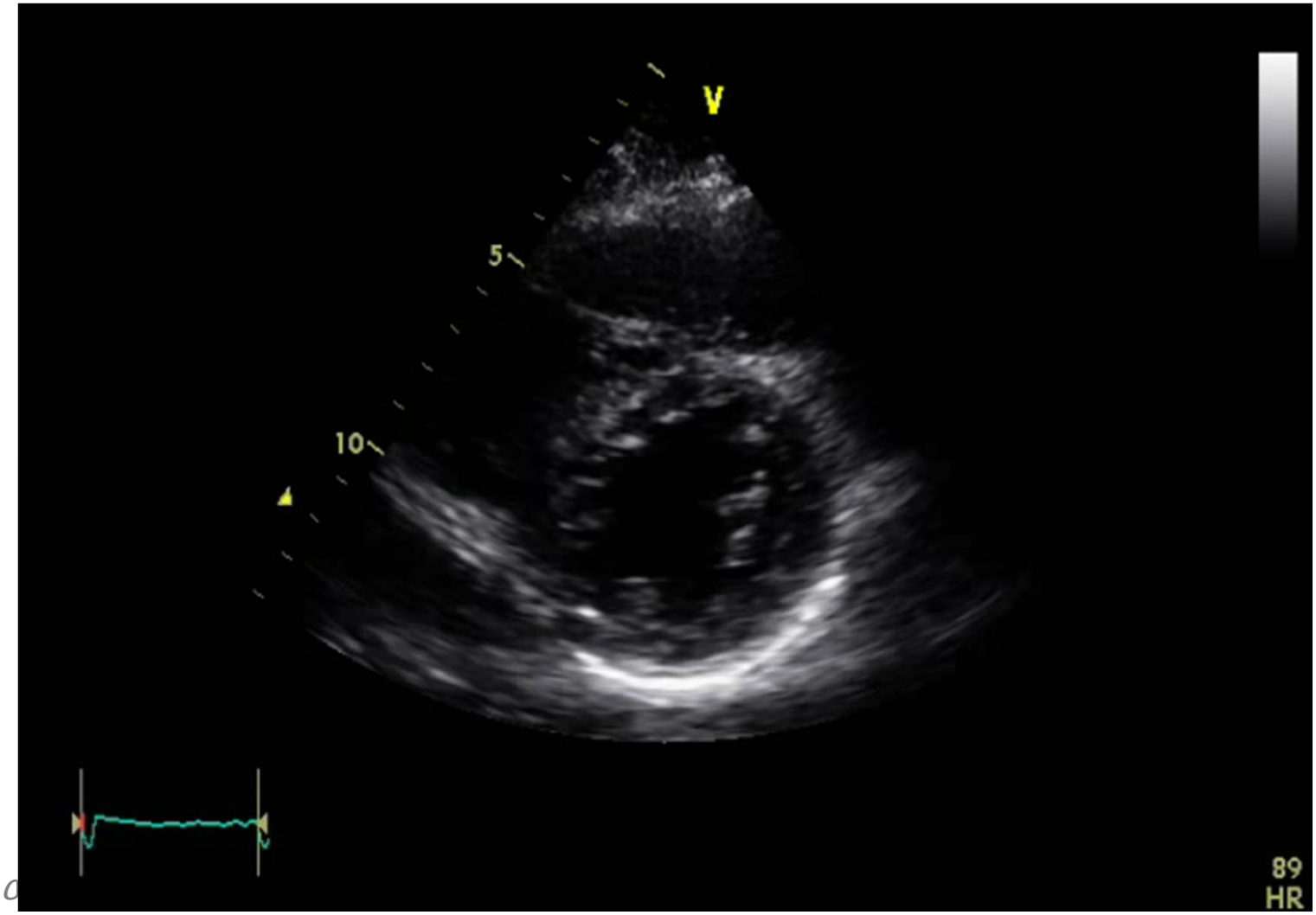
Thrombus in MPA

Thrombus in RA, RV and LA

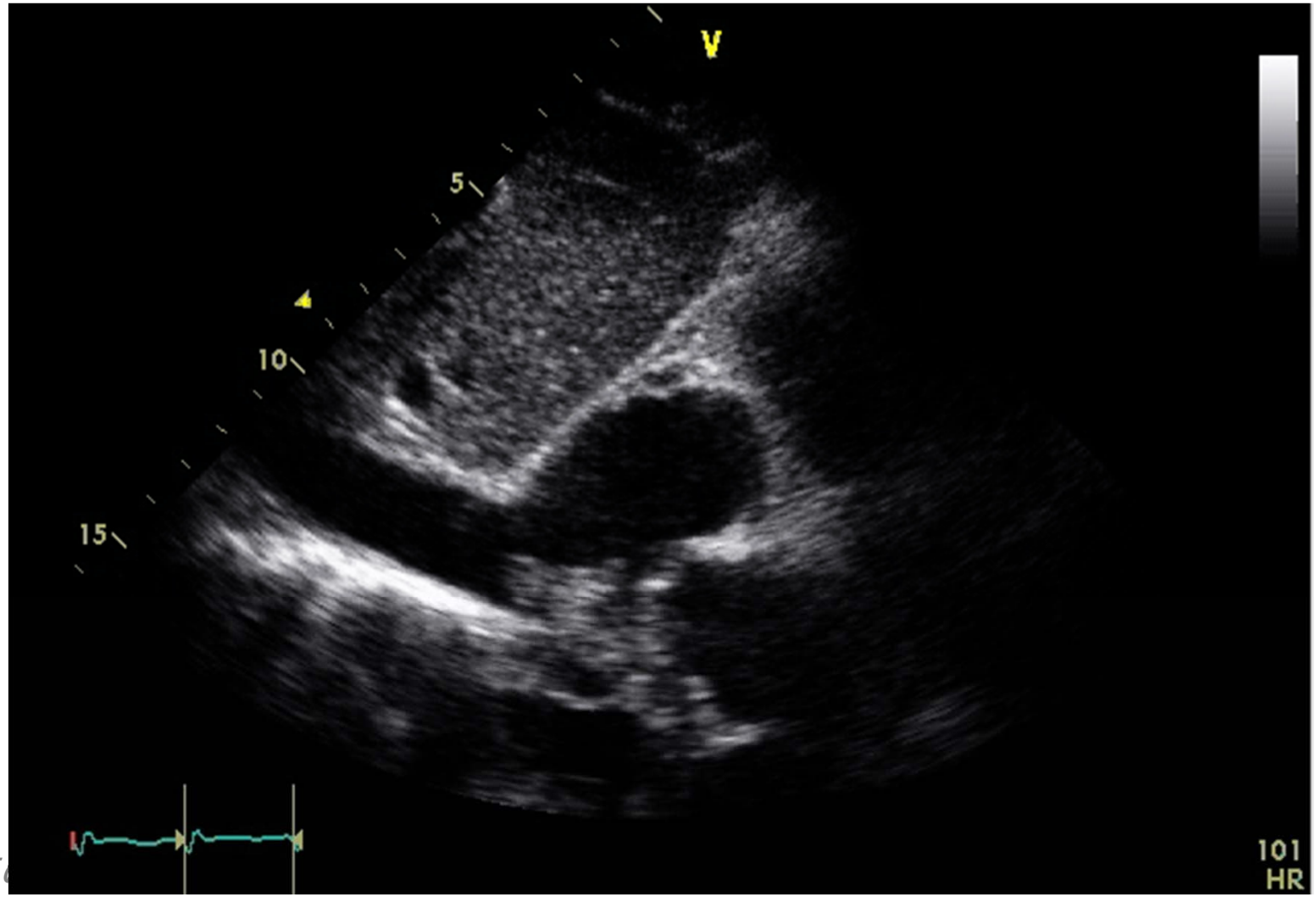
RV Dilatation & Hypokinesis



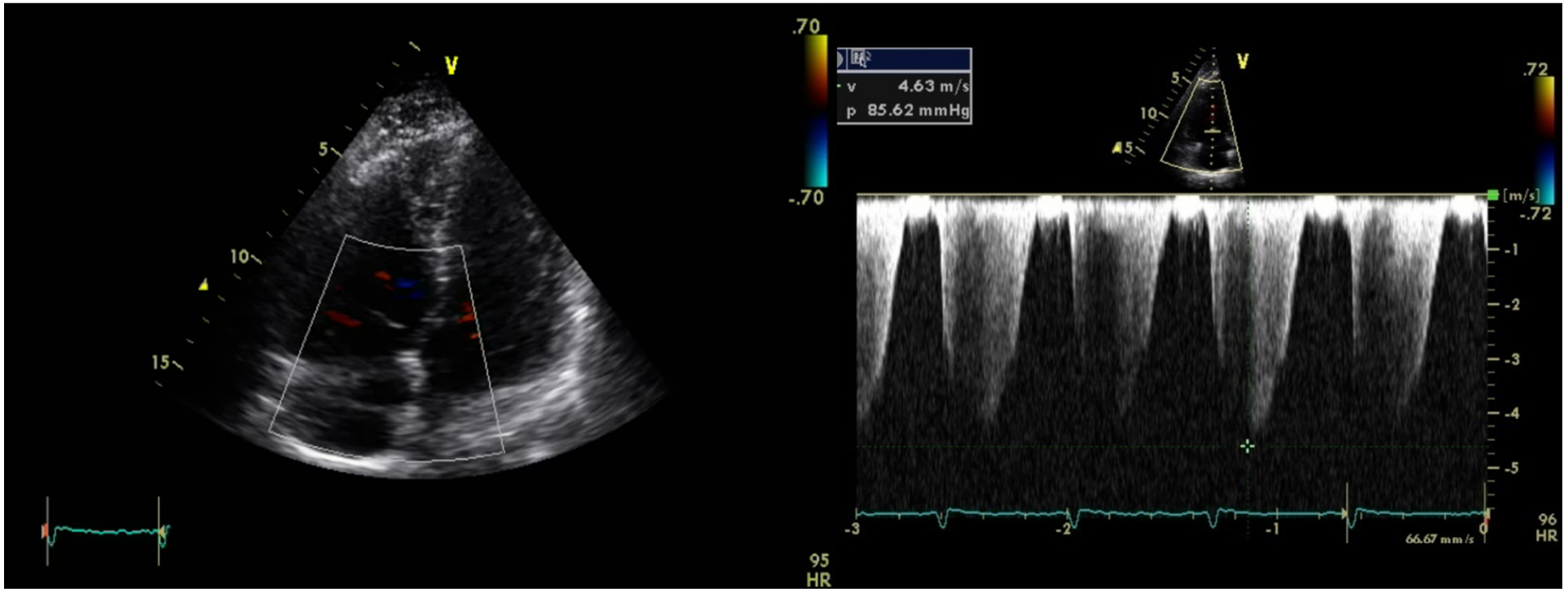
Abnormal Septal Motion



No inspiratory collapse of IVC



Increased TR Vmax



TR Vmax=4.6m/s

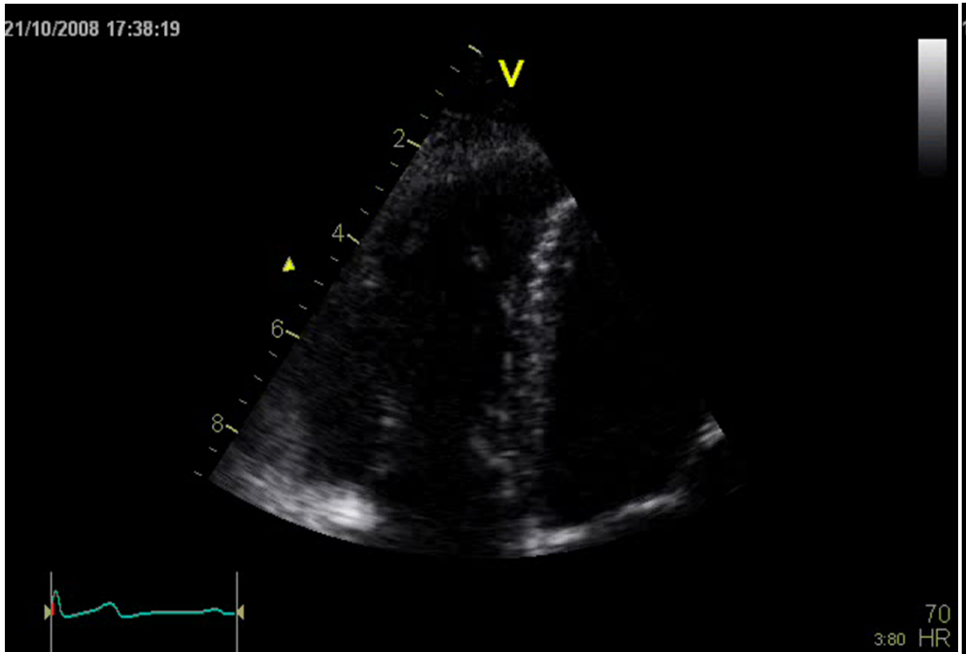
Roles of EchoCG in PTE

- **Two major roles of EchoCG in PTE**
  - Evaluation of RV function
  - Assessment of pulmonary hemodynamics

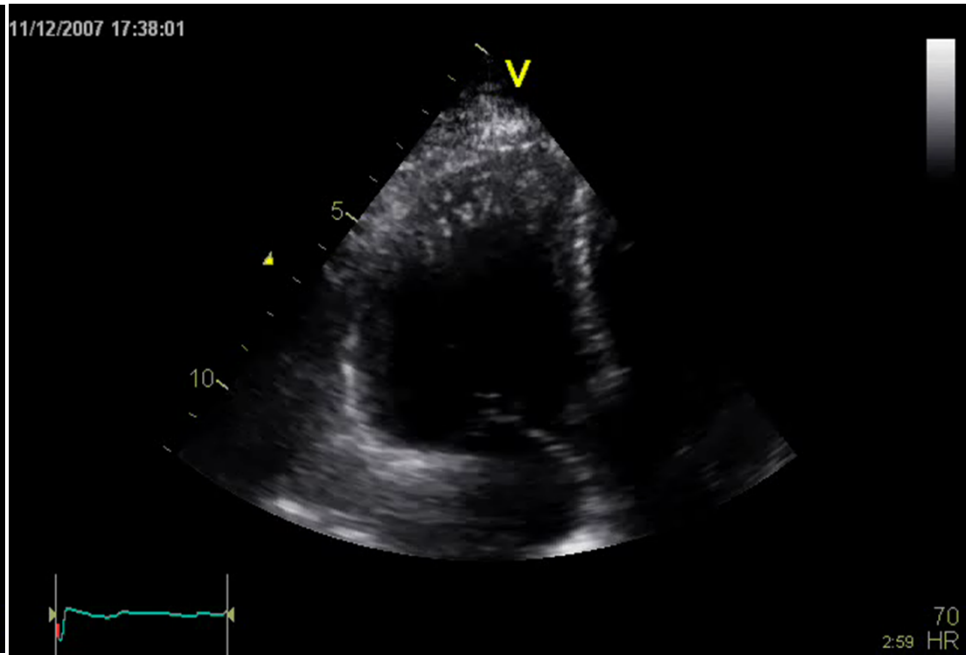
- **Evaluation of RV Function**

Evaluation RV Function

- See, just see!

