Pulmonary Embolism: is Echo of Any Use?

Aleksandar N. Neskovic

Clinical Hospital Zemun
Belgrade University School of Medicine

Земунска болница 1784
Клиничко-болнички центар
ЗЕМУН
БЕОГРАД

Наставна база
Медицинског факултета
у Београду

Important Facts on PE

- High morbidity
- Mortality is (still) high
- Low detection rate before death
- Frequent overdiagnosis & overtreatment
- Aggressive therapy required

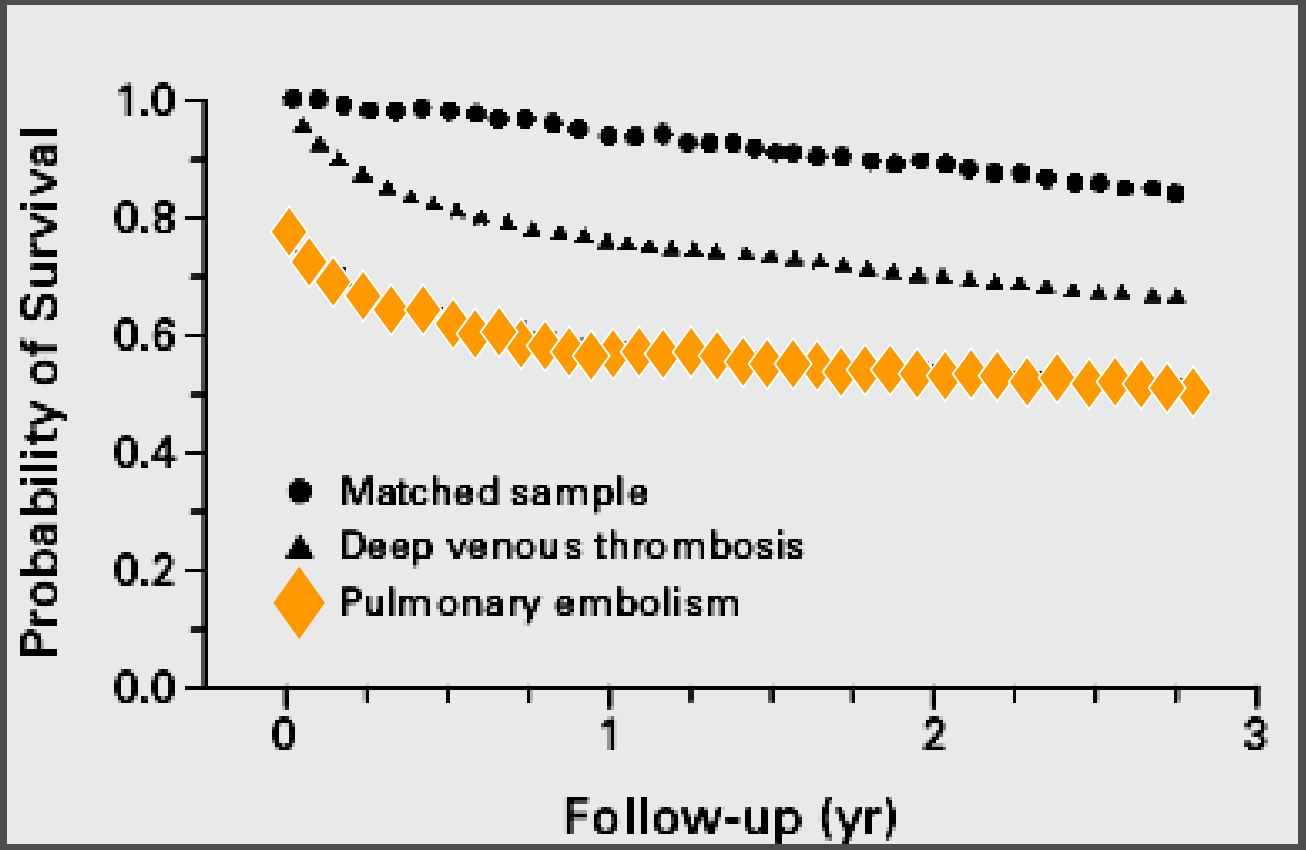
Incidence of PE

	Annual estimated rate
• USA	600 000
• France	100 000
• England and Wales	65 000
• Italy	60 000

Dalen JE et al. Prog Cardiovasc Dis 1975
ESC Guidelines, Eur Heart J 2000

Survival of Pts with Pulmonary Embolism

- *Medicare enrollees with DVT and PE*
- *Enrolles matched for age, sex and race*



Kniffin WD Jr et al, Arch Intern Med 1994

Important Facts on PE

- Prevalence of PE at autopsy is 12-15%
  - ✓*unchanged during last 30 yrs*
- Numerous cases unrecognized/untreated
- Mortality if untreated is ~30%
  - ✓*could be reduced to 2-8%*

ESC Gudielines, Eur Heart J 2000

Stein PD et al, CHEST 1995

Mortality Associated to Pulmonary Embolism Can Be Reduced !

- Majority of “preventable deaths” due to PE (range 27-68%) can be ascribed to missed Dg rather than existing therapies failure

Fedullo PF et al, NEJM 2003
Goldhaber SZ et al, Lancet 1999

Diagnostic Evaluation in Suspected PE

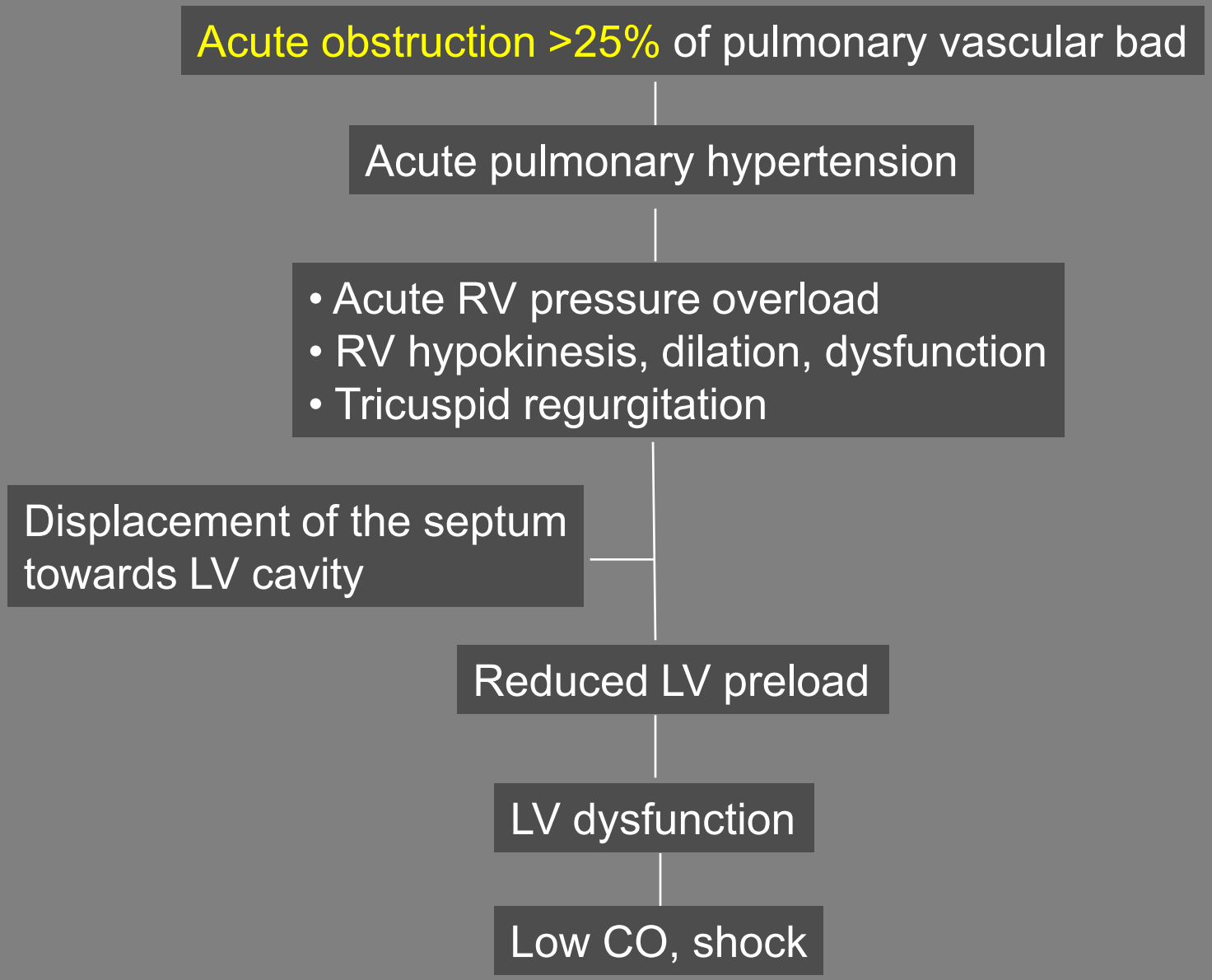
- D-dimer, BNP, troponin
- Chest x-ray, ECG
- V/P lung scan
- Spiral-CT
- Pulmonary angiography
- Angioscopy
- MSCT
- Duplex ultrasonography
- Echocardiography (TTE, TEE)

No single noninvasive diagnostic test is sensitive or specific enough!
Sequential diagnostic approach is necessary!

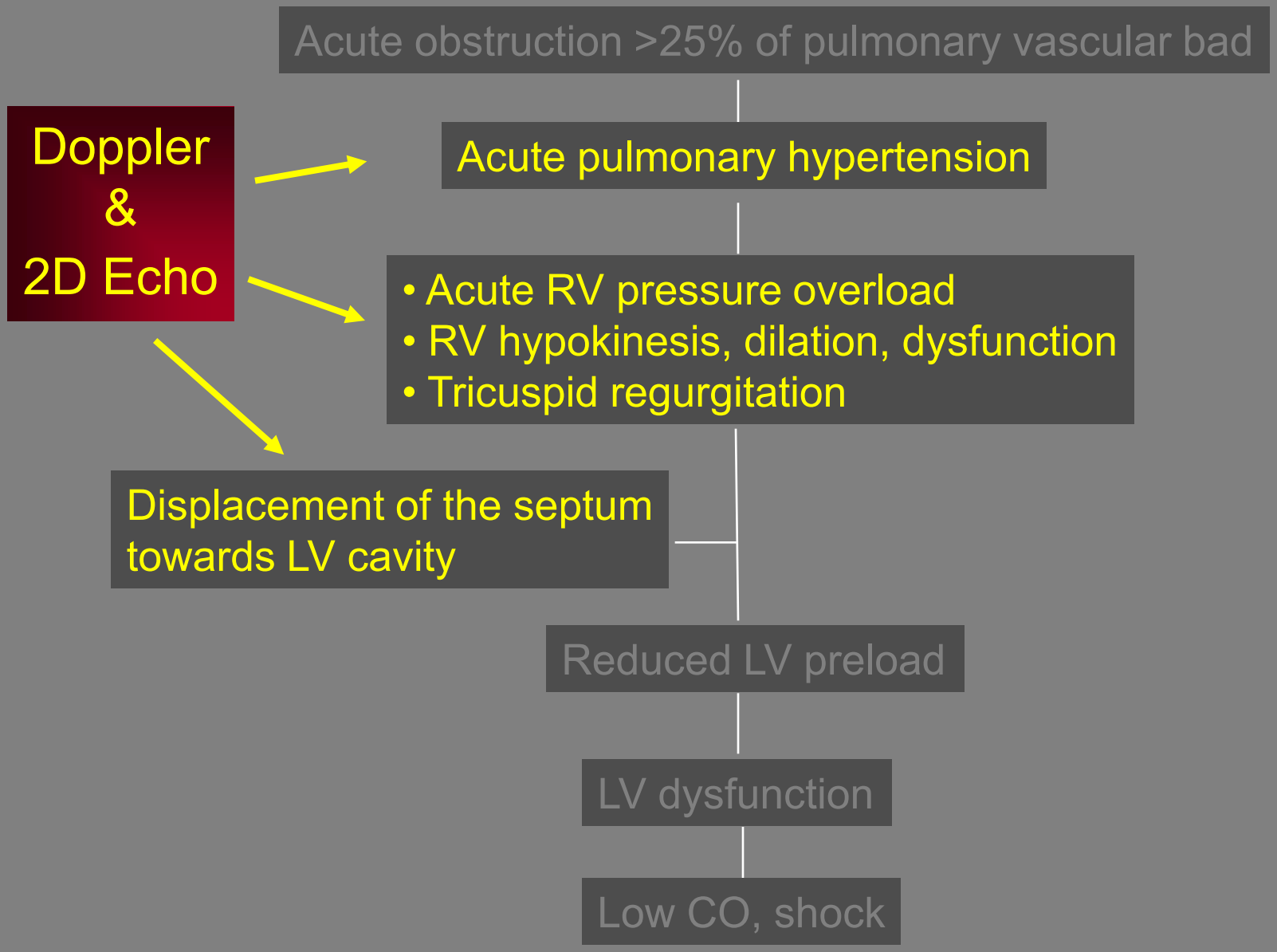
Rational for Echo in PE

- Pathophysiological responses to *increased pulmonary pressure* can be easily detected by echo (indirect signs)
- Rarely, direct visualization of *thrombus* in the right heart and/or PA is possible
- Noninvasive, available, portable

Pathophysiology of Acute PE



Pathophysiology of Acute PE



Role of Echo in Suspected PE

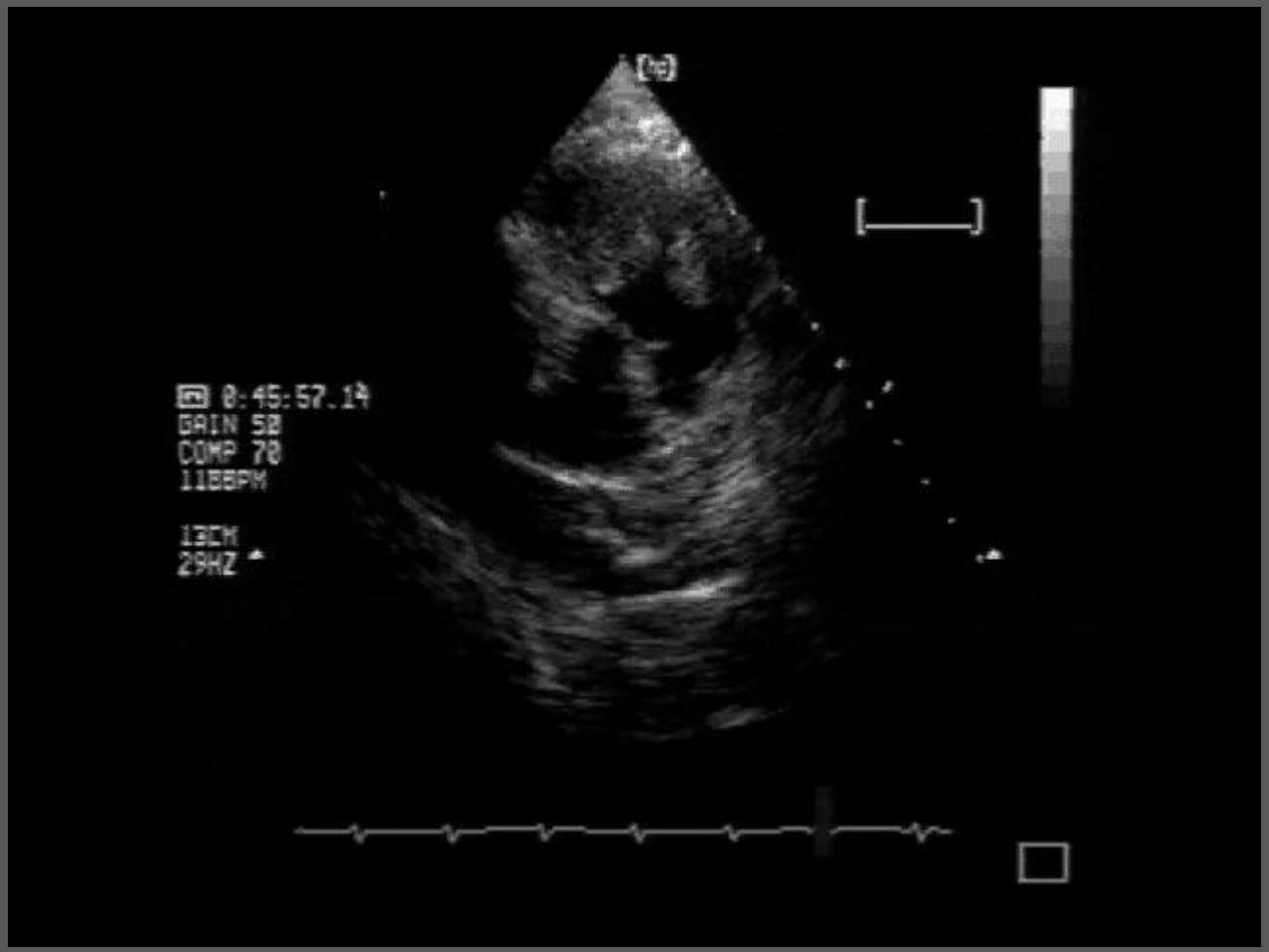
- Diagnosis
- Identification of high-risk pts
- Monitoring the effect of therapy
- Differential diagnosis

Echo Signs of PE

- RV dilatation/hypokinesis and subsequent TR
- RA dilation
- Dilation of PA and its branches
- Dilated (>20mm), non-collapsing (insp) IVC
- Flattened interventricular septum
- Decreased LV size
- Increased RV/LV end-diastolic diameter ratio
- TR jet >2.5 m/s (mild-moderate PA hypertension)
- RVOT mid-systolic “notching” pattern (AcT<80 ms, with mid-systolic deceler)