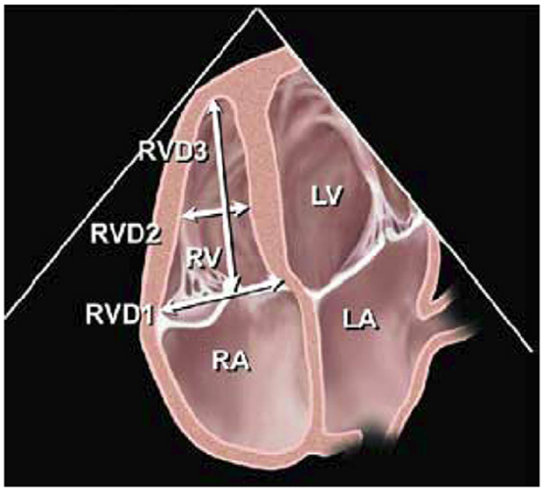


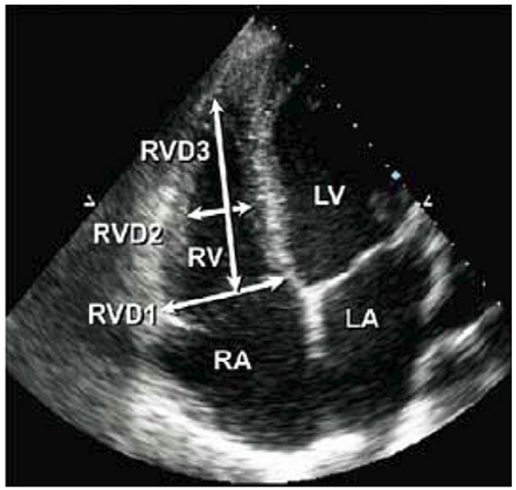
Normal

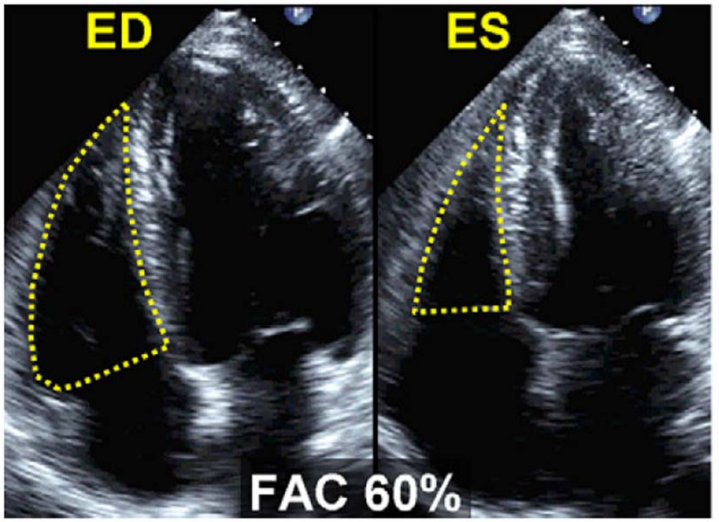


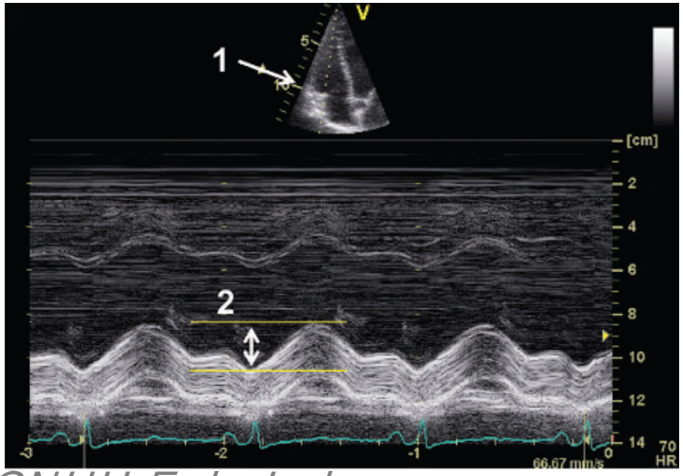
RV Dysfunction

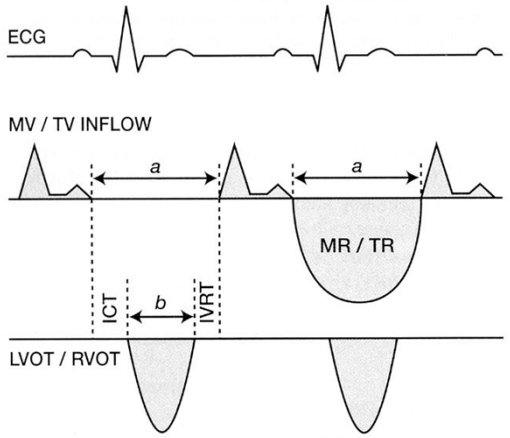
Evaluation of RV Function











CNUH EchoLab

Modified table from Rudski et al. JASE 2010;23:685

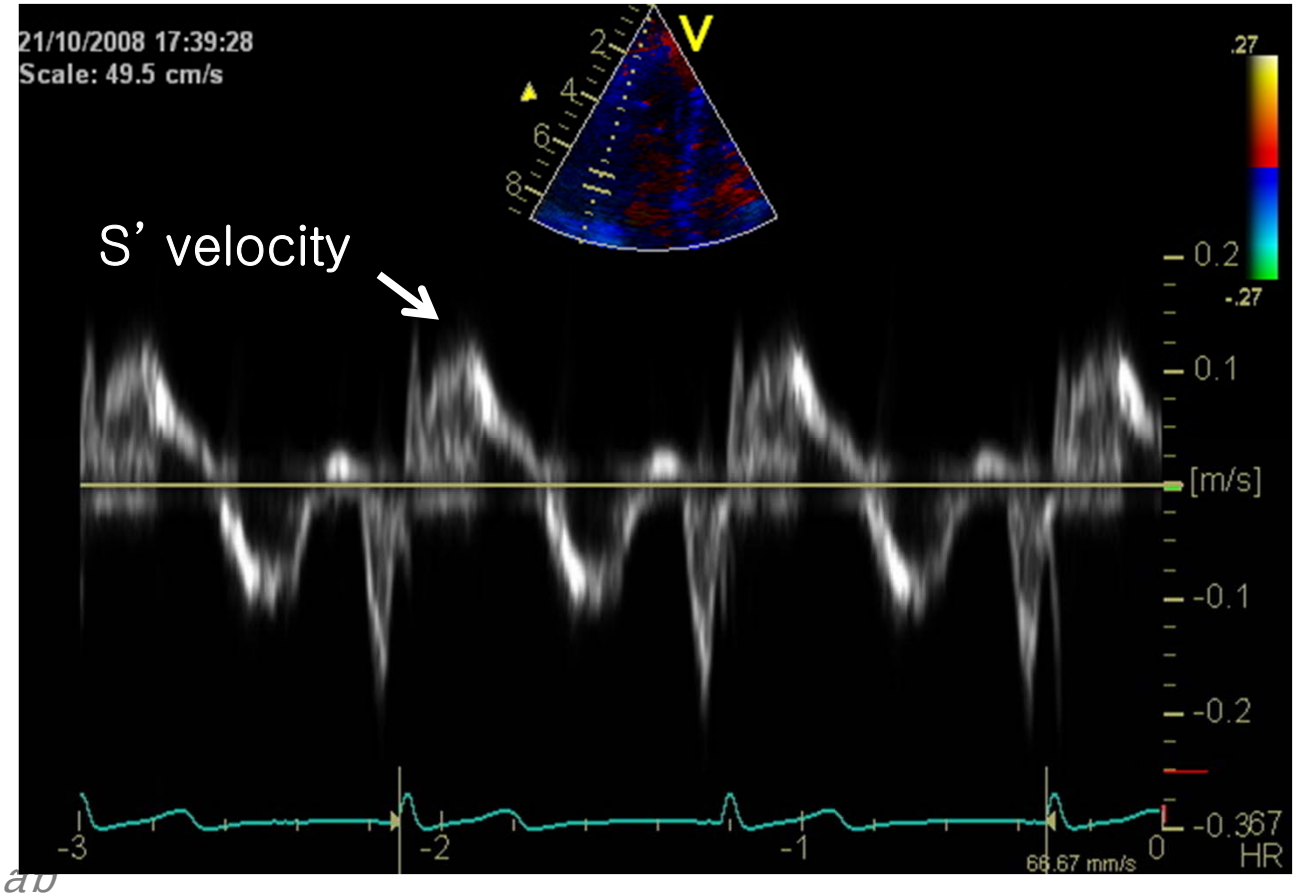
Evaluation of RV Function

Variables	Normal value	Abnormal value
Chamber dimensions		
RV basal diameter	3.3cm (2.4~4.2 cm)	>4.2cm
RV mid diameter	2.8cm (2.0~3.5cm)	>3.5cm
RV longitudinal diameter	7.1cm (5.6~8.6cm)	>8.6cm
Systolic function		
TAPSE	2.3cm (1.6~3.0cm)	<1.6cm
PW MPI	0.28 (0.15~0.40)	>0.40
FAC	49% (35~63%)	<35%

Modified table from Rudski et al. JASE 2010;23:685

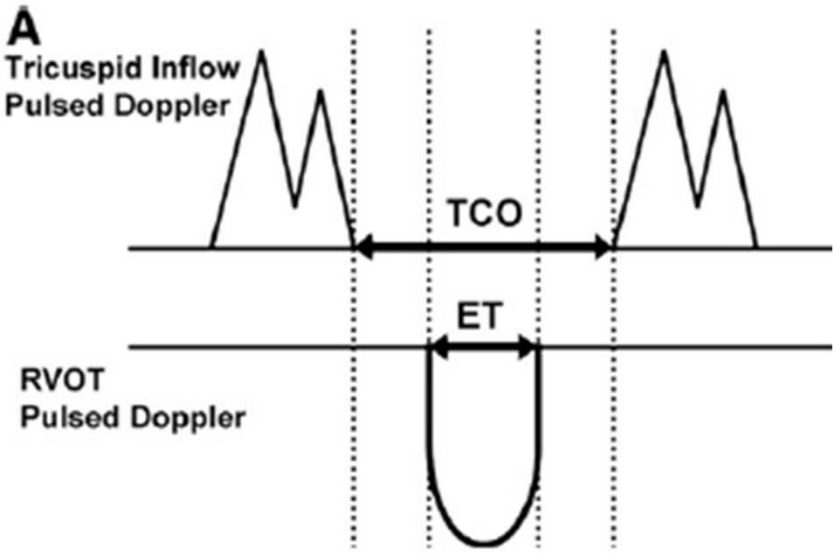
Evaluation of RV Function: TDI

- Tricuspid annular velocity

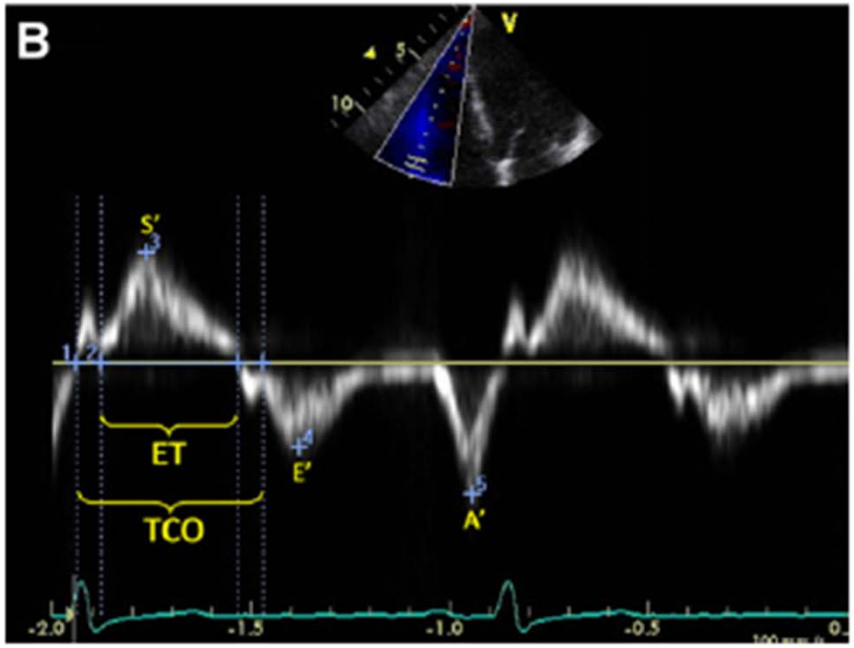


Evaluation of RV Function:
RV Tei Index

Traditional Method



TDI Method



Modified table from Rudski et al. JASE 2010;23:685

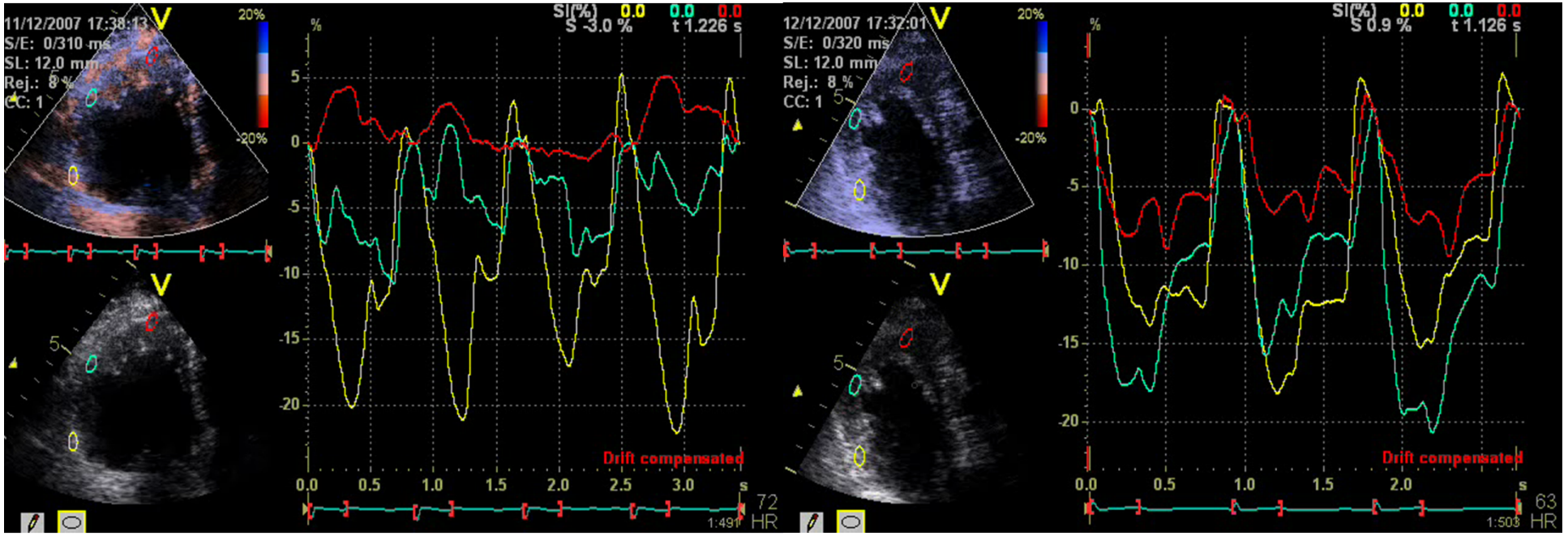
New Evaluation Methods

Variables	Normal value	Abnormal value
Systolic function		
PW annulus peak velocity	15cm/s (10~19cm/s)	<10cm/s
PW MPI	0.28 (0.15~0.40)	>0.40
Tissue Doppler MPI	0.39 (0.24~0.55)	>0.55