- Direct thrombus visualization in the right heart or PA

- *Direct sign of PE, thrombus in RVOT*

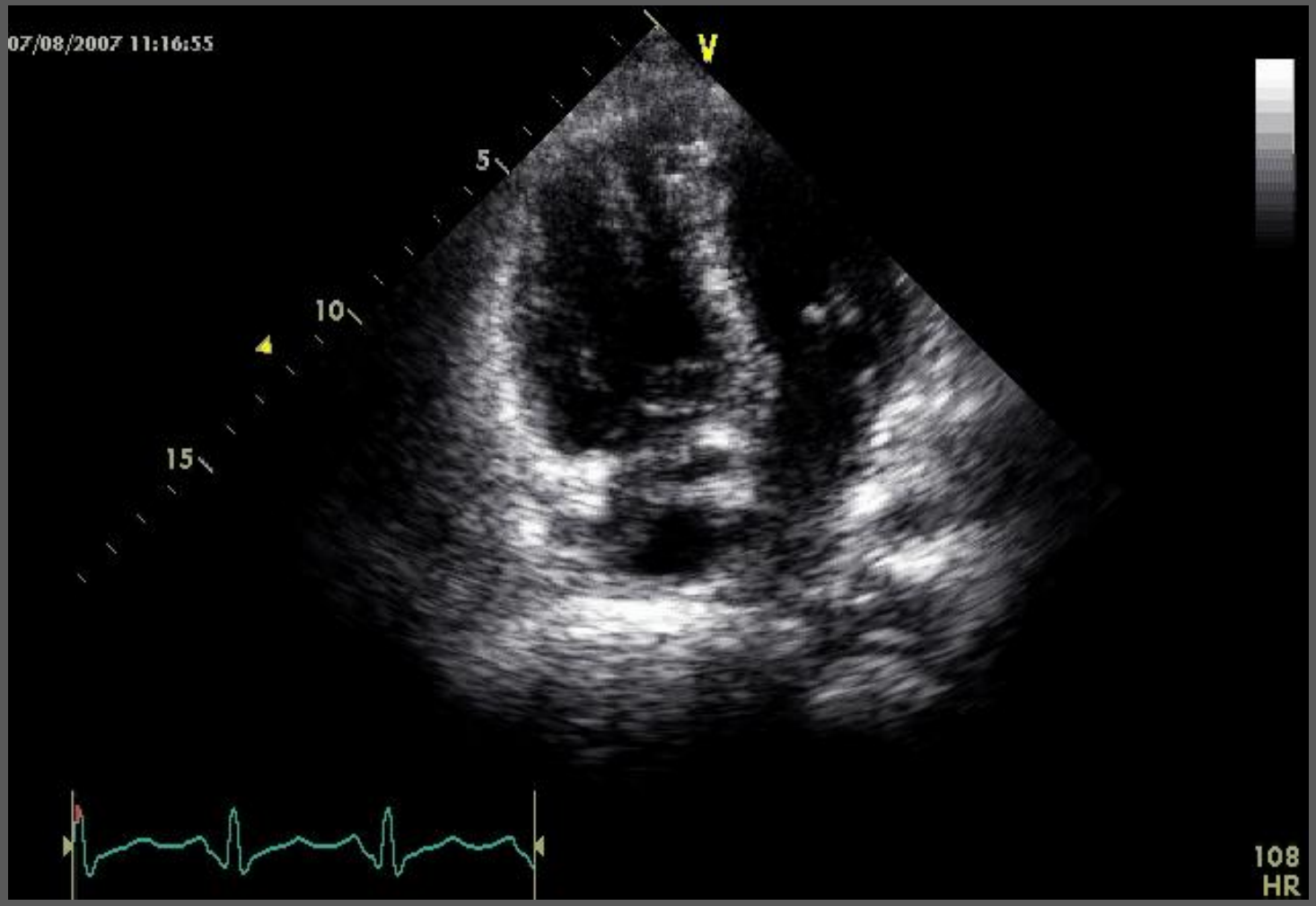


Only in 4% of pts in ICOPER*

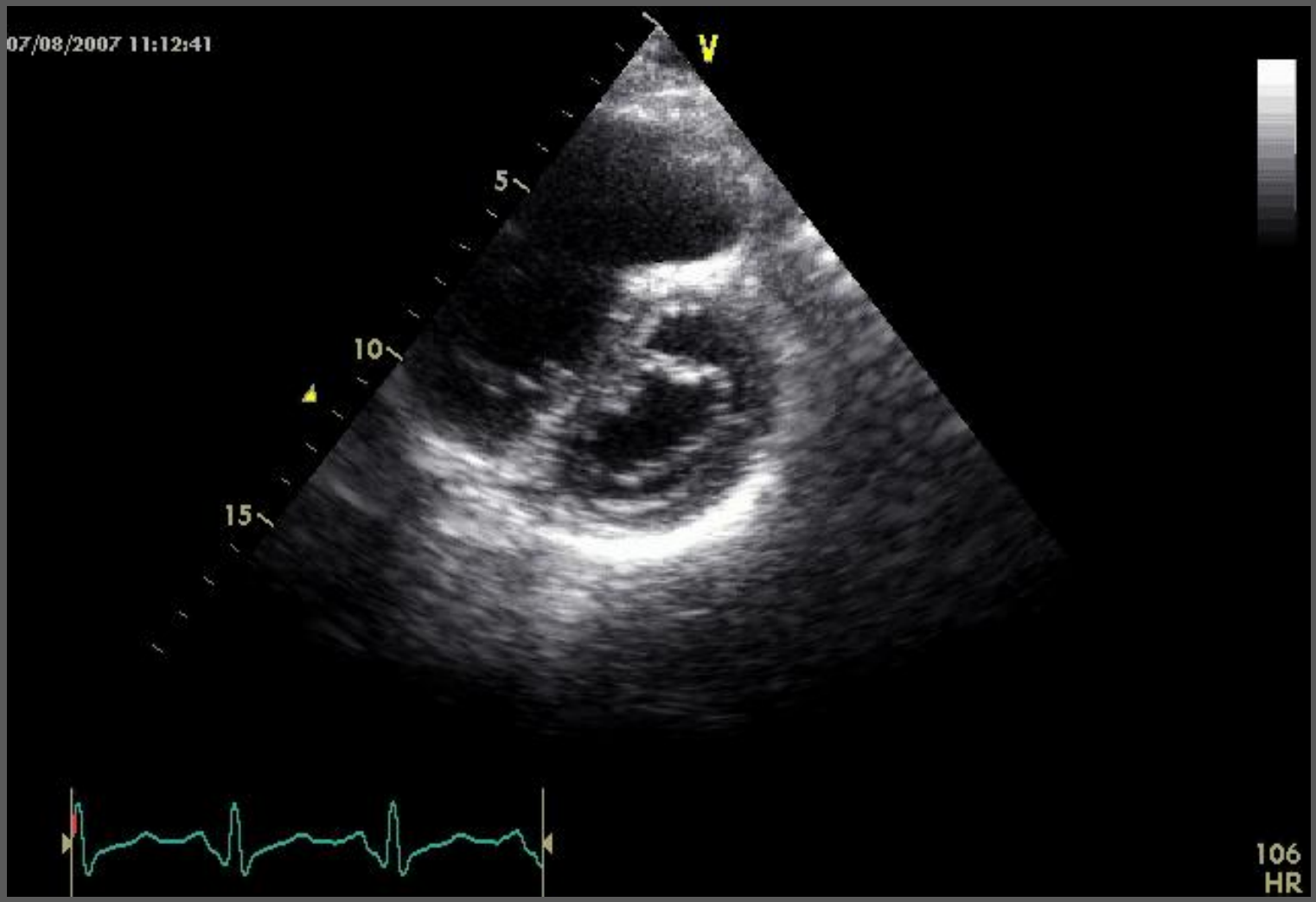
(International Cooperative Pulmonary Embolism Registry)

** Goldhaber SZ et al, Lancet 1999*

- *RV dilation / hypokinesis*
- *LV geometrical changes*



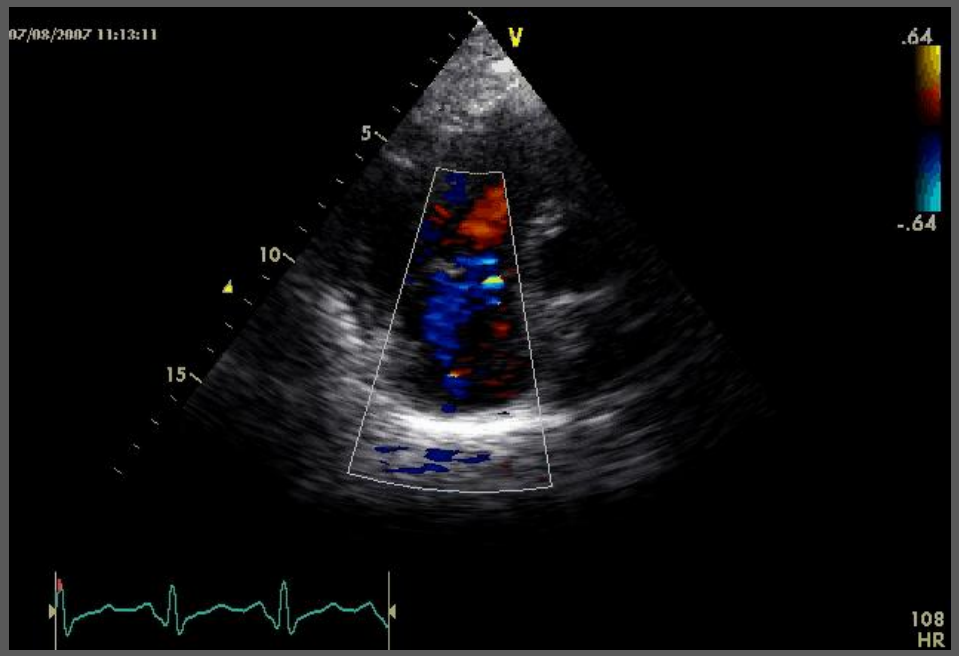
- *RV dilation / hypokinesis*
- *Flattened IVS*

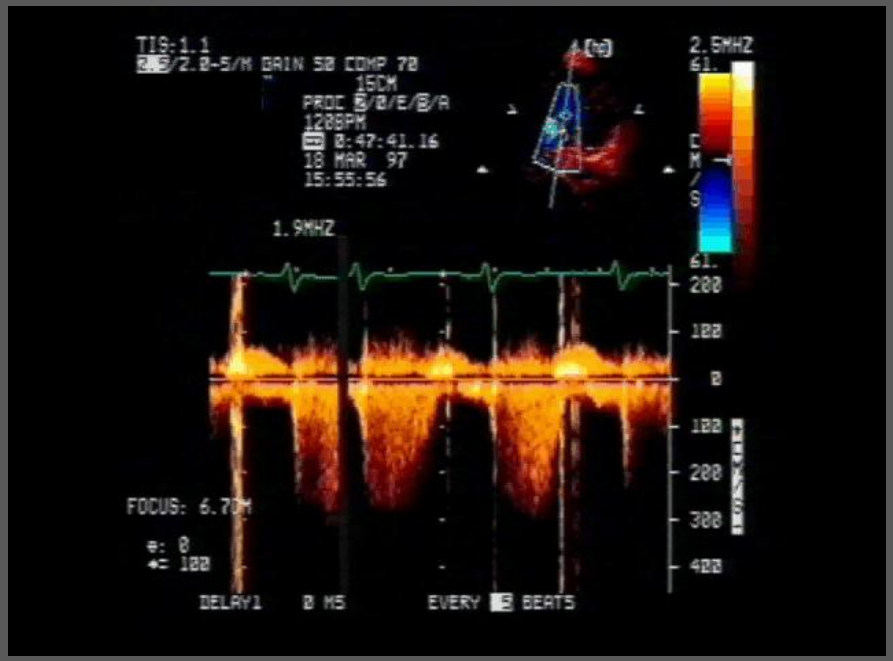


- *Acute pulmonary hypertension*

  TV systolic gradient typically ≤ 60 mmHg

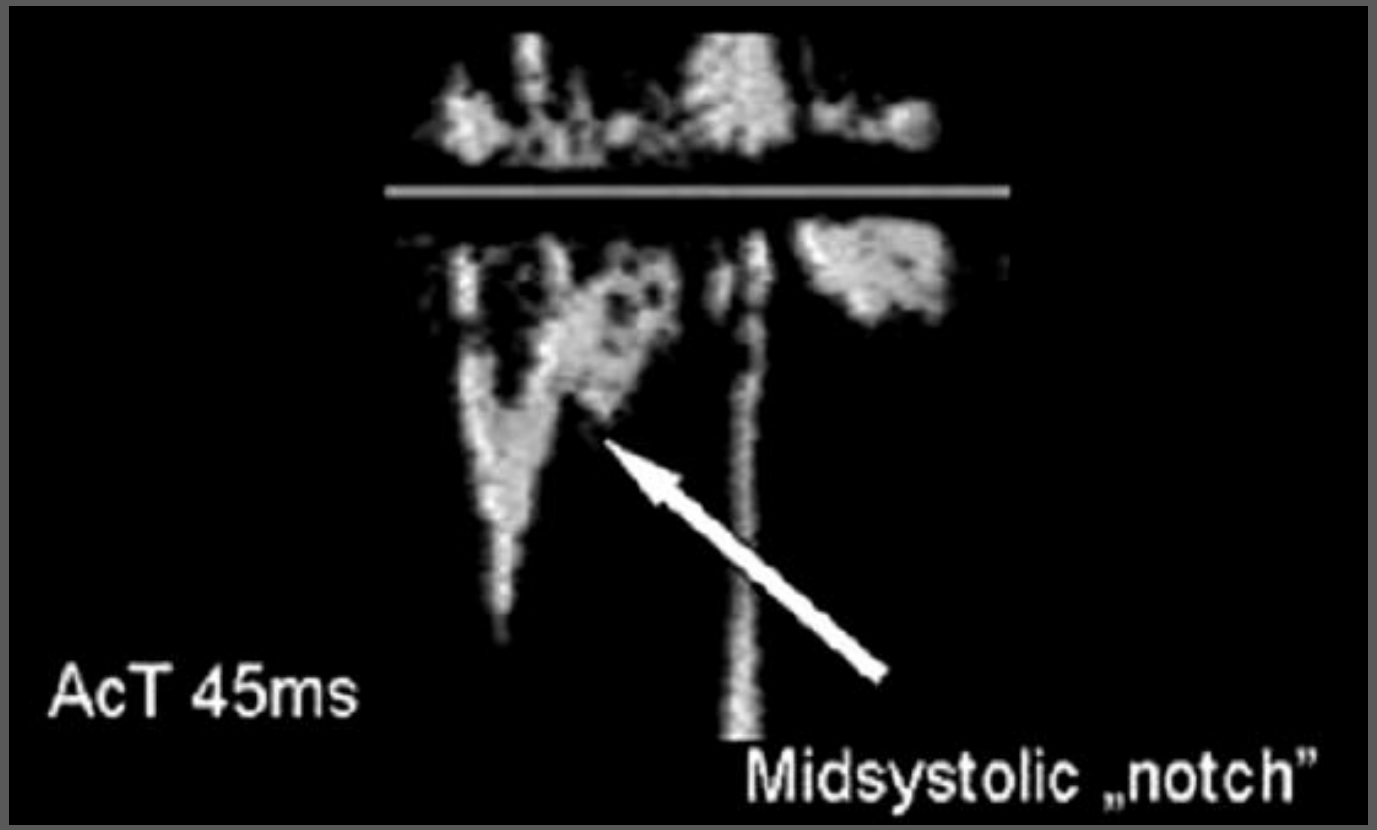
  (TR jet velocity, modified Bernoulli equation)





Characteristic alteration of pulmonary ejection flow pattern

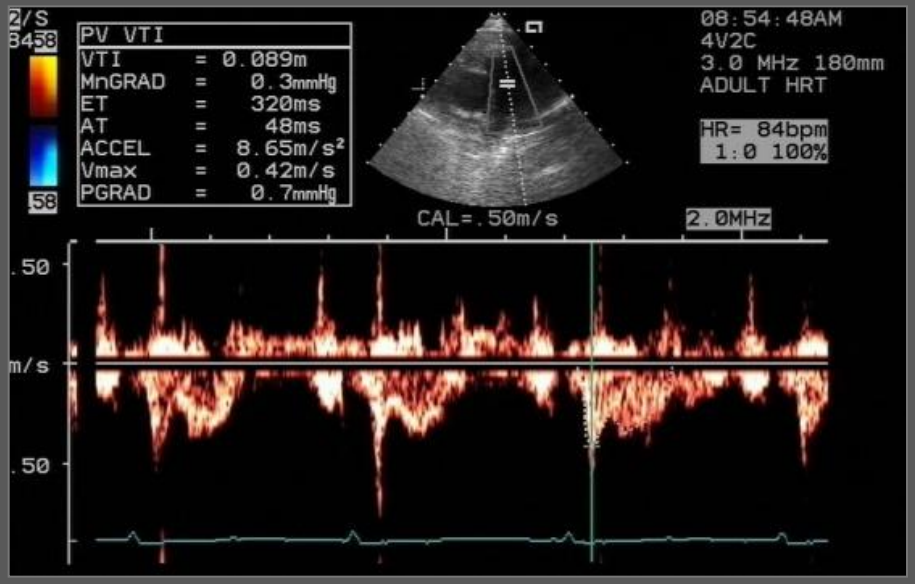
- *AcT <60 ms*
- *Midsystolic deceleration (“notching”)*

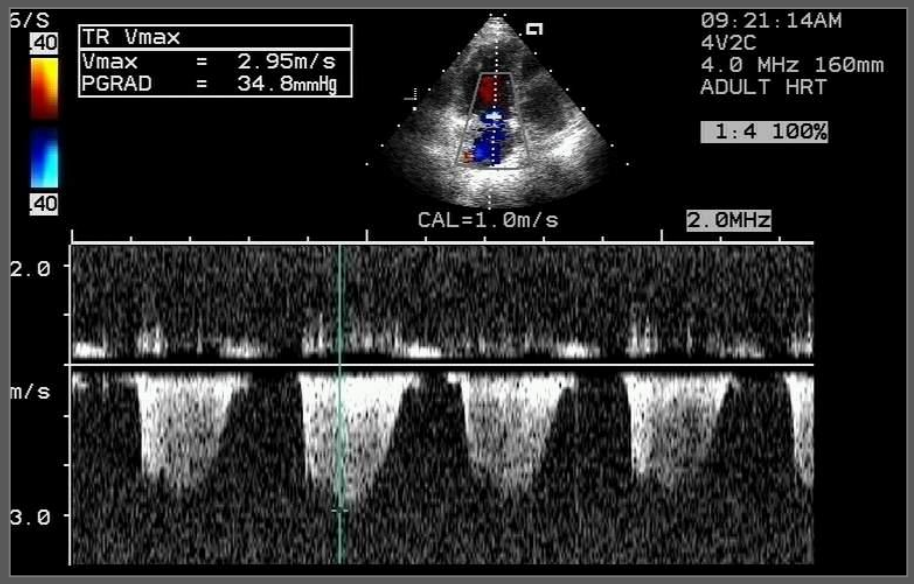


Courtesy of Pruszczyk P

“60/60” sign

Pulmonary ejection acceleration time in RVOT of ≤60 ms in the presence of tricuspid insufficiency pressure gradient ≤60 mmHg

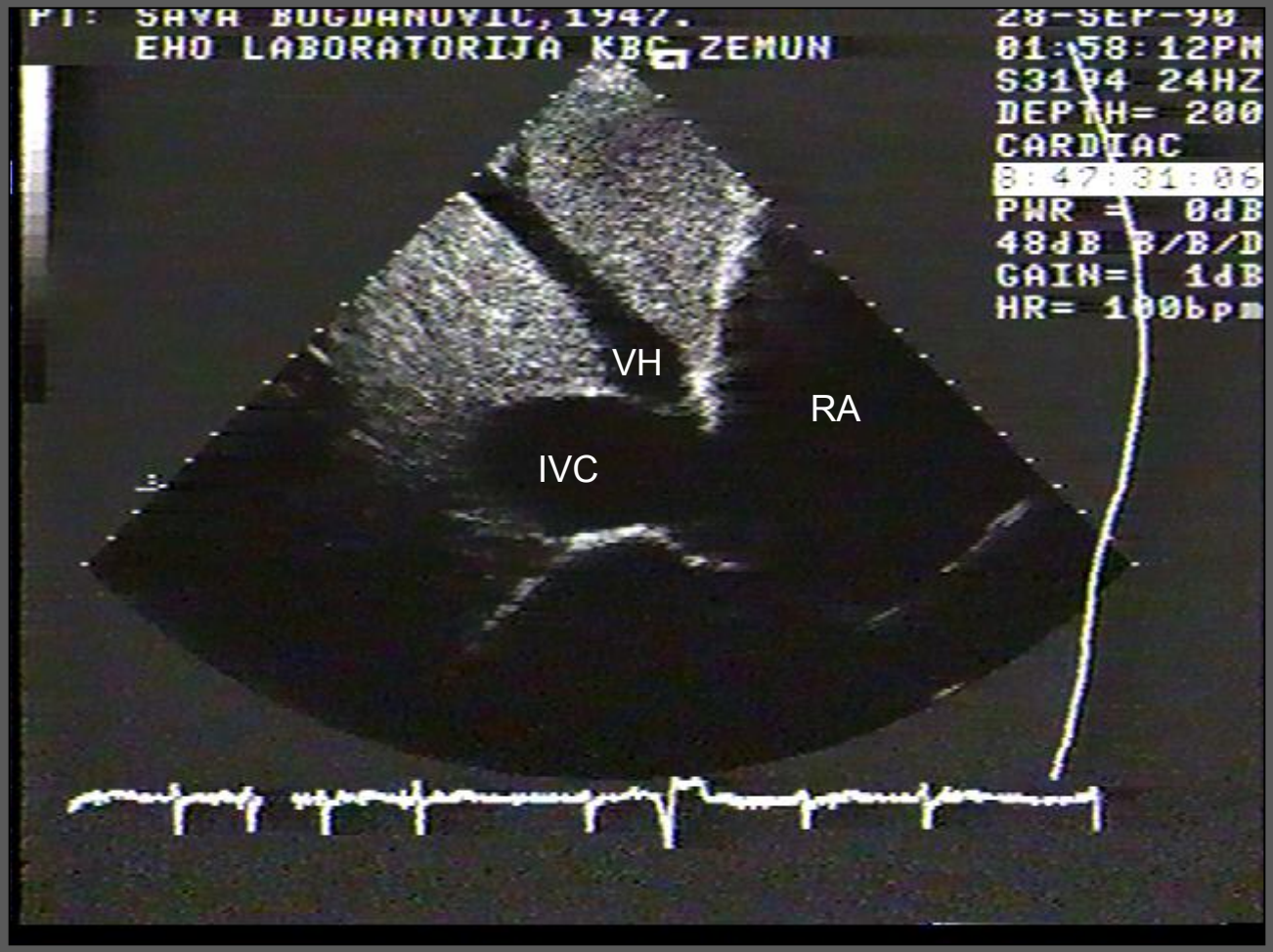




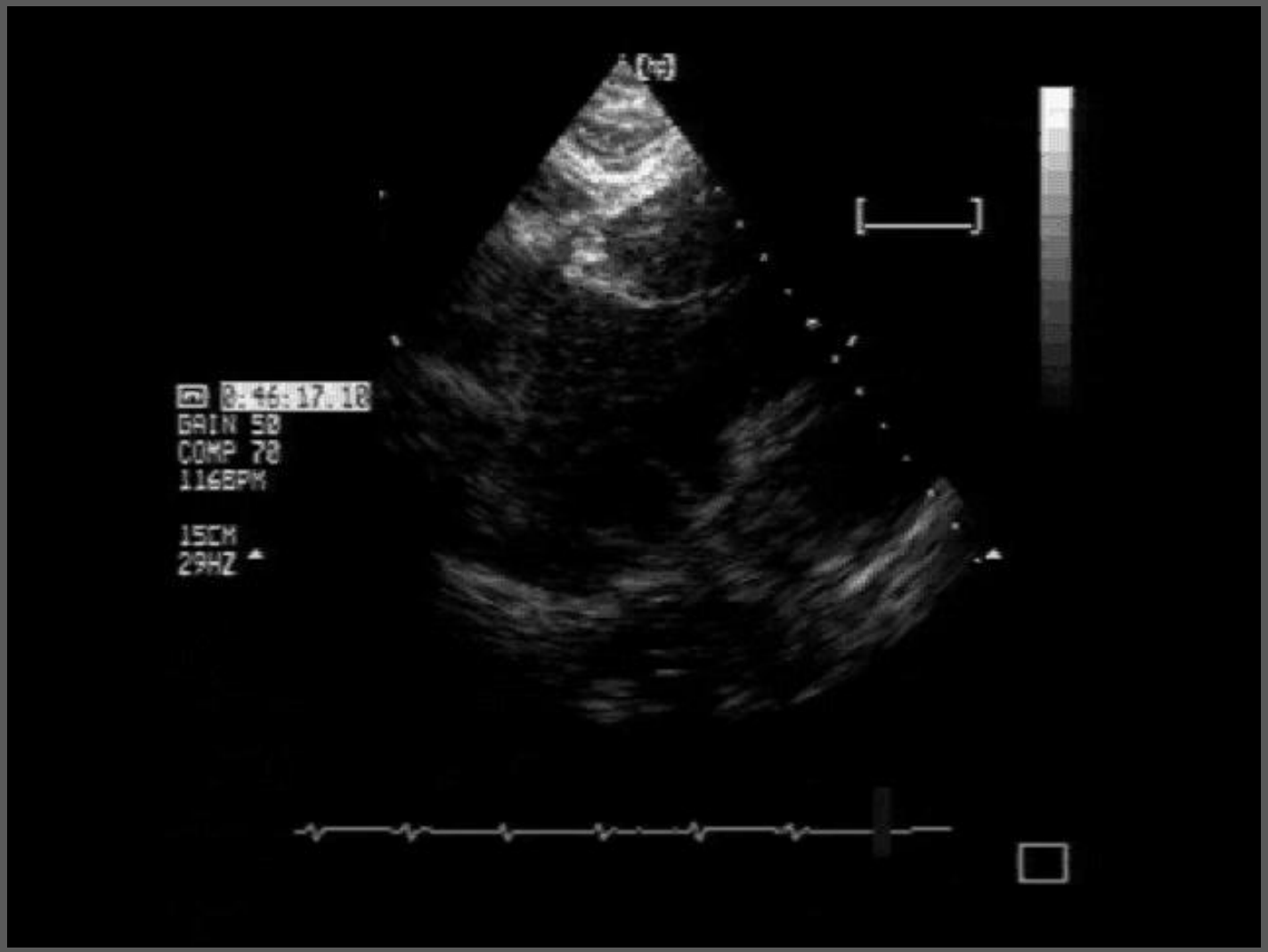
AcT ≤ 60 ms

TIPG ≤ 60 mmHg

- *Dilated IVC, non-colapsable in inspirium*



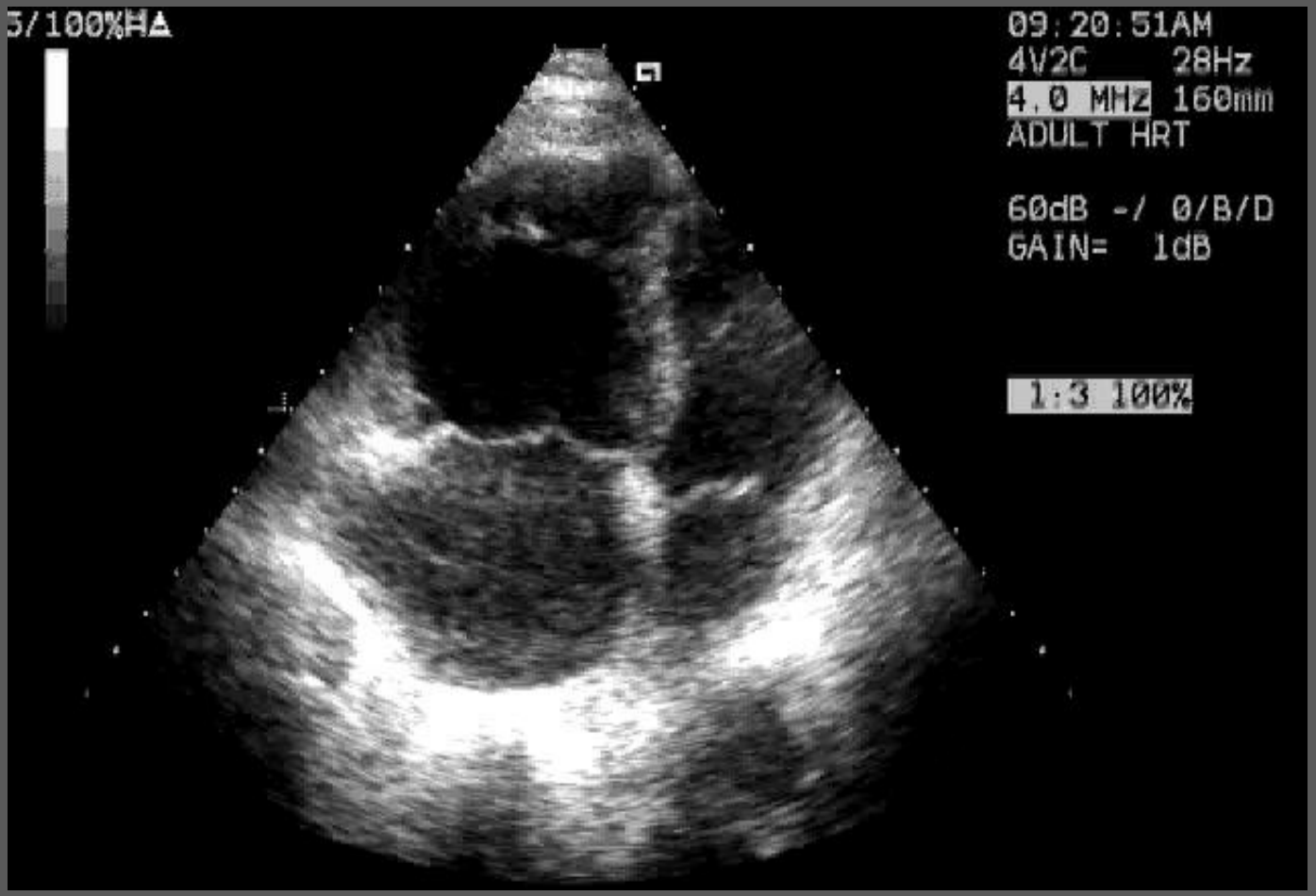
- *Dilated IVC, non-colapsable in inspirium*



Regional RV Dysfunction in Acute PE

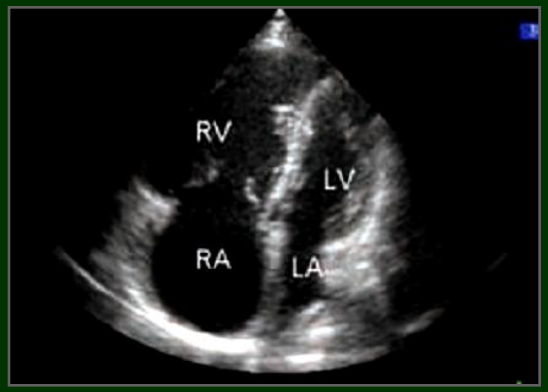
McConnell's sign

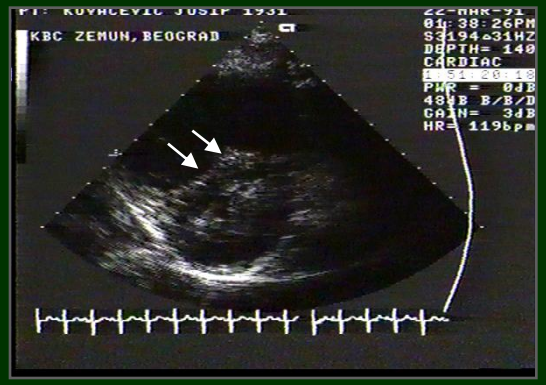
"distinct echocardiographic pattern of RV dysfunction"

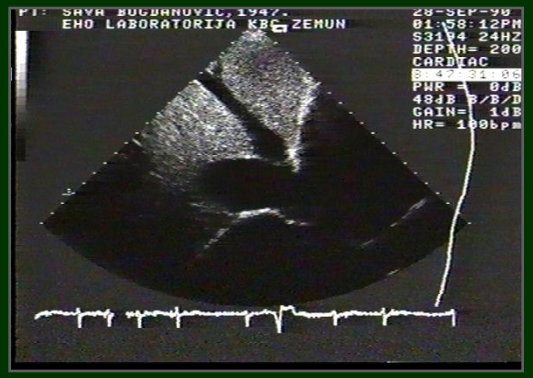


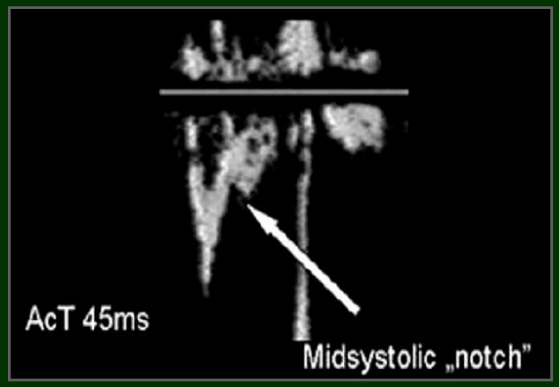
McConnell MV, et al. AJC 1996

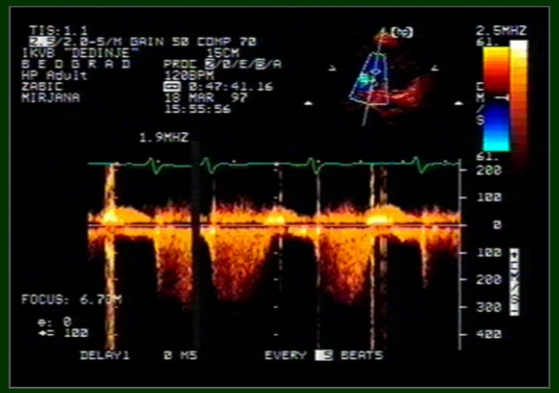
What is the real diagnostic value of echo signs suggesting pulmonary embolism ?