Modified table from Rudski et al. JASE 2010;23:685

Evaluation of RV Function: TDI

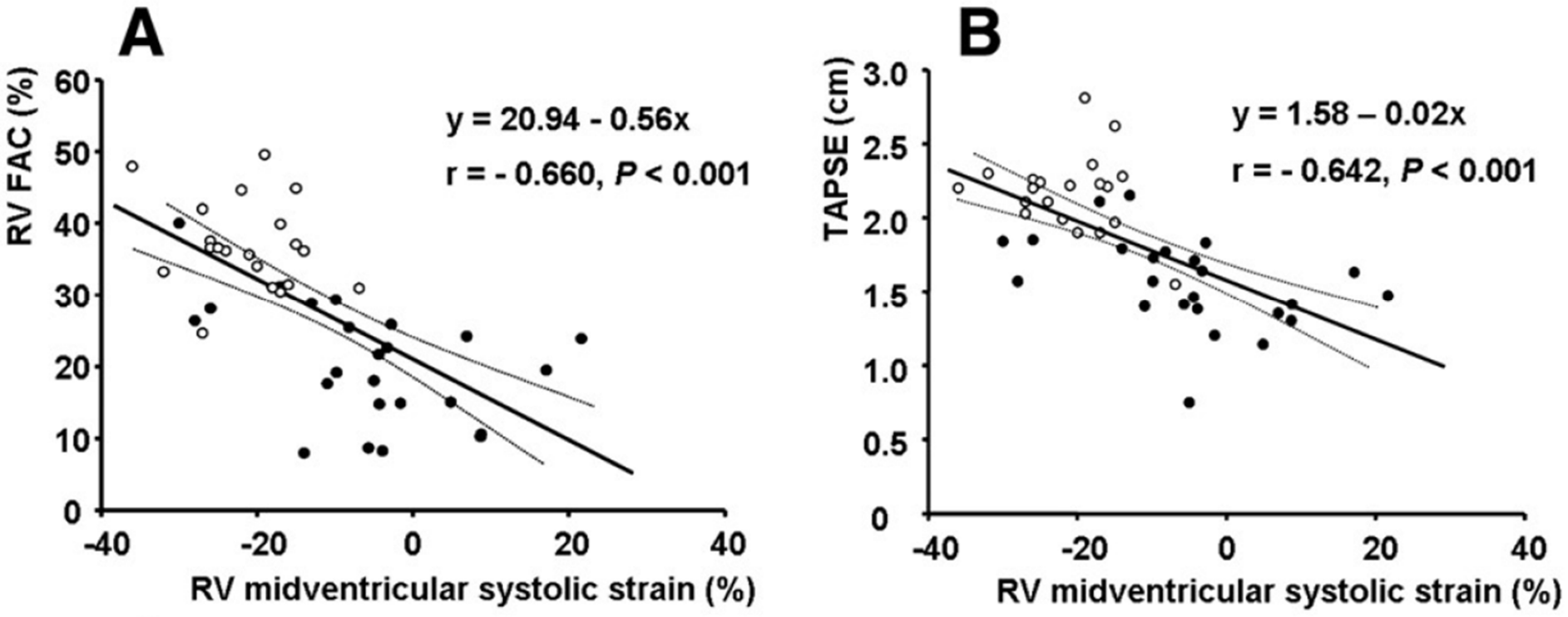
- Tissue Doppler imaging in acute PTE



Baseline

1 day after

Evaluation of RV Function: TDI

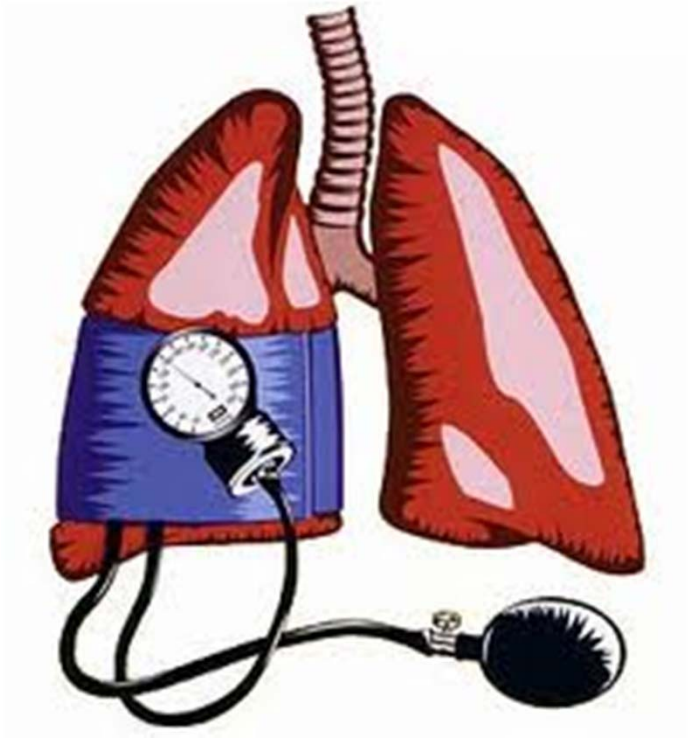


Park JH, et al. Int J Cardiol 2008;125:319

- **Assessment of Pulmonary Hemodynamics**

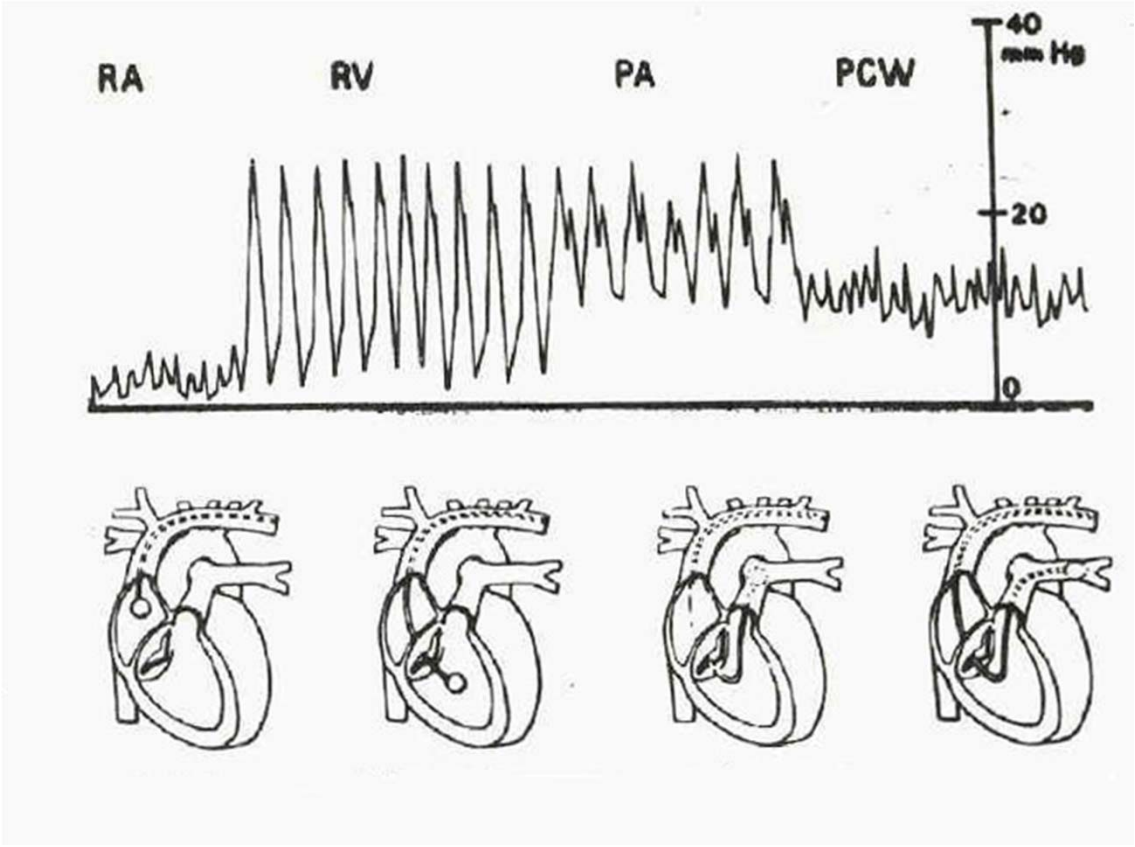
Pulmonary Arterial Pressure

Systemic arterial pressure



Pulmonary arterial pressure

Right Heart Catheterization



- Invasive
- Characteristic intercardiac pressure waveforms

EchoCG Measurement of PASP

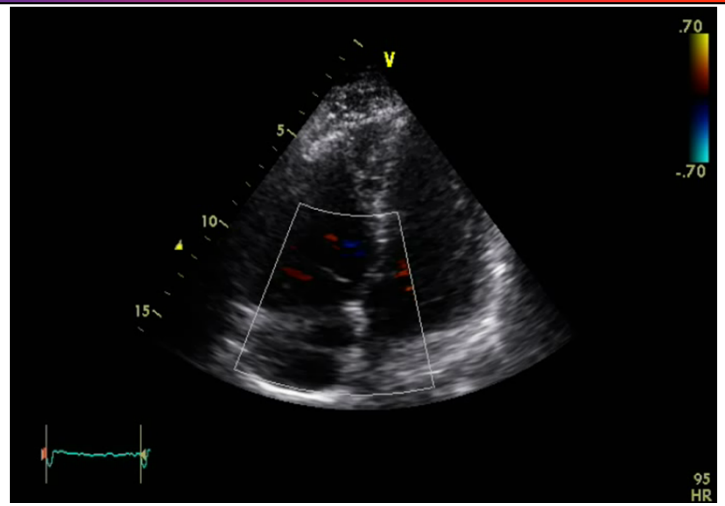
- **EchoCG method**
  - Non-invasive
  - Usually use TR Vmax and modified Bernoulli equation