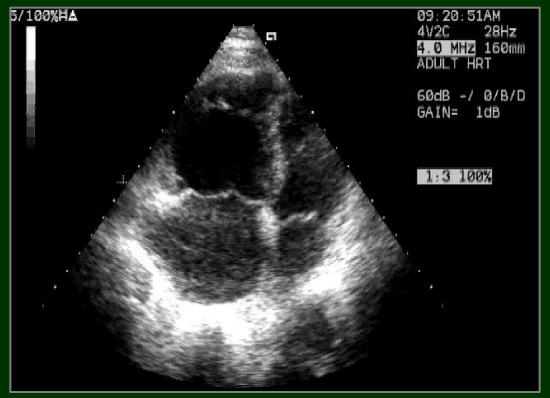












Major Studies Evaluating Diagnostic Value of Echo Signs Suggesting Pulmonary Embolism

Source	*n*	*Screened population*	*Echocardiographic criteria used*	*Sens*	*Spec*	*PPV*	*NPV*
Nazeyrollas et al[10]	132	Out-patients, no known previous serious cardio-respiratory disease	RV/LVEDD > 0.5 (parasternal M-mode echo) TI jet velocity > 2.5 m/s	93%	81%	78%	93%
Grifoni et al[11]	117	Consecutive patients seen at emergency department	One or more of four signs: 1. Right heart thrombus 2. RV >30 mm parasternal view or RV/LVED > 1.3 3. Systolic flattening of inter-ventricular septum 4. AcT or <90 ms or TIPG >30mmHg but no RV hypertrophy	51%	87%	82%	60%
Perrier et al[12]	50	Consecutive patients, mostly from emergency ward	RV dilation 'by visual inspection' on 2-D echo and TI jet velocity >2.6 m/s	67%	94%	86%	83%
McConnell et al[17]	85	Hospitalized patients with RV dysfunction	Hypokinetic RV free wall but normo/hyperkinetic RV apex	77%	94%	71%	96%
Torbicki et al[19]	86	Hospitalized patients with precapillary pulmonary hypertension	AcT <60 ms with TIPG <60 mmHg	48%	98%	n.a.	n.a.
Miniati et al[13]	110	Consecutive patients with clinically suspected APE	Two of the following: signs: 1. RV hypokinesis, 2. RV diameter >27 mm, long parasternal 3. TI velocity >2.7 m/s	56%	90%		

Diagnostic Value of Echo in PE

Possible sources of confusion:

- There are only few *prospective* studies
- Major differences in:
  - *patient's selection*
  - *severity of PE*
  - *previous cardiorespiratory disease*
  - *diagnostic echo criteria*

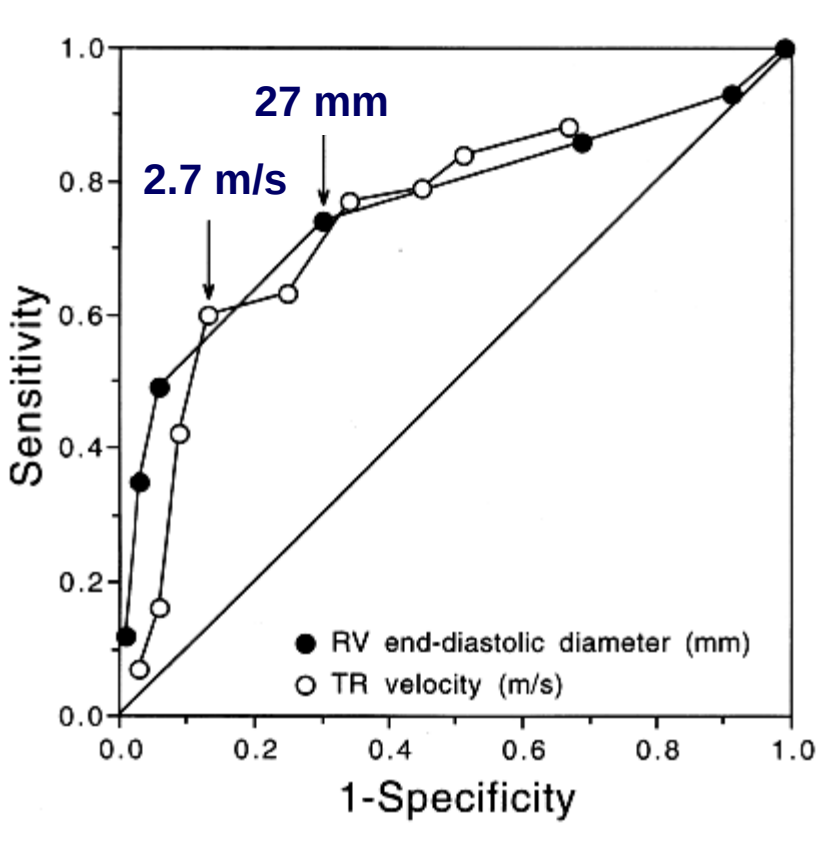
- Enrolled pts were not a representative sample of the severity spectrum of the disease
  - *majority had massive and submassive PE*

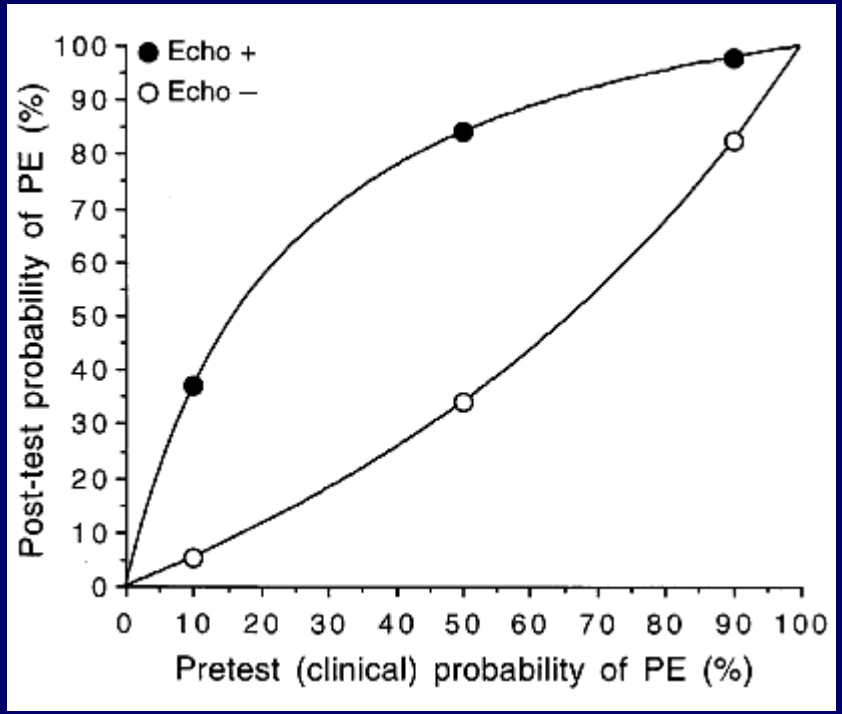
Diagnostic Value of Echo in PE

Echo Dg of PE, if any 2 of 3:
- *RV EDD > 27 mm*
- *RV hypokinesis*
- *TR velocity > 2.7 m/s*

At least 2/3 echo criteria were present in:
- *24/43 pts with angio-proven PE*
- *7/67 pts without PE*

Sn 56%
Sp 90%





Miniati M, et al. Am J Med 2001

Diagnostic Value of Echo in PE

- TTE has limited diagnostic value: it fails to identify ~ 50% of pts with angio-proven PE in a prospective study of *unselected pts*

- Should not be used for PE screening

Miniati M, et al. Am J Med 2001

Regional RV Dysfunction in Acute PE

McConnell's sign

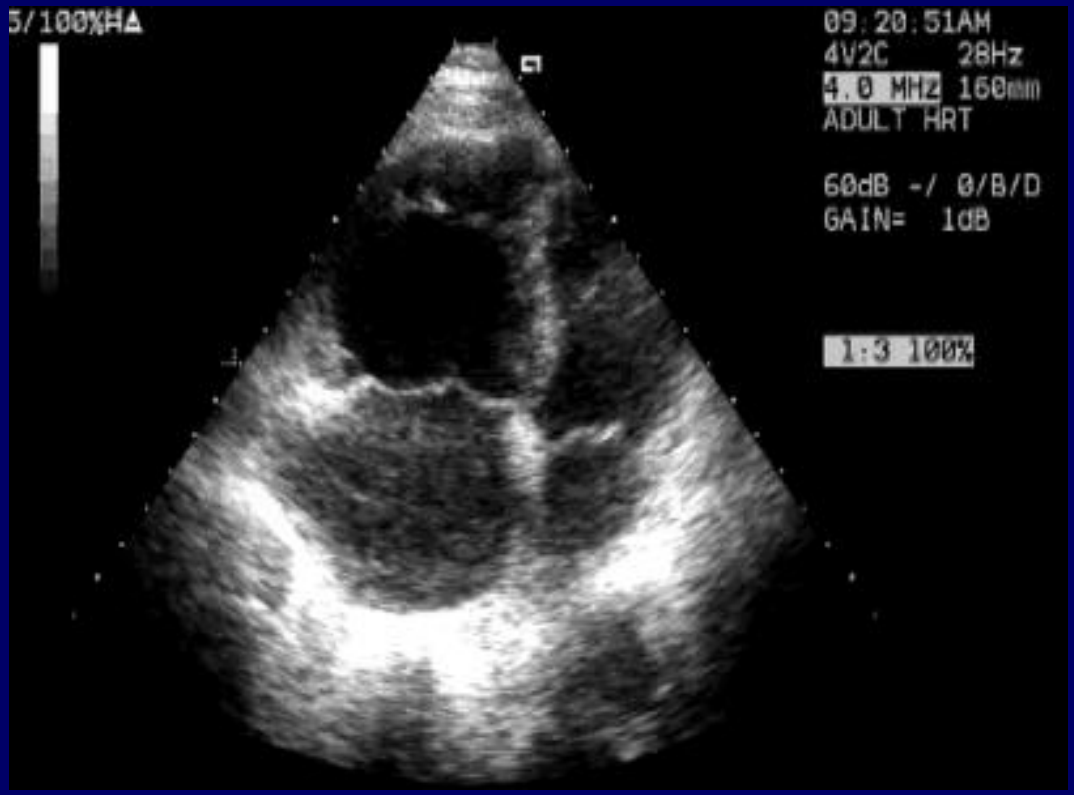
RV free wall hypokinesis with normal wall motion of the RV apex →

- *14 pts with PE*
- *9 pts with PPH*
- *18 normal controls*

McConnell sign:

Sn	77%
Sp	94%
PPV	71%
NPV	96%

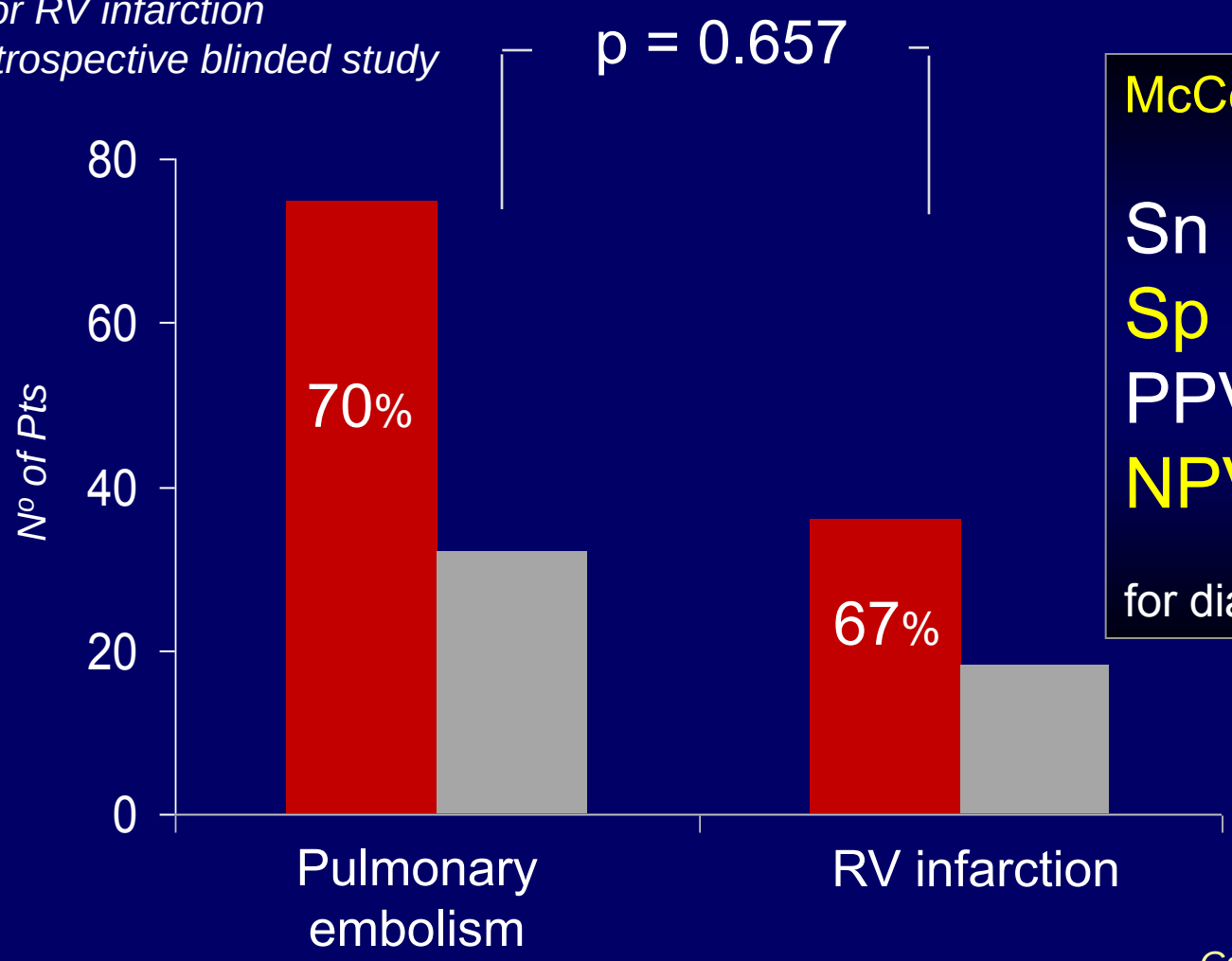
for diagnosis of PE



McConnell MV, et al. AJC 1996

Prevalence of McConnell Sign in pts with Acute PE and RV Infarction

- *161 pts with RV dysfunction*
- *PE or RV infarction*
- *Restrospective blinded study*



McConnell sign:

Sn	70%
Sp	33%
PPV	67%
NPV	36%

for diagnosis of PE

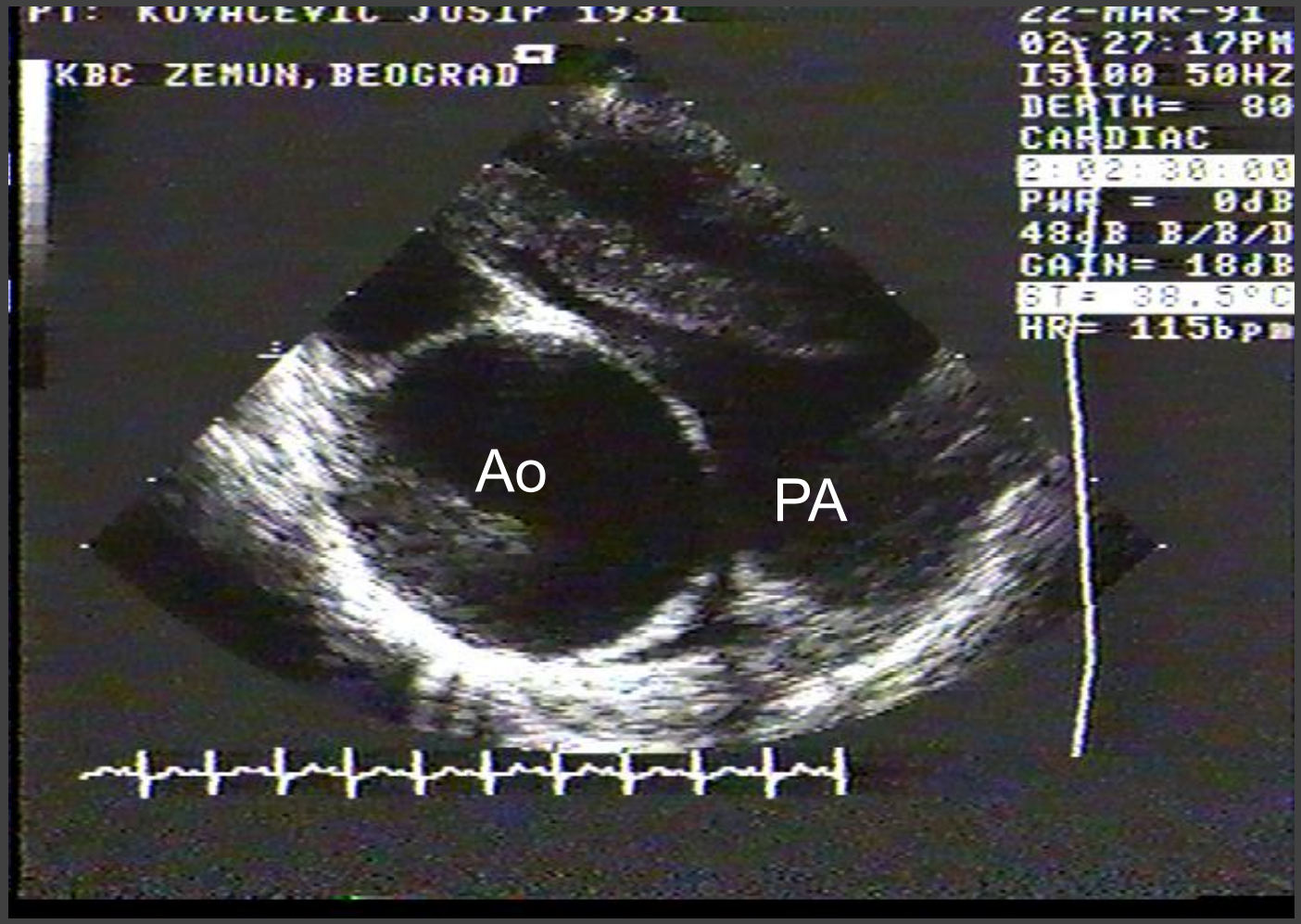
Casazza F et al, EJE 2005

TEE in PE

TEE in Diagnosis of PE

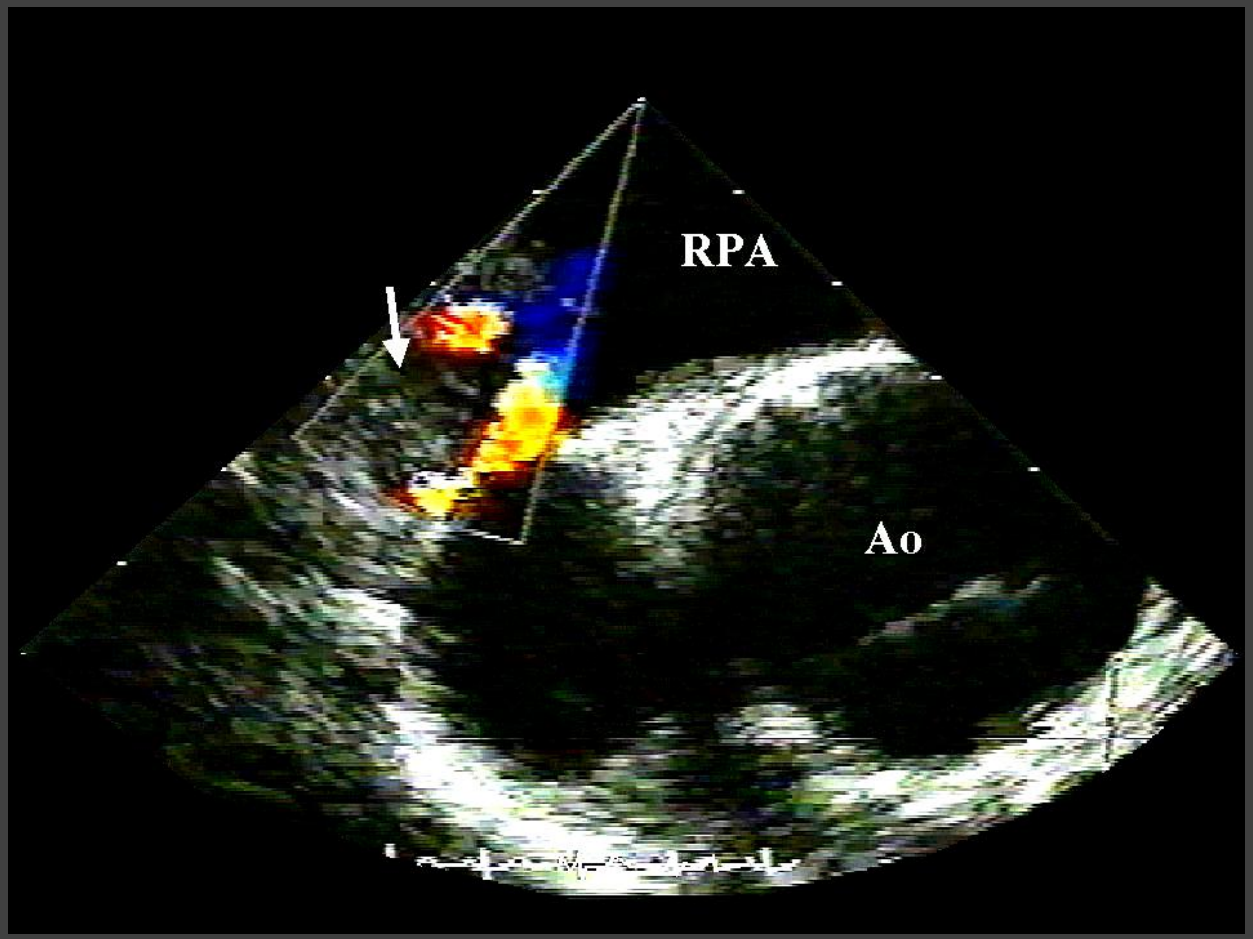
- Direct visualization of thrombus in proximal parts of pulmonary arteries and right heart
- Good sensitivity in selected pts
- High specificity
  - ✓ *If intraluminal mass with distinct borders, different in echodensity from the vascular wall is considered as thrombus*
- Experience/learning curve (left PA?)
  - ✓ *special care to avoid overdiagnosis of acute PE*
  - ✓ *TEE result often serves as justification of aggressive Th*

Diagnosis of Central Massive PE by TEE

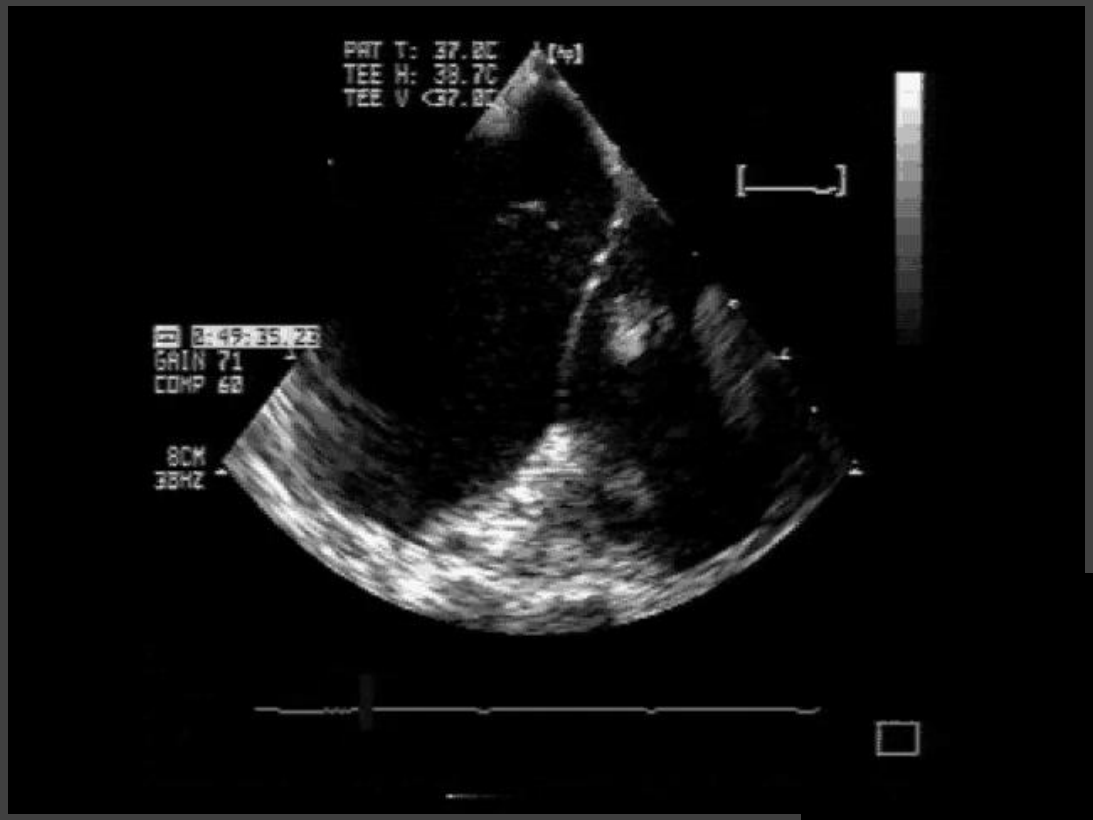


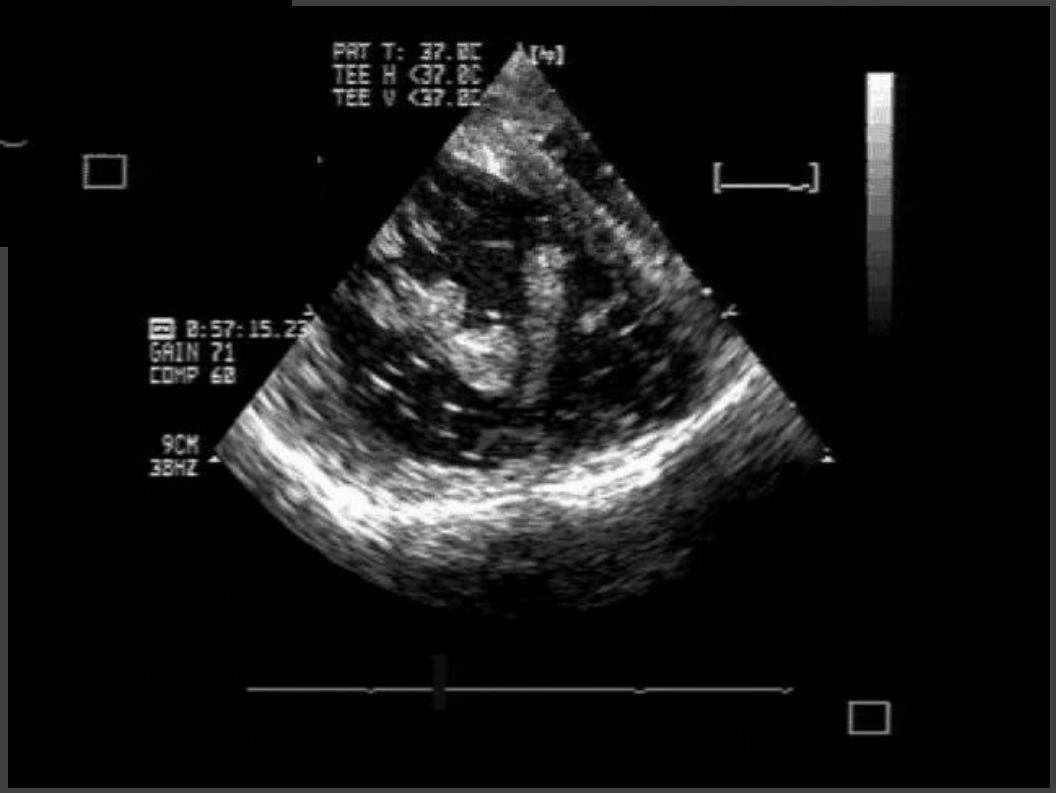
Popovic AD, Neskovic AN, et al. Cardiology 1992

Improvement of Diagnostic Accuracy of TEE by Color Doppler in Cases With Incomplete Obstruction

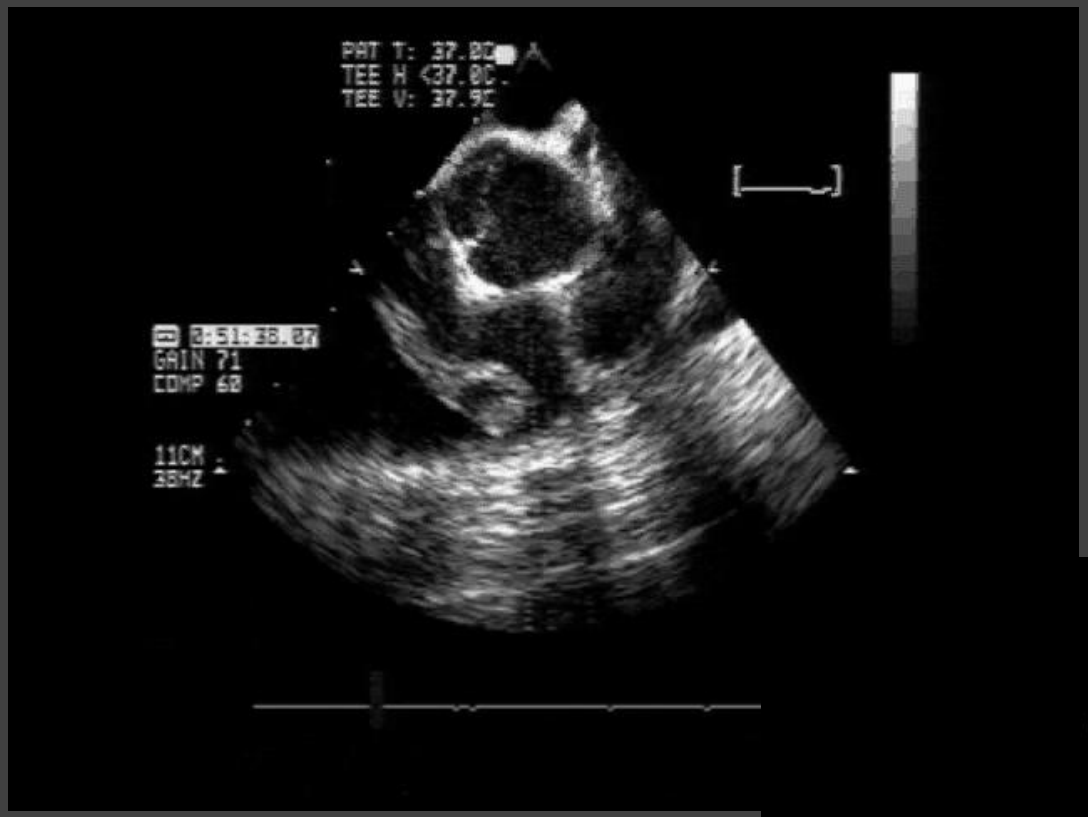


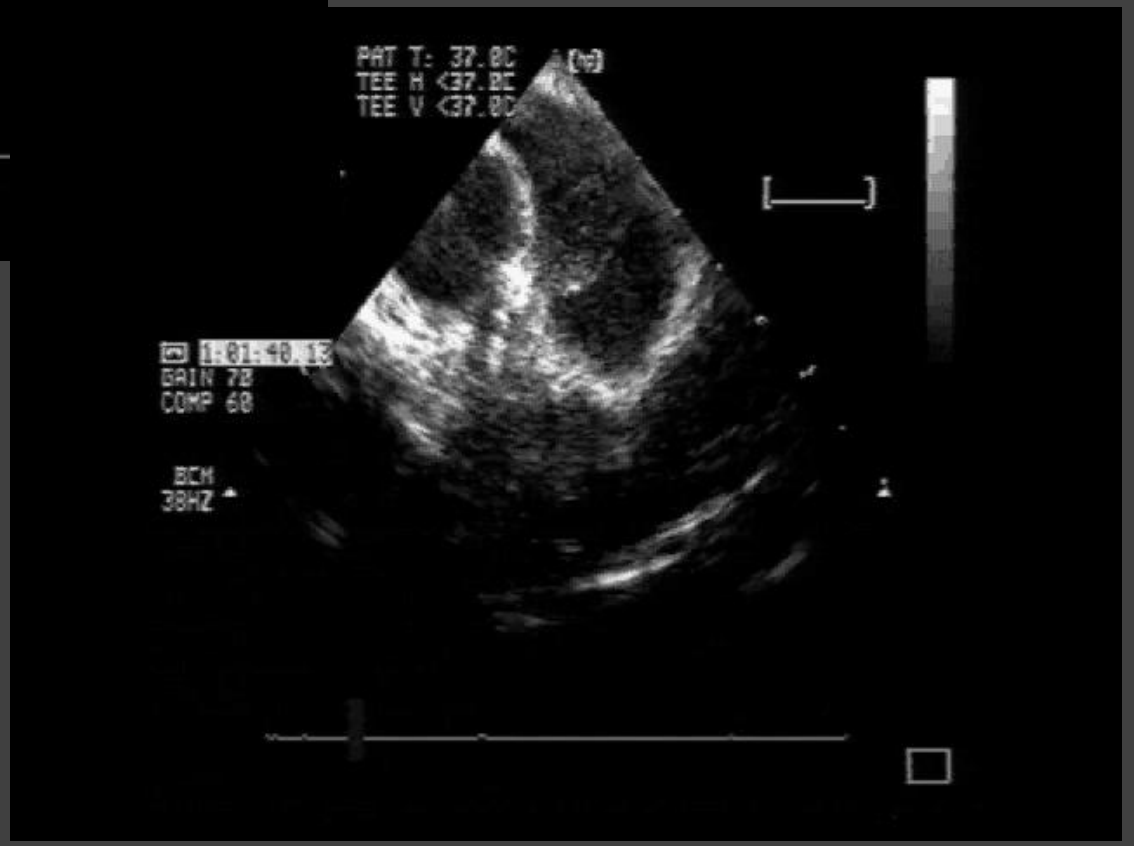
Neskovic AN, Popovic AD, et al. Echocardiography 1996