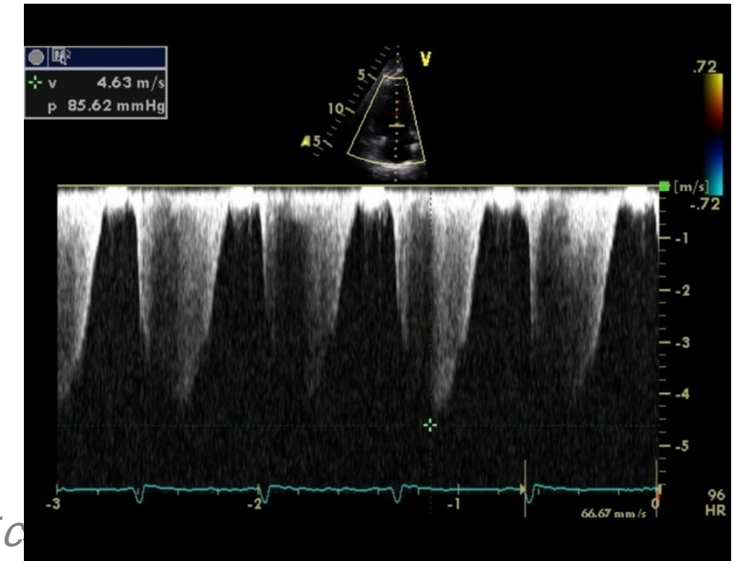
    ($\Delta Pr = 4\ TR\ Vmax^2$)

EchoCG Measurement of PASP

- **Assessment of pulmonary hemodynamics with EchoCG**
  - Gives clues in the initial diagnosis
  - Monitor the severity of PTE and response of the therapy.

Estimation of RVSP/ PASP





- RVSP = RAP+4TRVmax^2
- PASP ≒ RVSP

(if no RVOT obstruction or PV stenosis)

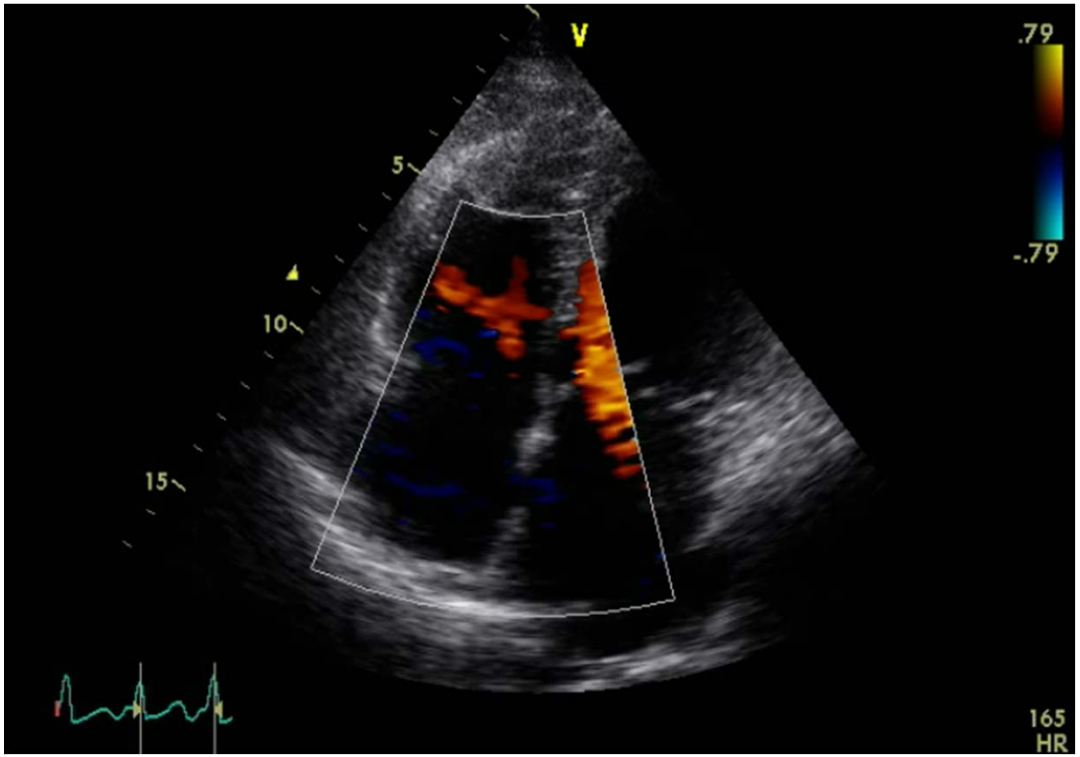
Consideration in Measuring TR Vmax

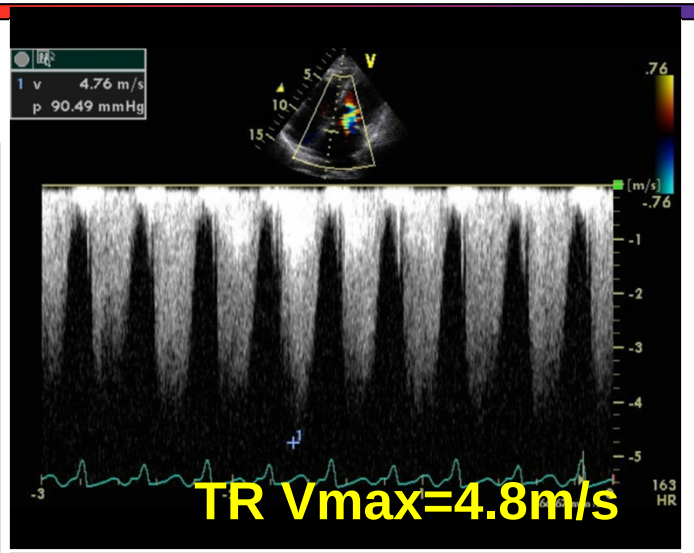
- Normal adult population: TR >75% (trivial)
  - Normal TR Vmax = 1.7~2.3m/s at rest
    - Higher in athletes and during exercise
  - Higher TR Vmax in Pul HT, RVOT obstruction, PS
  - Lower TR Vmax in RV infarct, RV failure, severe TR

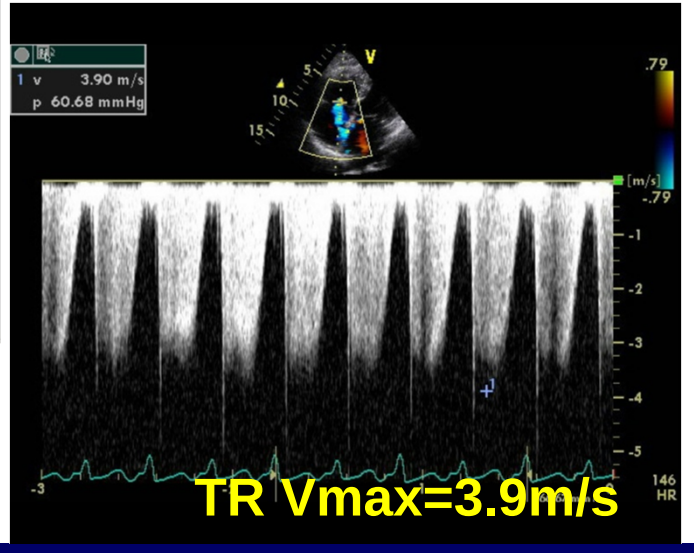
Technical Caveats

- To avoid respiratory variation, TR Vmax is obtained with a patient in held-expiration
- AS or MR often mimic TR
- As TR Vmax increases, greater potential of miscalculation of PASP
- Avoid too high Doppler gain that can cause overestimation of TR Vmax

Technical Caveats: Eccentric MR







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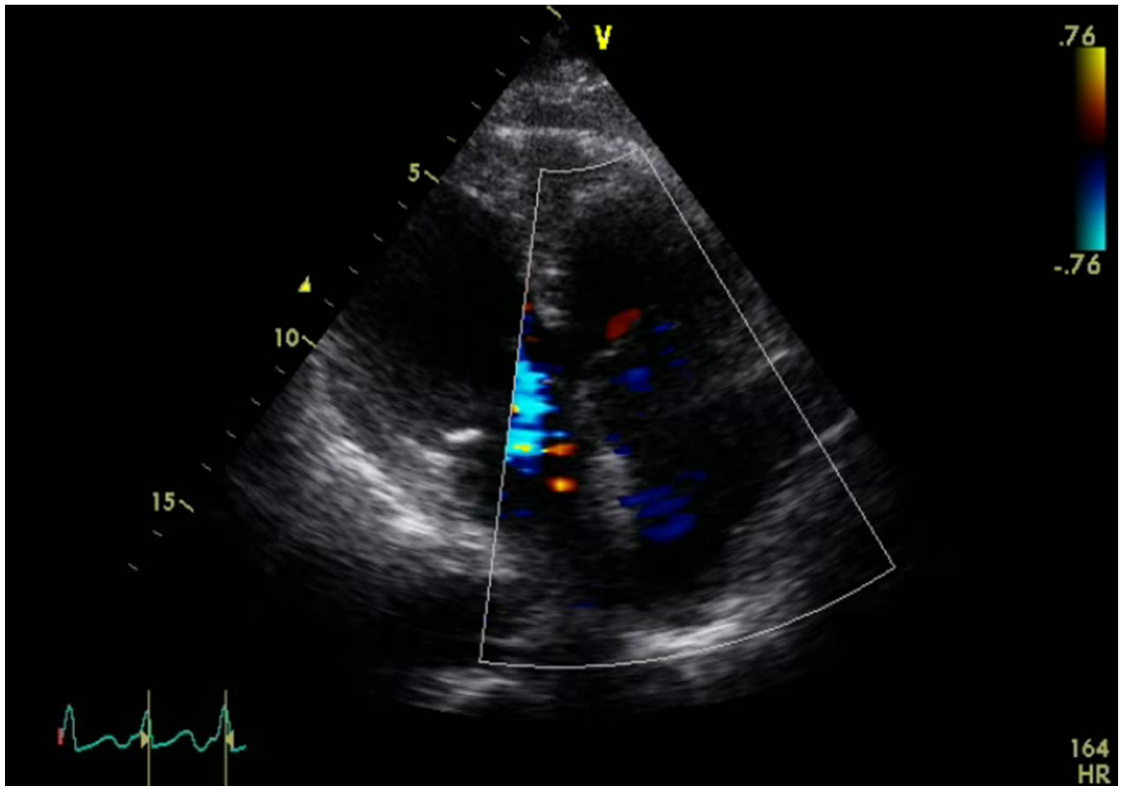
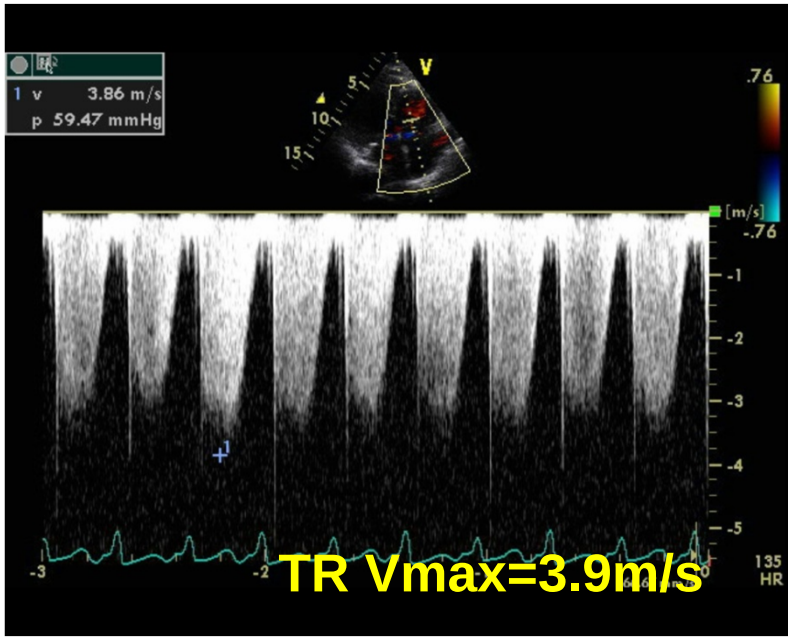
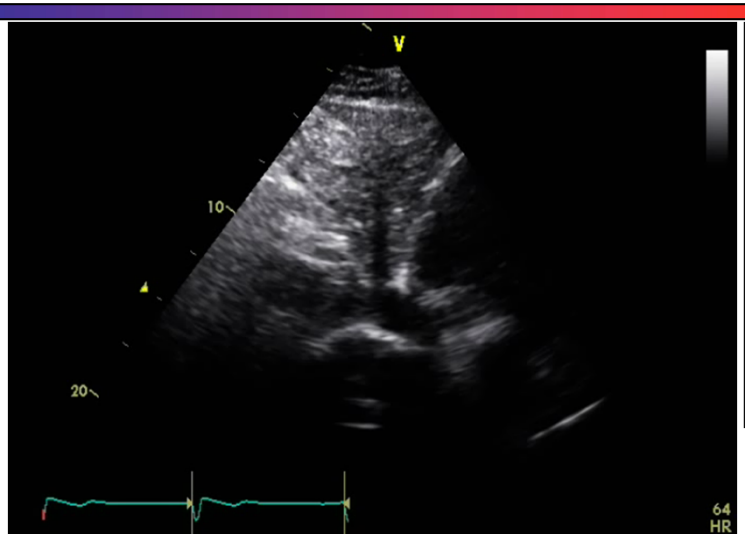
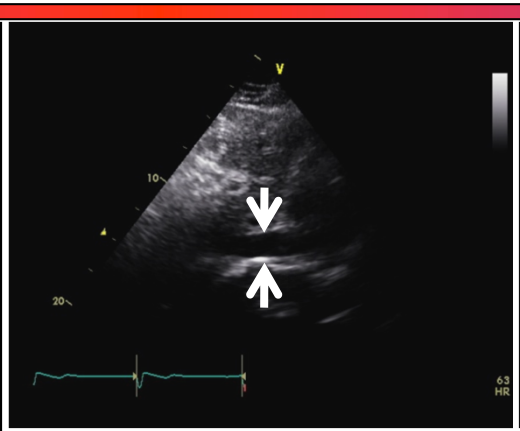
Technical Caveats: Eccentric MR





Estimation of RA Pressure





Expiration

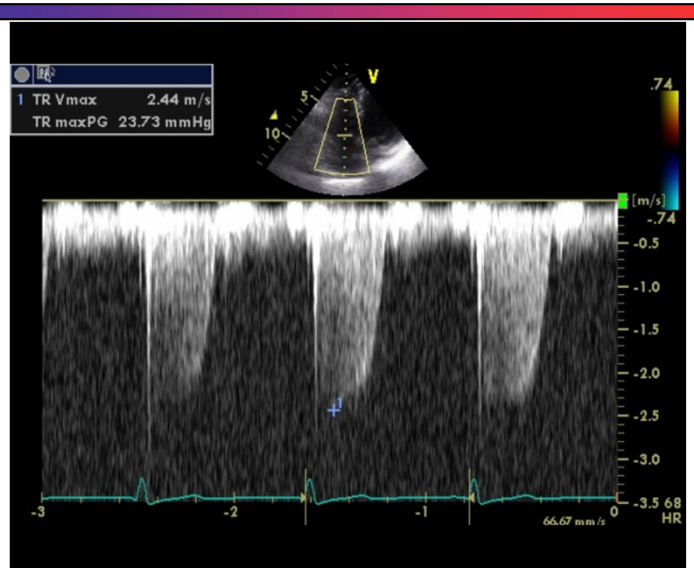
Inspiration

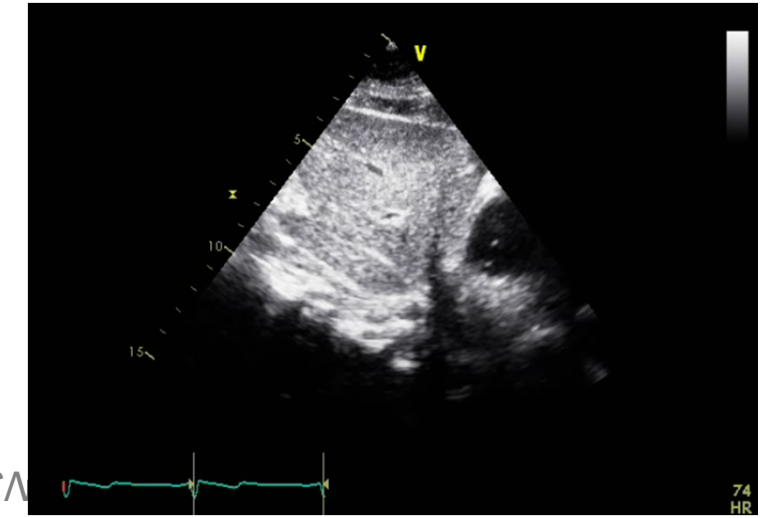
IVC size (cm)	Collapse (%)	RAP (mmHg)
<1.5	≥50	0-5
1.5~2.5	≥50	5-10
1.5~2.5	<50	10-15
>2.5	<50	15-20
>2.5	0	>20