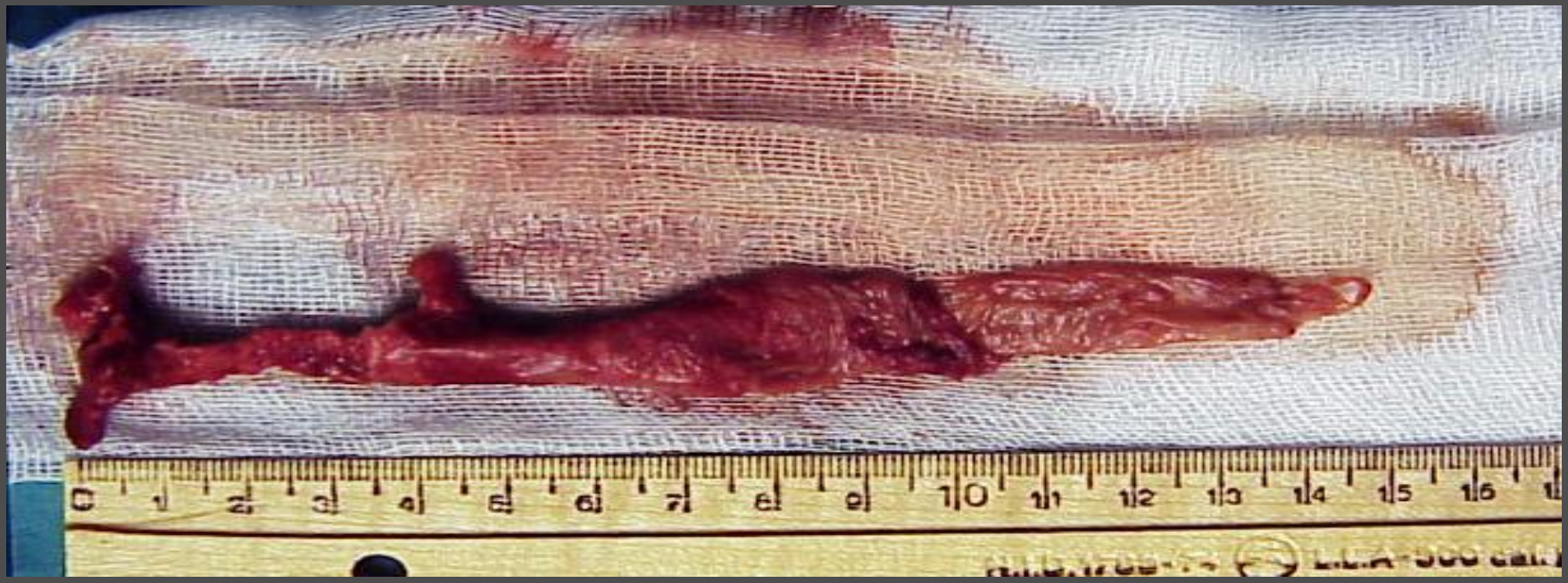


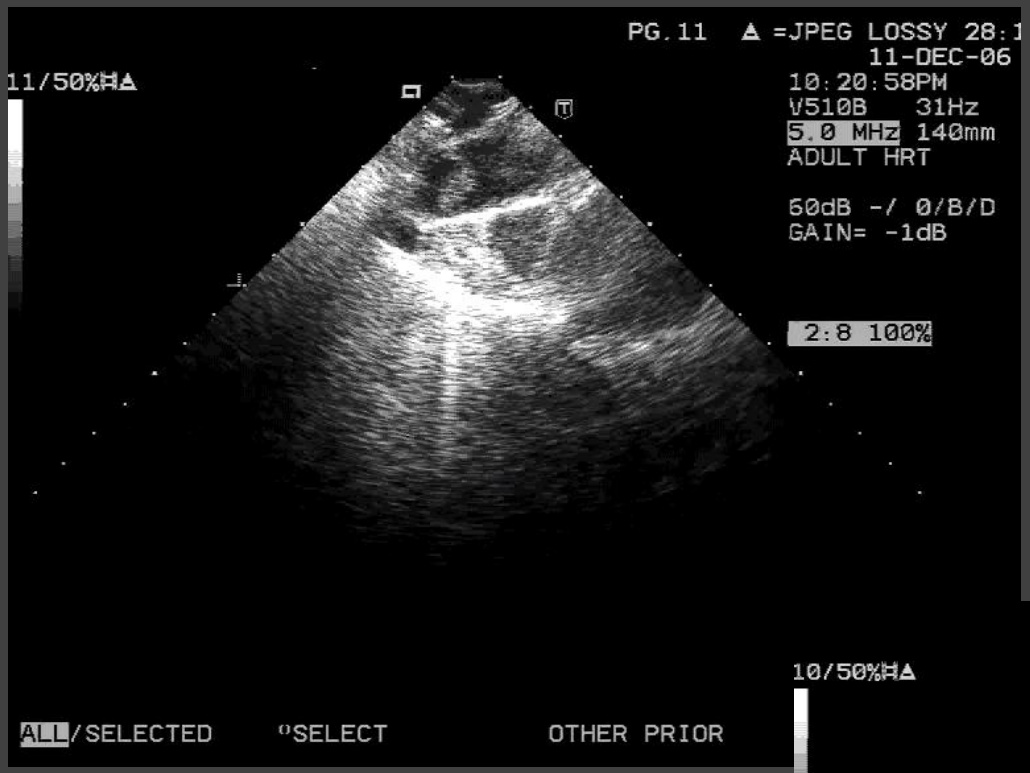
Courtesy to A. Lazarevic

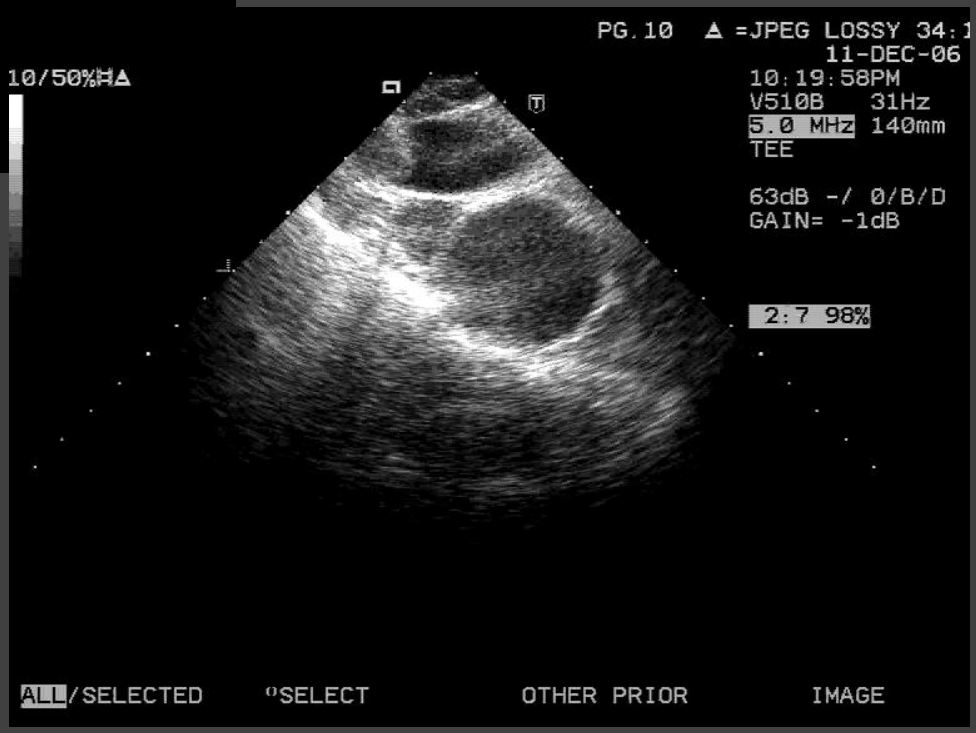


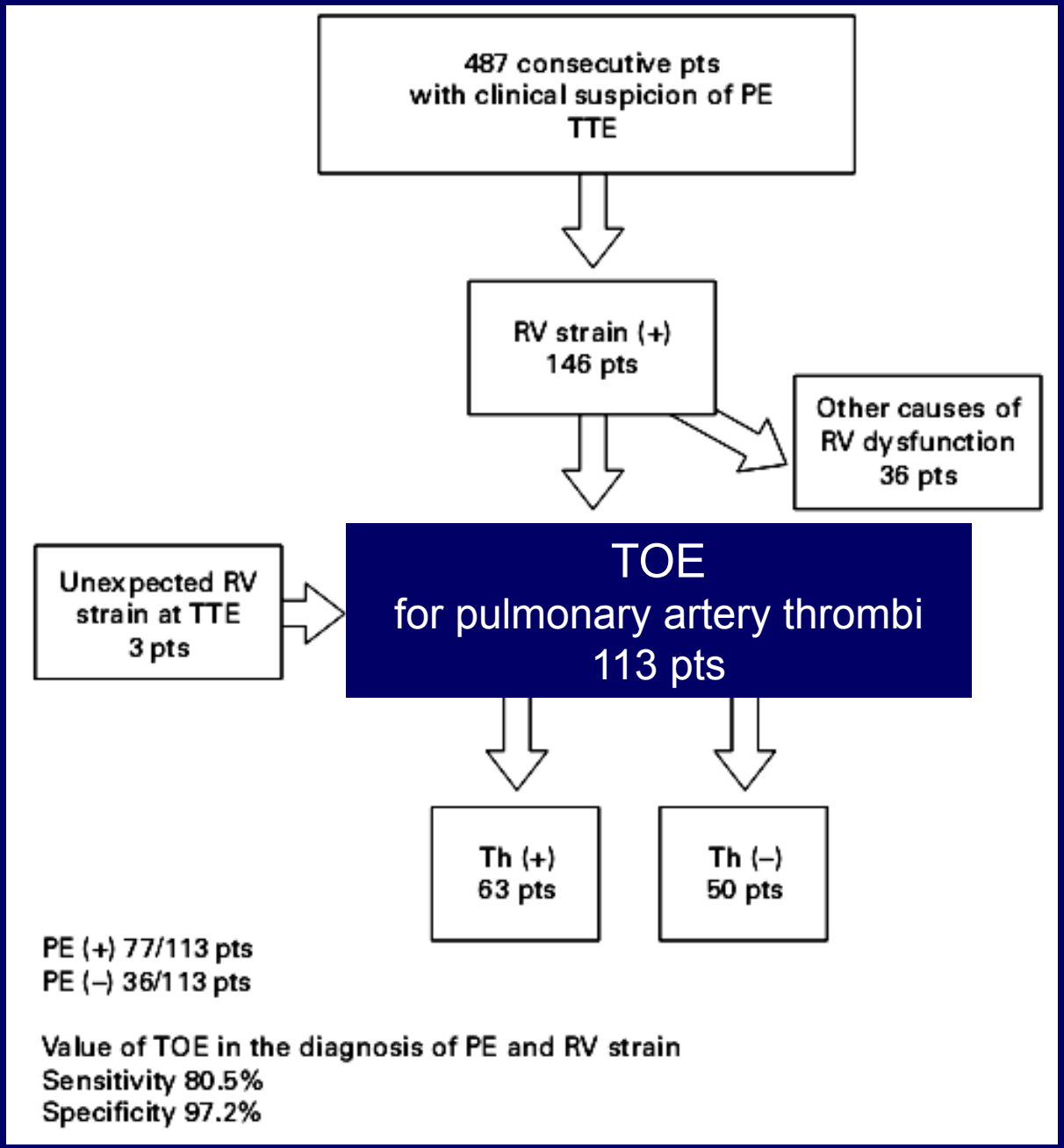


Courtesy to A. Lazarevic


0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16


PG.11 ▲ =JPEG LOSSY 28:1
11-DEC-06
11/50%HA
10:20:58PM
V510B 31Hz
5.0 MHz 140mm
ADULT HRT
60dB -/ 0/B/D
GAIN= -1dB
2:8 100%
ALL/SELECTED
SELECT
OTHER PRIOR


PG.10 ▲ =JPEG LOSSY 34:1
11-DEC-06
10/50%HA
10:19:58PM
V510B 31Hz
5.0 MHz 140mm
TEE
63dB -/ 0/B/D
GAIN= -1dB
2:7 98%
ALL/SELECTED
SELECT
OTHER PRIOR
IMAGE



Diagnostic value of TEE in pts with suspected PE and signs of RV overload at TTE ?

PA thrombi

- 11 right
- 15 left
- 25 bilateral

Sn 80.5%

Sp 97.2%

Pruszczyk P, et al. Heart, 2001

TEE in Diagnosis of PE

- TEE can be used for bedside confirmation of significant PE in 80% of cases.
- However, due to topographic limitations it can not rule out PE.
- Bedside TEE: 1st choice Dg test in *selected* pts with RV dysfunction, shock, or during CPR.

Echo Identification of High-Risk Pts with Confirmed PE

High-Risk Features:

- RV dysfunction
- Free-floating RH thrombi
- PFO

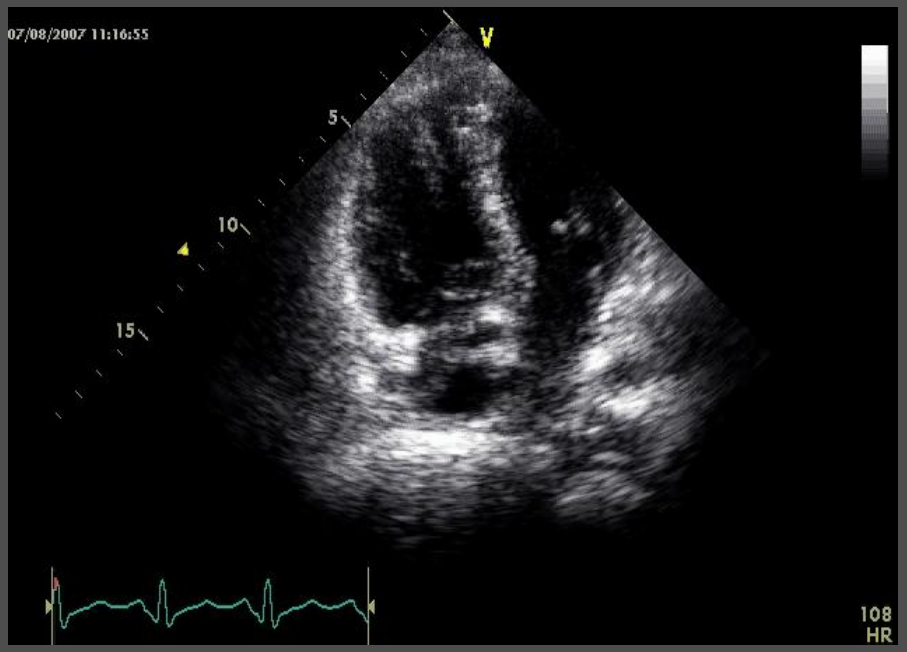
RV dysfunction

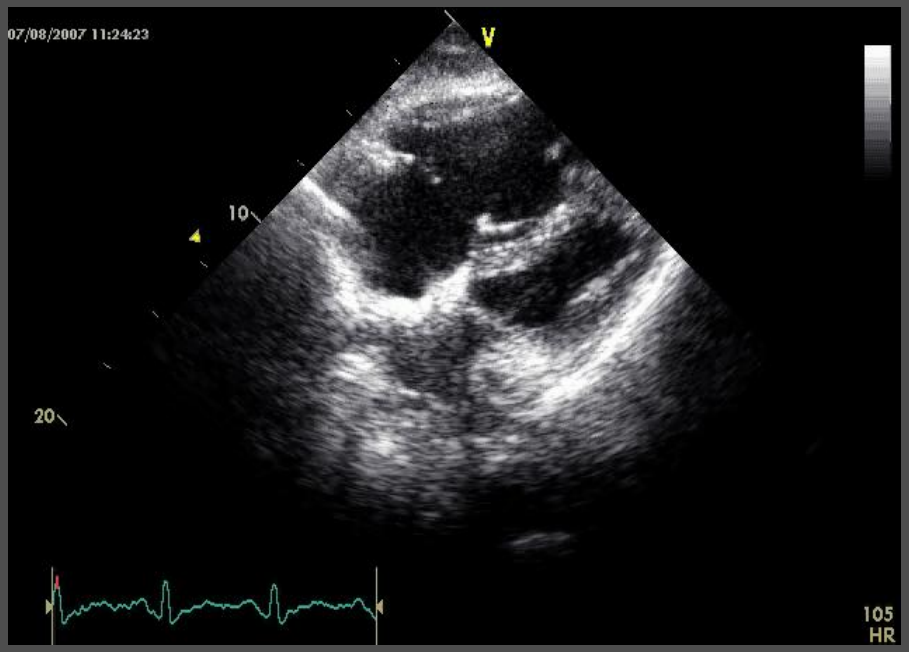
Echo Signs of RV dysfunction

- RV / LV EDD > 1
- RV EDD > 30 mm (RV dilation)
- RV hypokinesis
- Paradoxical RV septal motion
- McConnell's sign