CNUH EchoLab

Otto CM. Textbook of Clinical Echocardiography. 3rd Ed 2004, p157

For Example

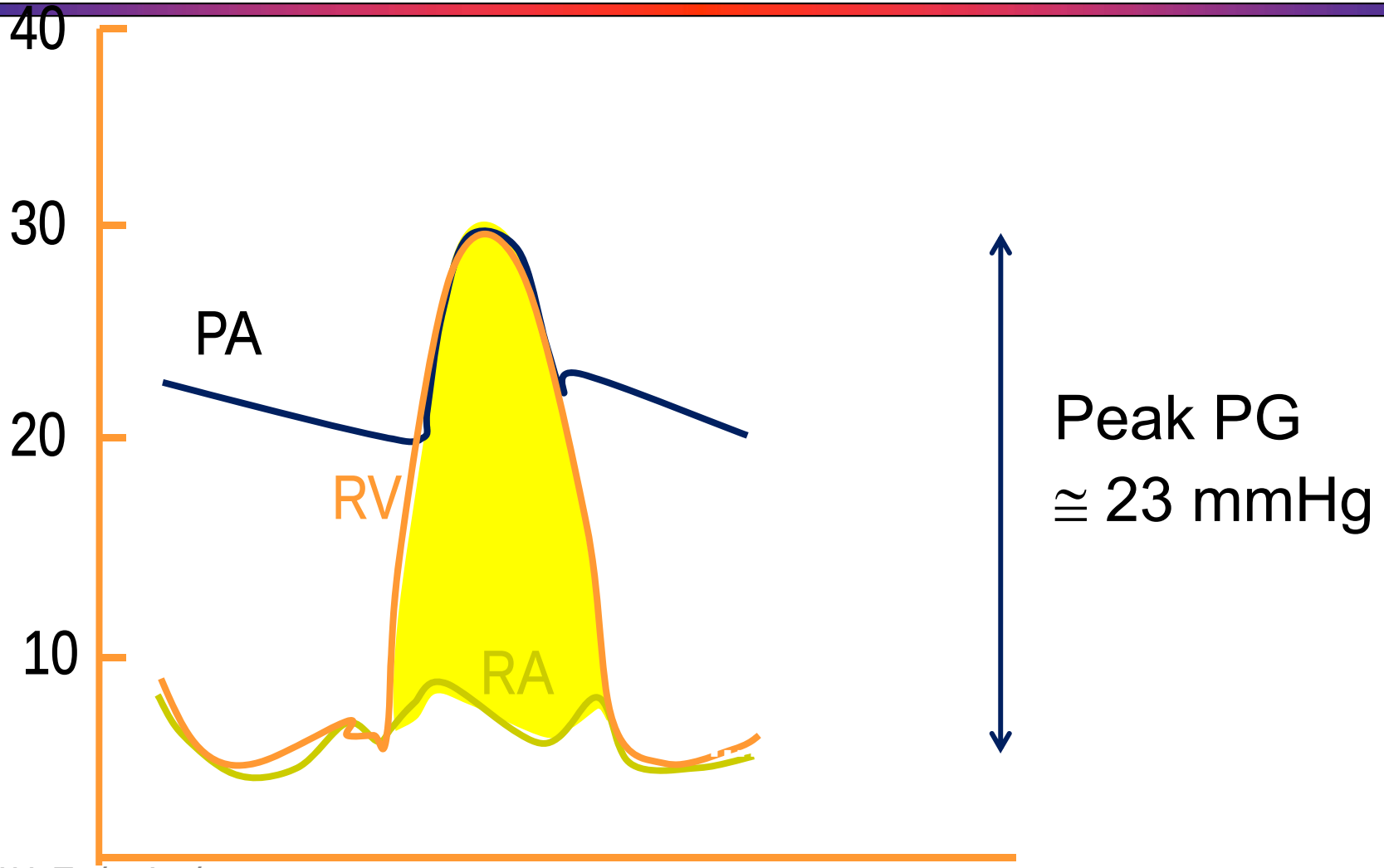




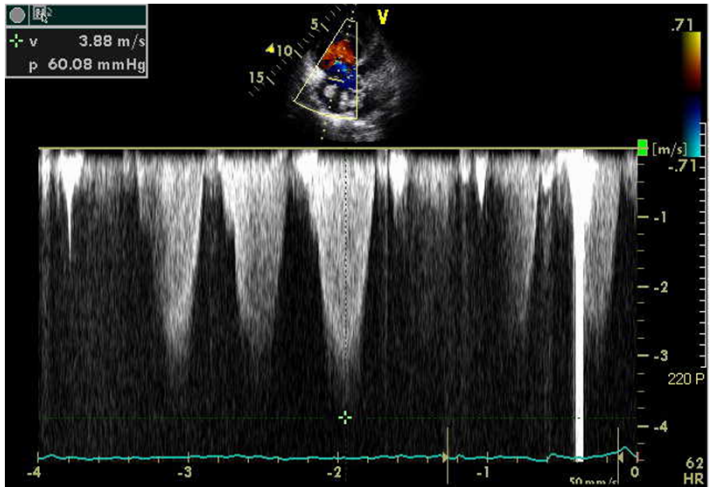
- TR Vmax=2.4m/sec
- Not dilated IVC with collapse >50%
- $\Delta Pr = 4\ (2.4)^2$

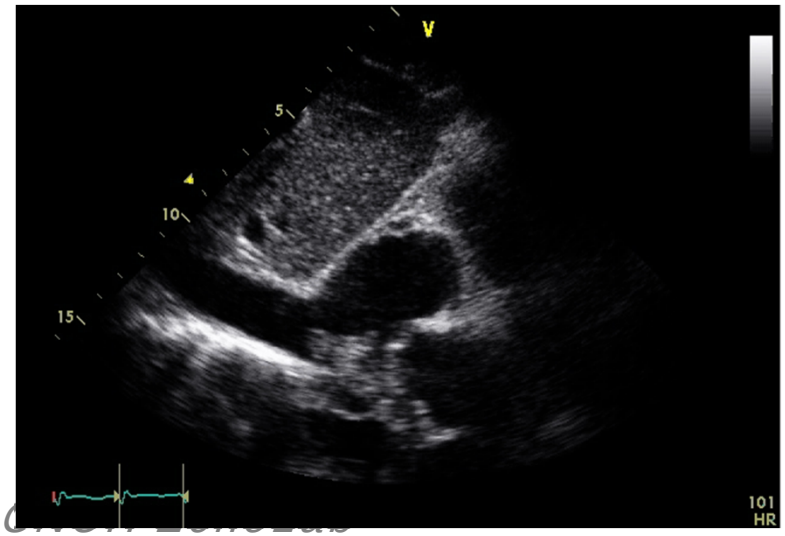
  $= 23mmHg$
- Estimated RAP = 5mmHg
- RVSP = 28mmHg

For Example



For Example

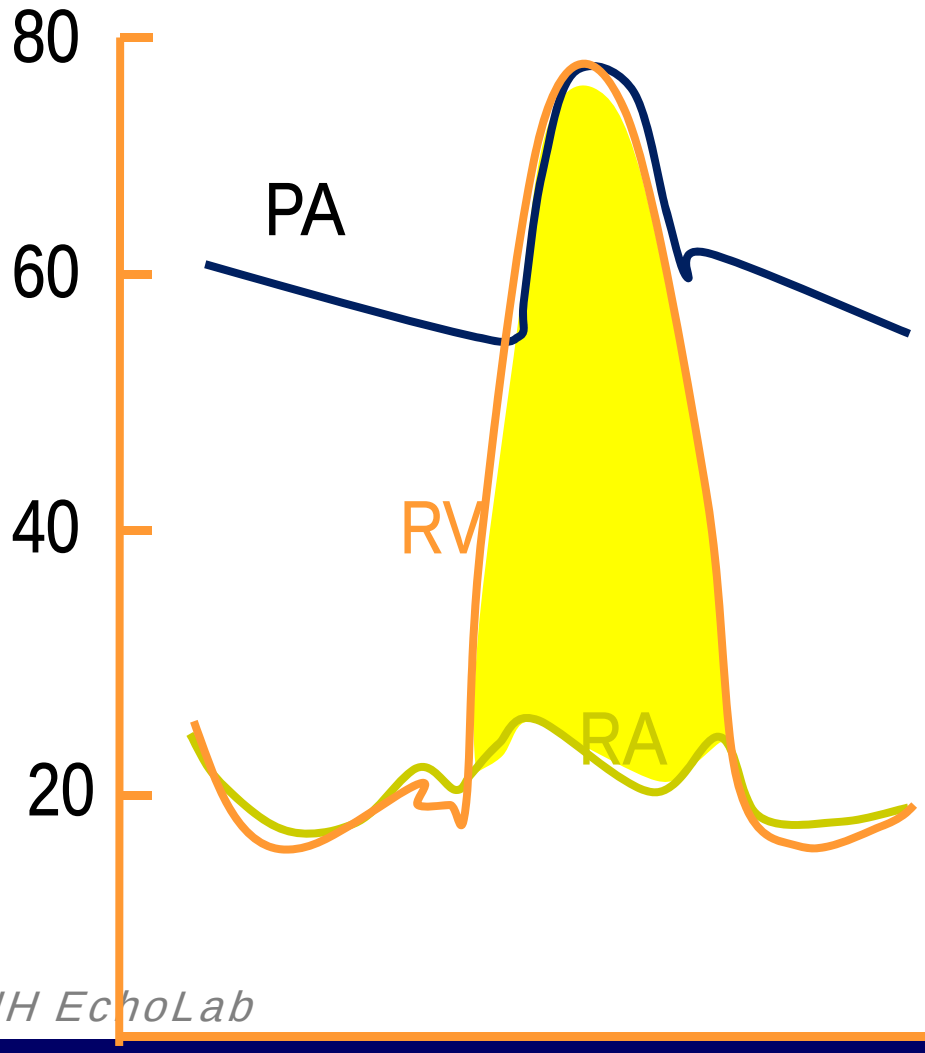




- TR Vmax=3.8m/sec
- Dilated IVC with collapse <50%
- $\Delta Pr = 4\ (3.8)^2$

  $= 60mmHg$
- Estimated RAP = 20mmHg
- RVSP = 80mmHg

For Example

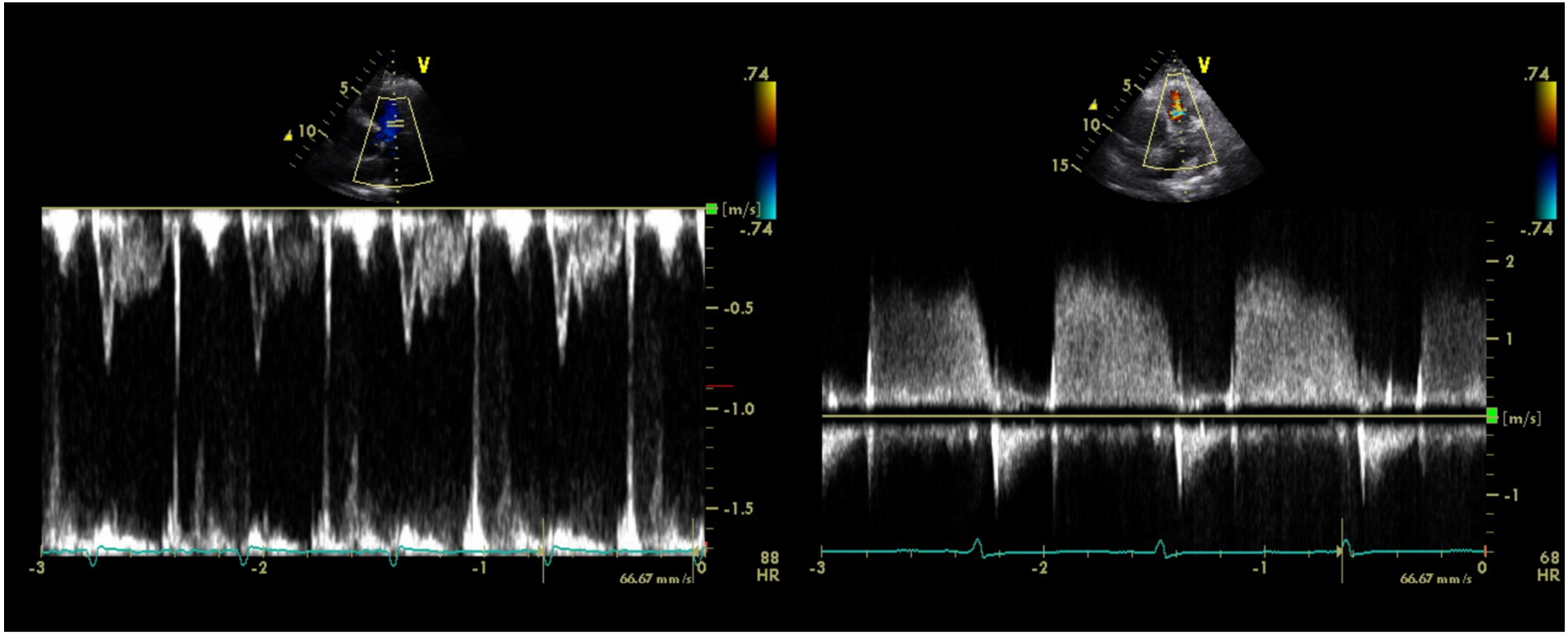


Peak PG
≅ 60 mmHg

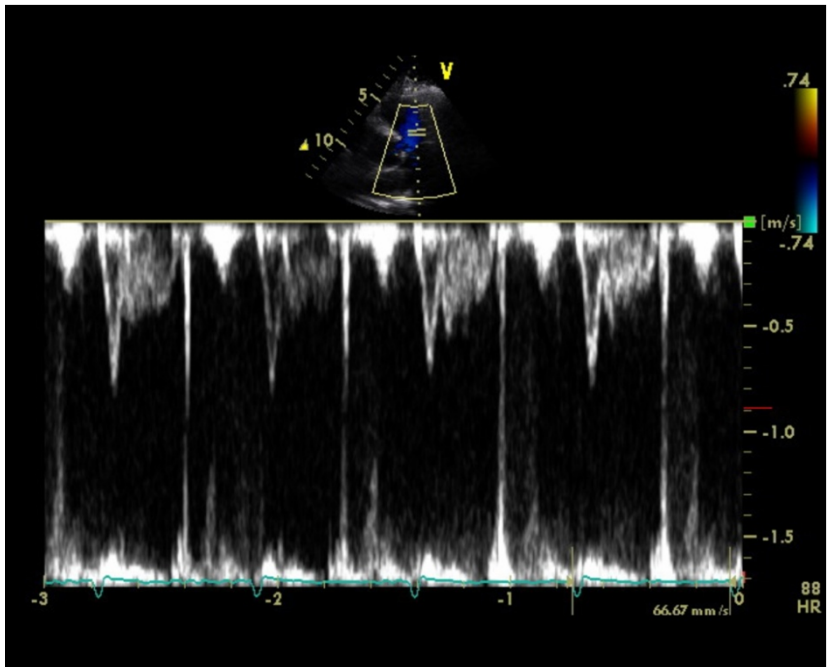
Other Methods

RVOT-PW Doppler

PR-CW Doppler

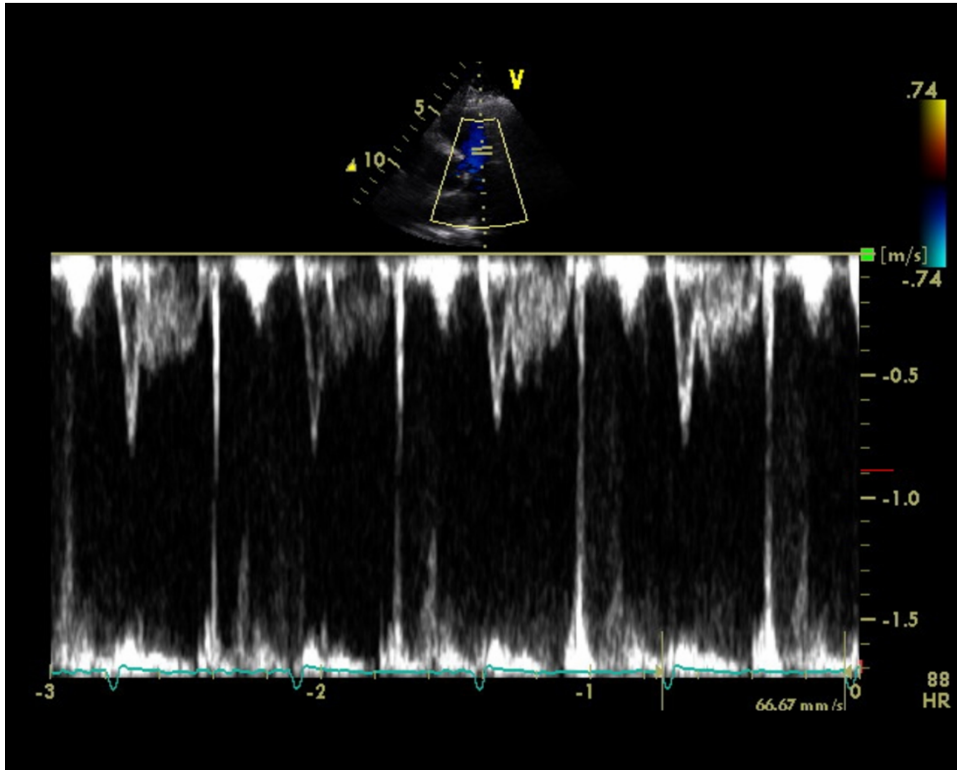


Estimation of Mean PAPr

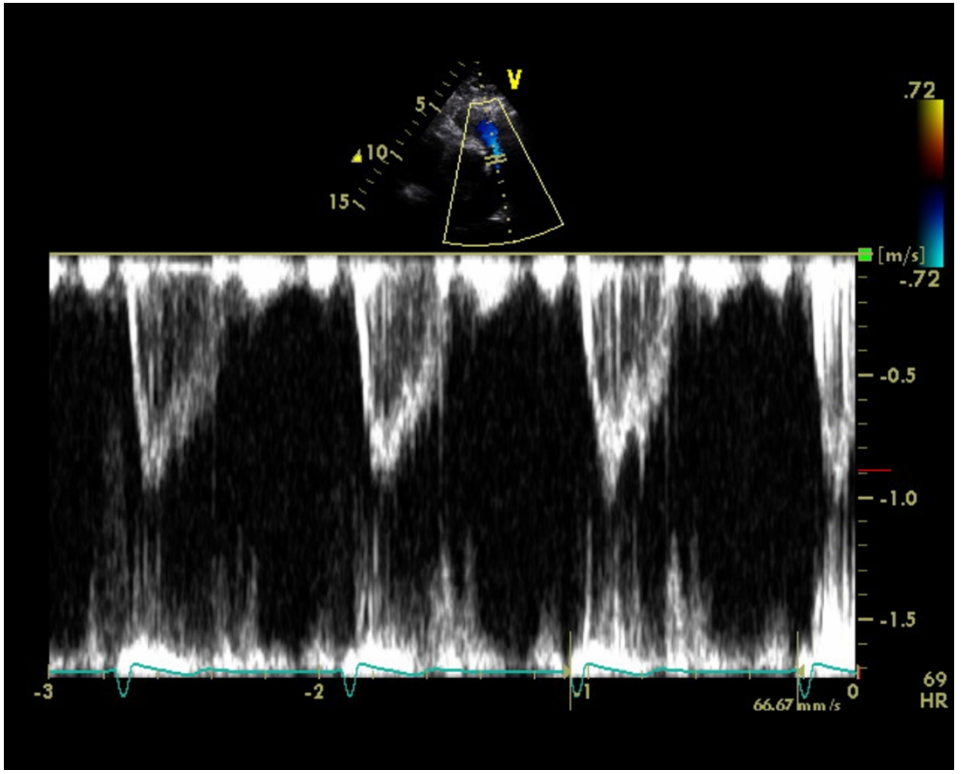


- Mahan's equation
  - mPAP=79-0.45xAct (msec)
- RVOT Doppler gives the clue