RV dysfunction

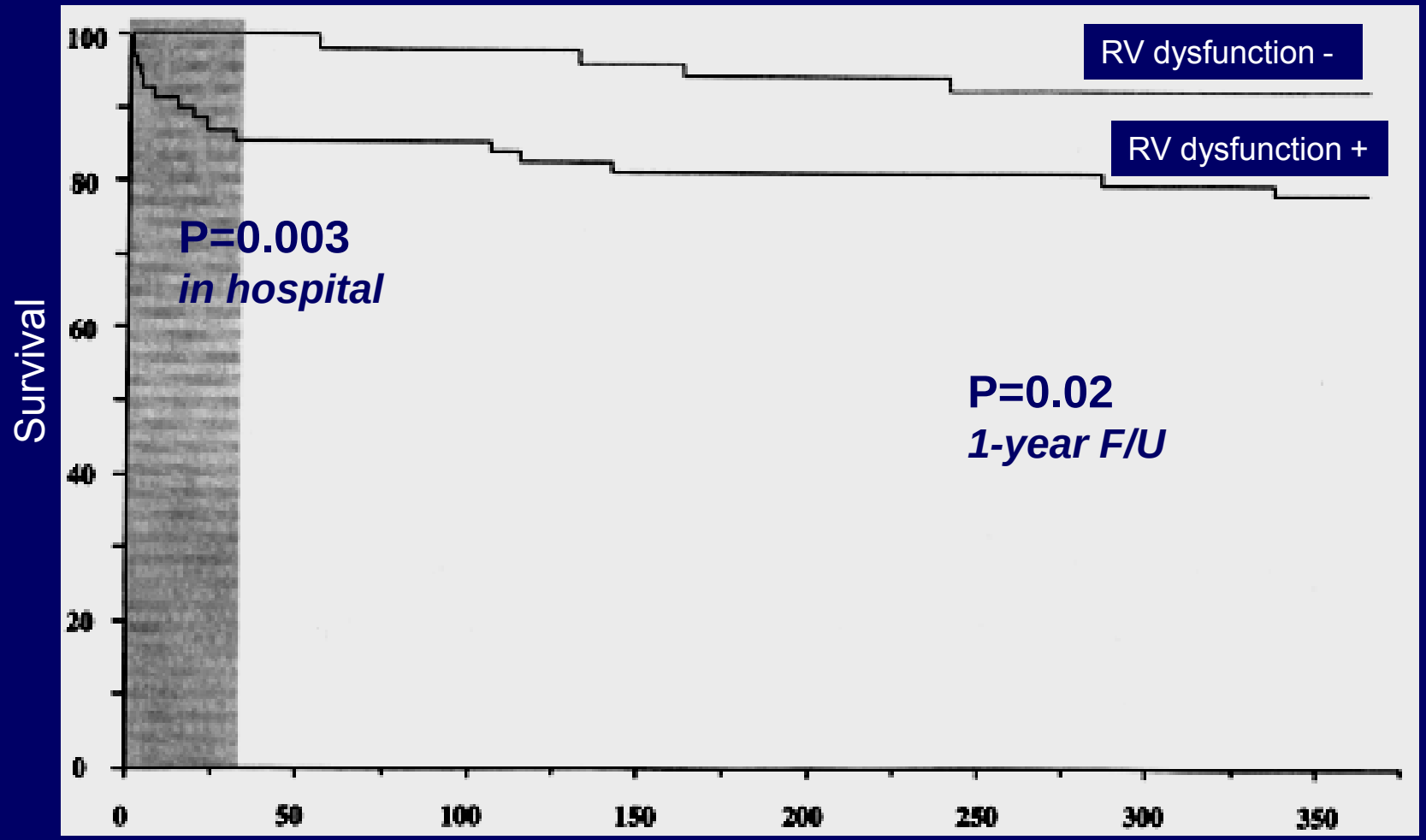
- *Dilation*
- *Hypokinesis*
- *McConnell‘s sign*





RV Dysfunction as a Marker of Worse Outcome in Pts with PE

- *126 pts with PE*
- *RV function assessed by WMA analysis*



Ribeiro A , et al. AHJ 1997

Prognostic Significance of RV afterload stress in Pts with Suspected PE

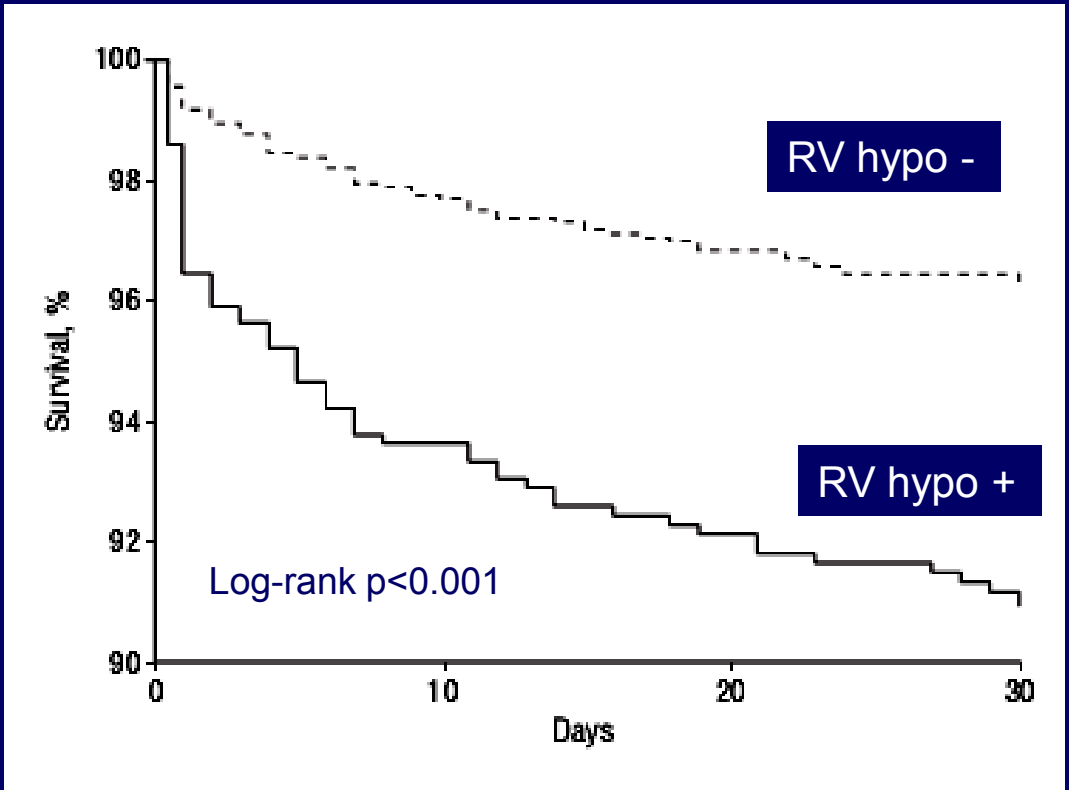
- *317 pts with clinically suspected PE*
- *Echo for the presence of RV afterload stress*

In-hospital events	*RV afterload stress +*	*RV afterload stress -*	*P value*
Total mortality	16 (18.4%)	13 (5.7%)	< 0.001
Mortality due to PE	11 (12.6%)	2 (0.9%)	< 0.001
CPR	16 (18.4%)	5 (2.1%)	< 0.001
1-year mortality due to PE	11 (12.6%)	3 (1.3%)	< 0.001

Kasper W, et al. Heart 1997

Impact of RV Dysfunction on Survival* in Pts with Acute PE and Preserved Systolic Arterial Pressure

- *1035 ICOPER pts with PE*
- *SBP ≥ 90 mmHg at presentation*
- *Baseline echo for RV hypokinesis*



RV hypokinesis in pts with PE and SBP ≥90mmHg:

Independent predictor of 30-day mortality

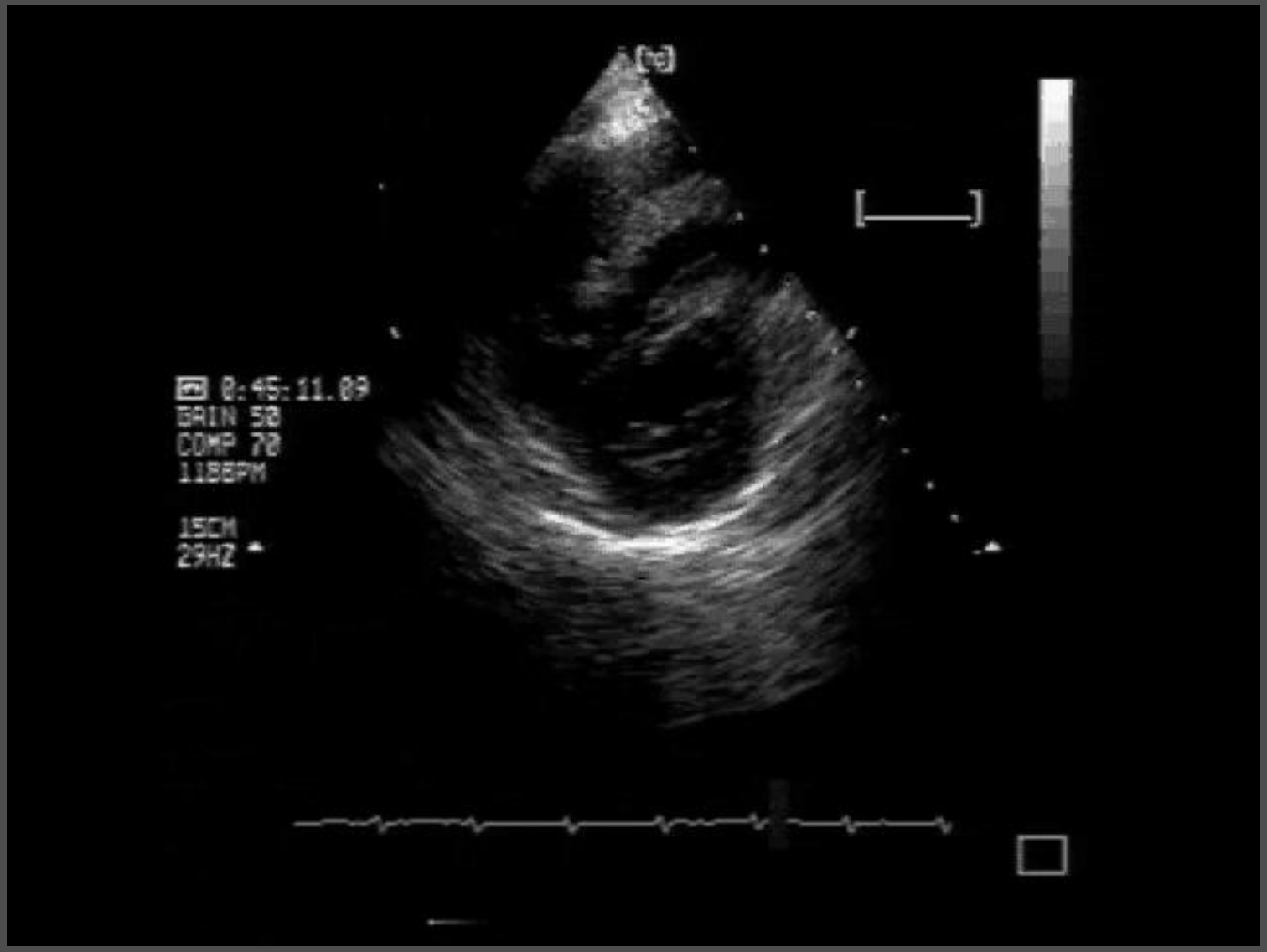
HR 1.94 (1.23-3.06)

*, Survival adjusted for: cancer, CHF, COPD, age, and TA

Kucher N, et al (ICOPER). Arch Intern Med 2005

Right Heart Thrombi

Right Heart Thrombi



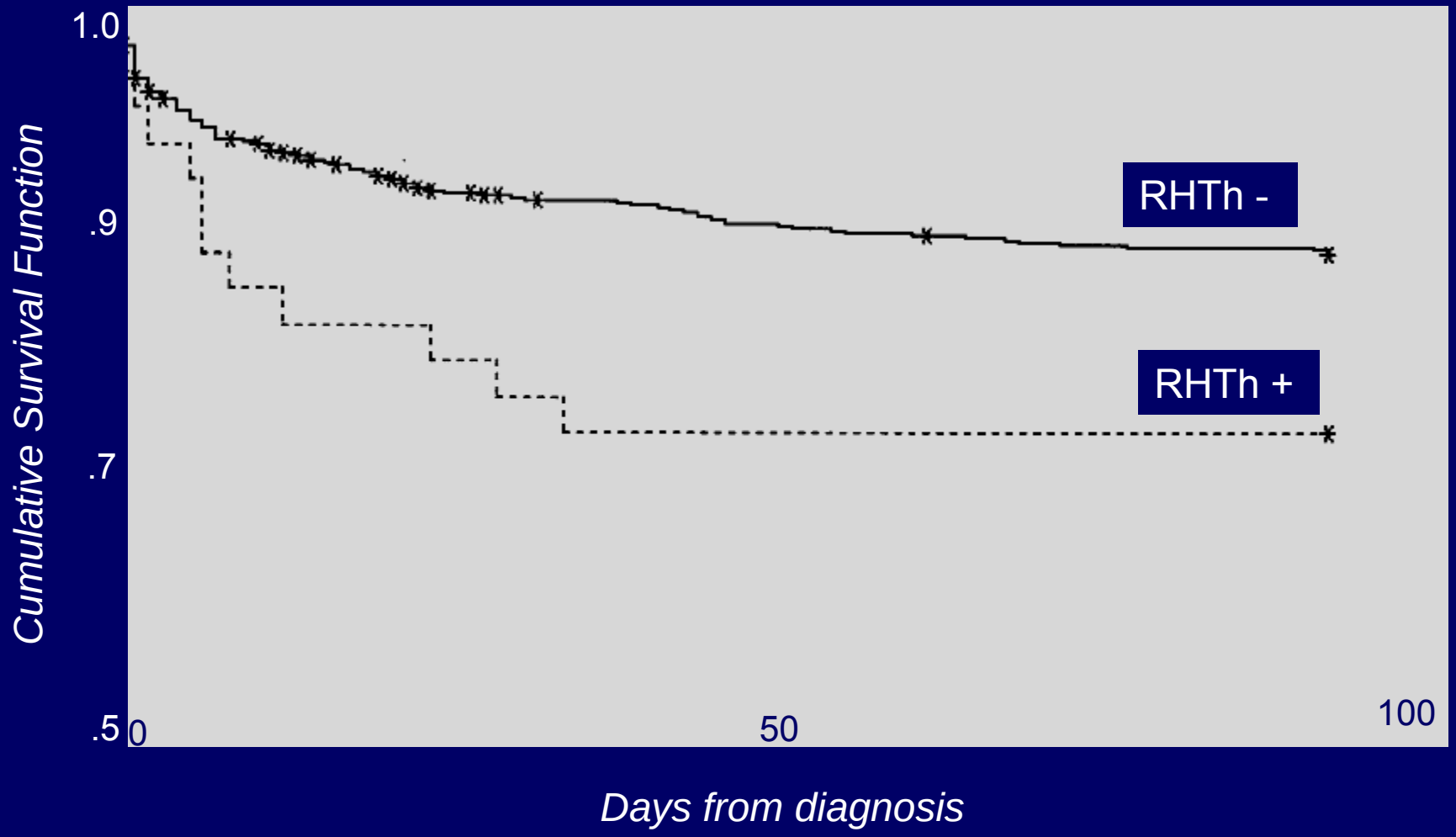
Characteristics of Pts With and Without Right Heart Thrombi on Baseline Echo

- *2452 ICOPER pts with PE*
- *1113 have baseline ECHO*
- *42 RHTh+ and 1071 RHTh -*

	Right Heart Thrombi + (42 pts)	*Right Heart Thrombi -* (1071 pts)	*P value*
CHF	26%	13%	0.024
Heart rate	107±19	101±22	0.030
Systolic BP	116±29	126±25	0.008
Systolic BP <90	14%	5%	0.012
Respiratory rate	28±8	25±10	0.037
RBBB	27%	13%	0.023
RV hypo (Echo)	64%	40%	0.002
Mortality at 14 d	21%	11%	0.032
Mortality at 3 mo	29%	16%	0.036

Torbicki A, et al (ICOPER). JACC 2003

3-Month Survival According to the Presence or Absence Of Right Heart Thrombi on Baseline Echo



Torbicki A, et al (ICOPER). JACC 2003

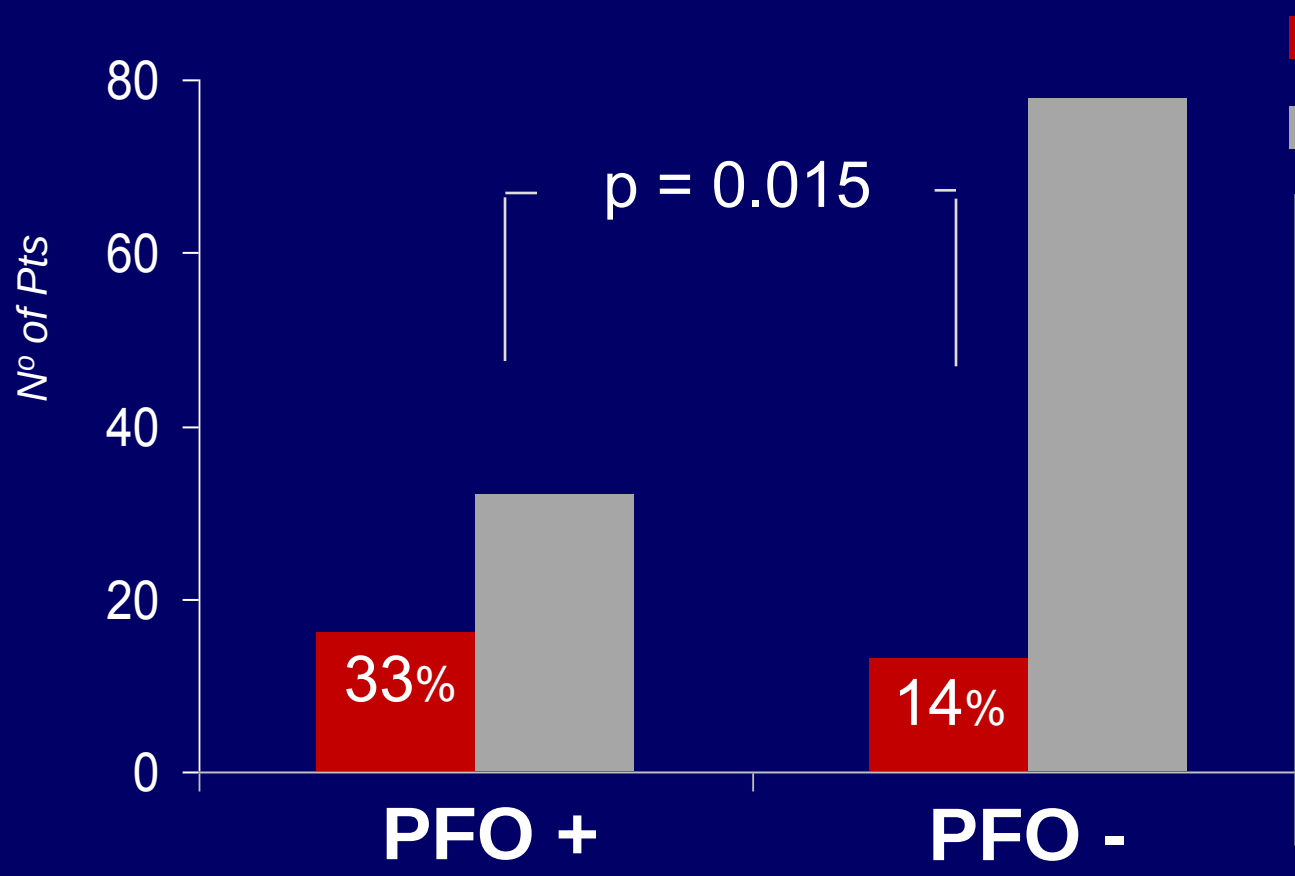
PFO

patent foramen ovale

PFO is Important Predictor of Adverse Outcome in Pts with Major PE

- *139 consecutive with major PE*
- *Contrast Echo for PFO detection at presentation*
- *F/U: in-hospital death and complications*