  - Notched pattern
  - Prox flow acceleration <100msec

Estimation of Mean PAPr

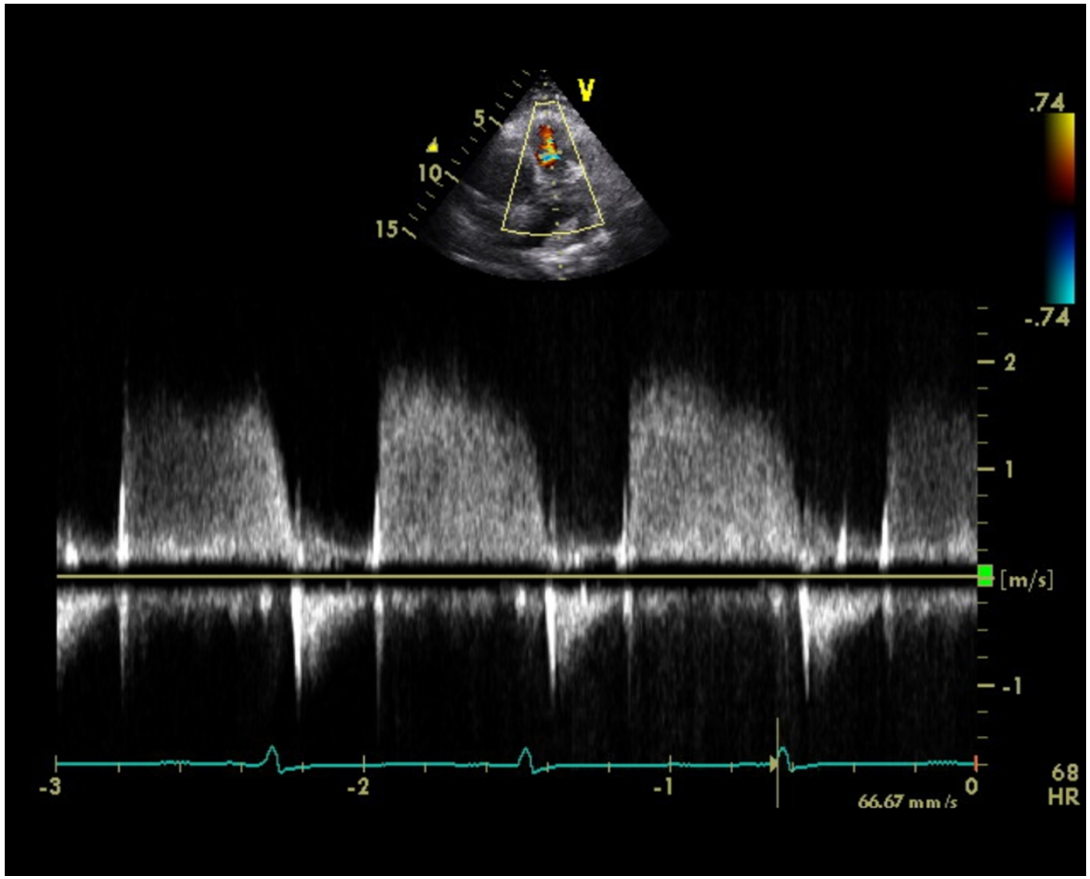


Baseline



Post-treatment

Estimation of PA End-diastolic Pr



- PAEDP=4 $PRed^2$ + RAP

Conclusion

- Evaluation of RV function and assessment of pulmonary hemodynamics are two major roles of EchoCG in patients with PTE

Conclusion

- Prompt evaluation of RV function can gives good prognostic information

- Assessment of pulmonary hemodynamics is used to monitor the severity of PTE and response of the therapy.

- Thank you for your attention!