PFO in 48/139 pts (35%)



PFO+ *vs* PFO-

Ischemic stroke

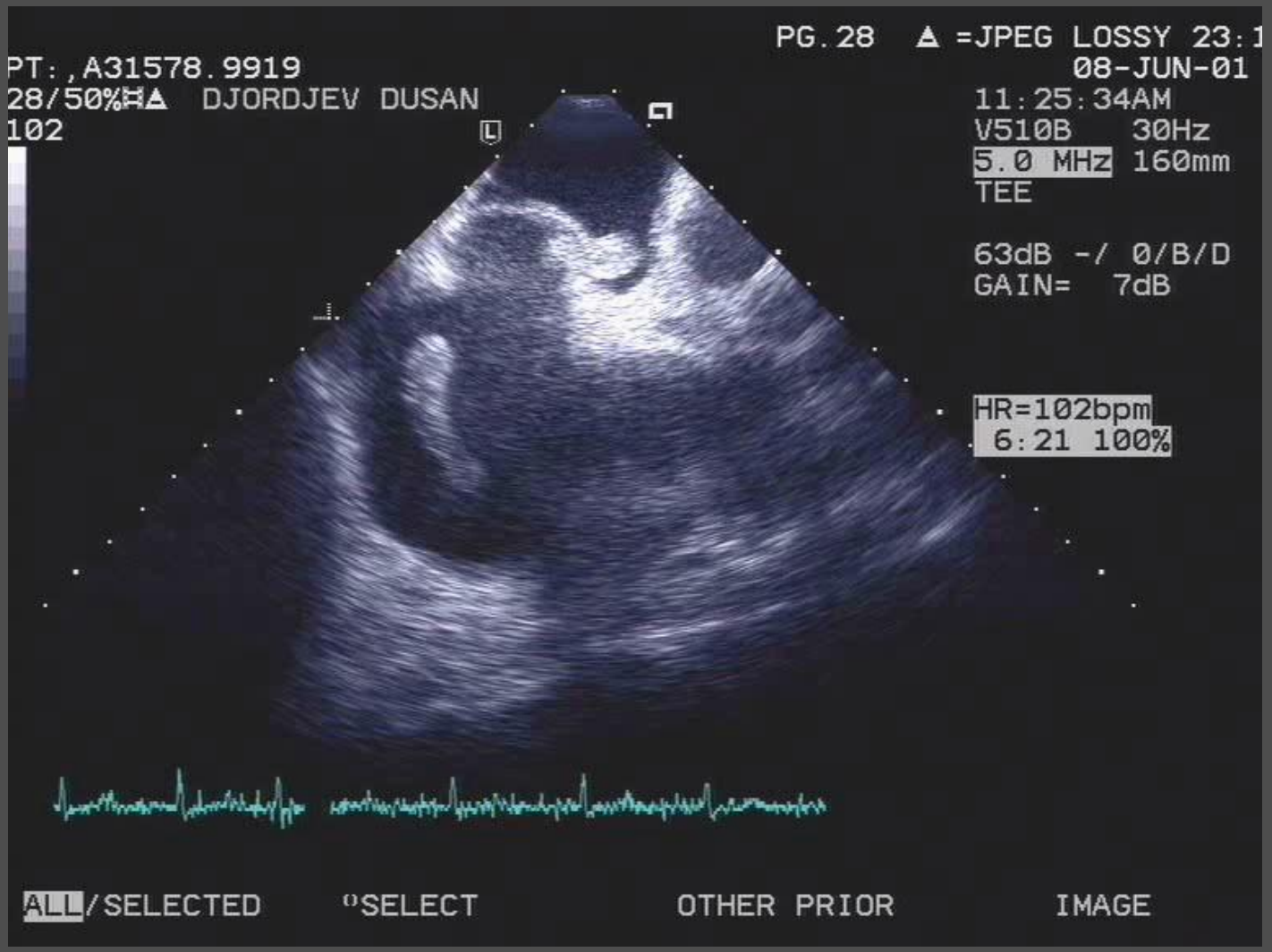
13% *vs* 2.2 %, p=.02

Peripheral artery embolism

15% *vs* 0%, p<.001

Konstantinides S, et al. Circ 1998

Thrombus Lodged in PFO



Differential Diagnosis of PE

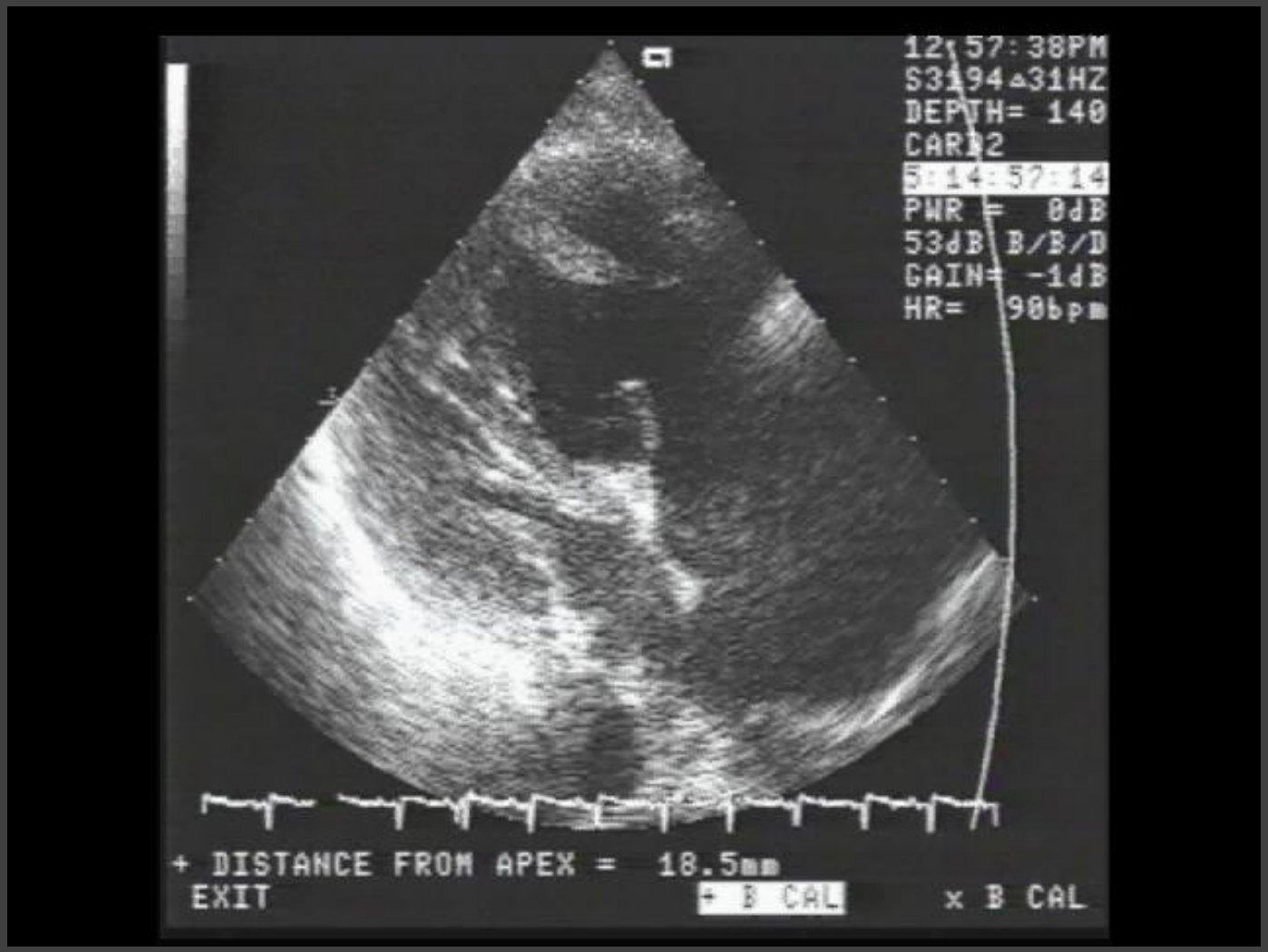
- Secondary pulmonary hypertension
- RV infarction
- Atrial septal defect
- Pulmonary stenosis
- Primary pulmonary hypertension
- Aortic dissection
- Tamponade
- ARDS
- ARVD

Acute Pulmonary Hypertension

vs. chronic:

- Dilated, hypokinetic RV *(McConnell?)*
- Absence of RV hypertrophy
- Absence of significant left heart pathology
- TR, with flow velocities indicating mild to moderate elevation of PAP

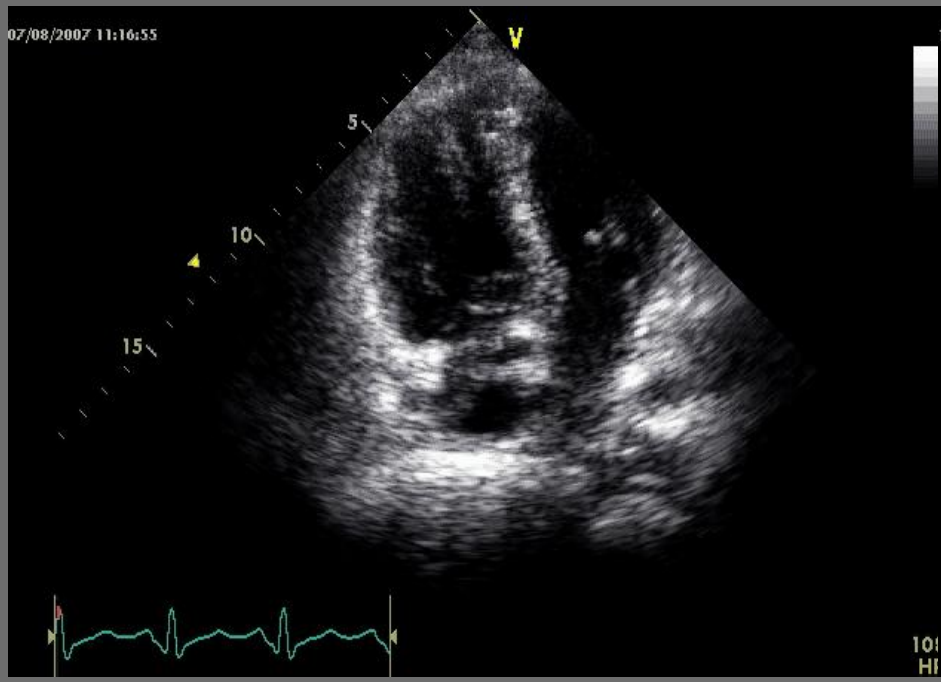
Cor pulmonale



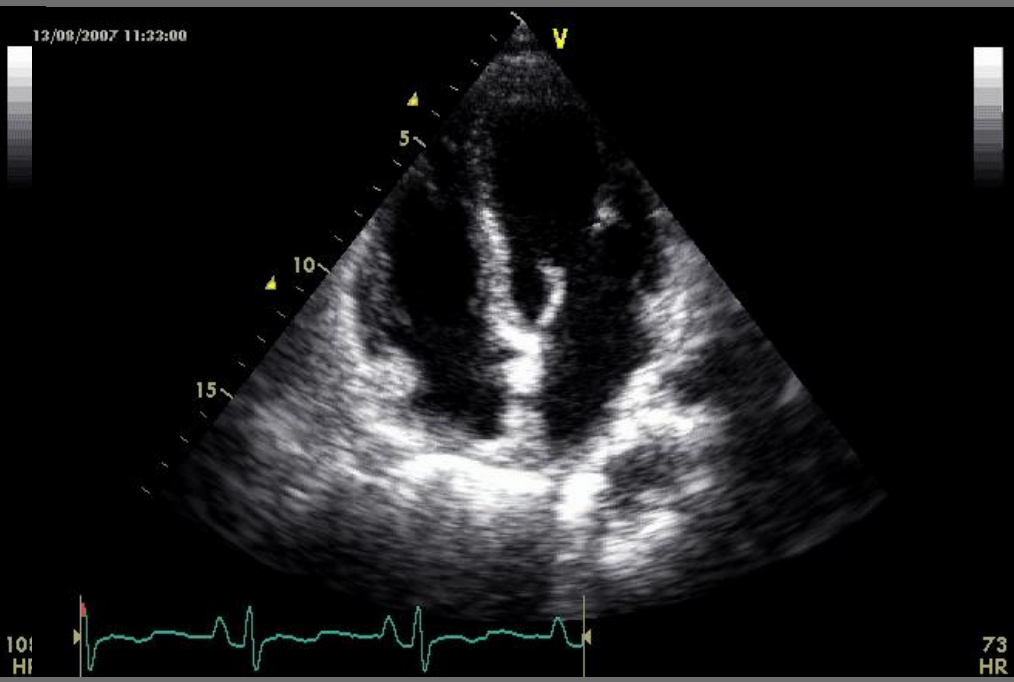
Echo in Monitoring Effects of Therapy for PE

- Reversal of RV dysfunction
- Normalization of RV ejection flow
- Reduction of PA systolic pressure
- Disappearance of thrombi

Day 1, before Th

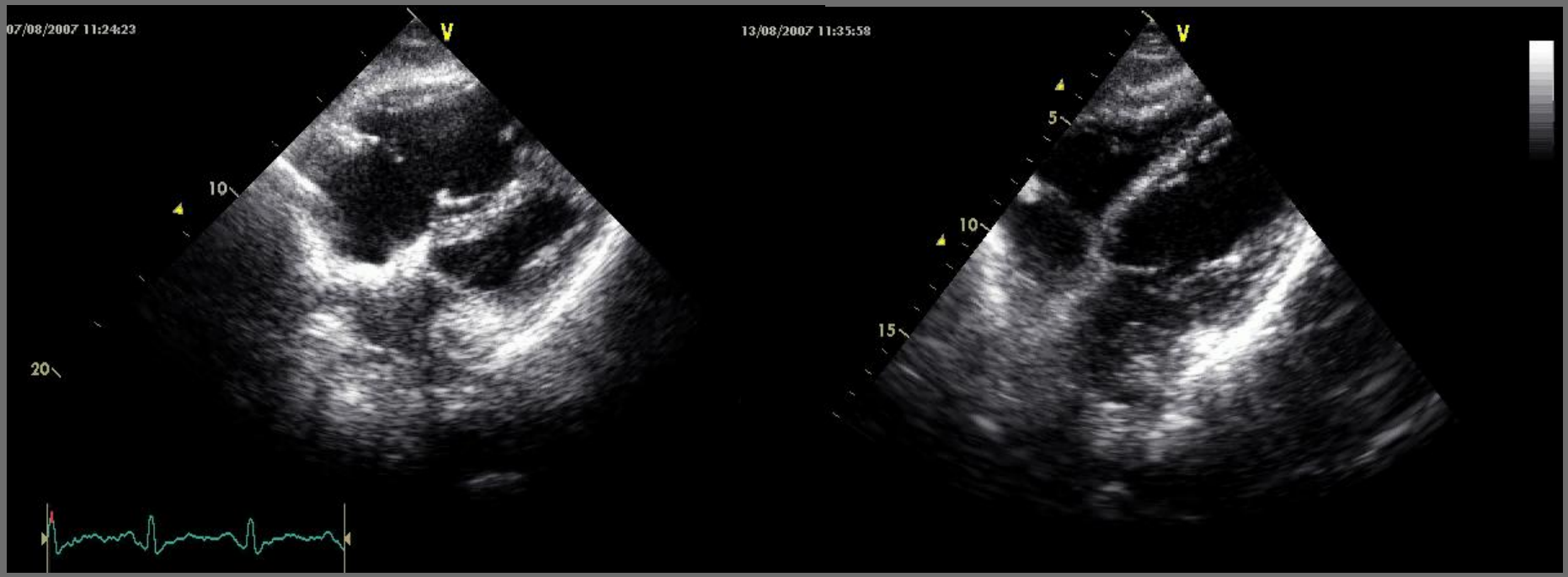


Day 3, after thrombolysis



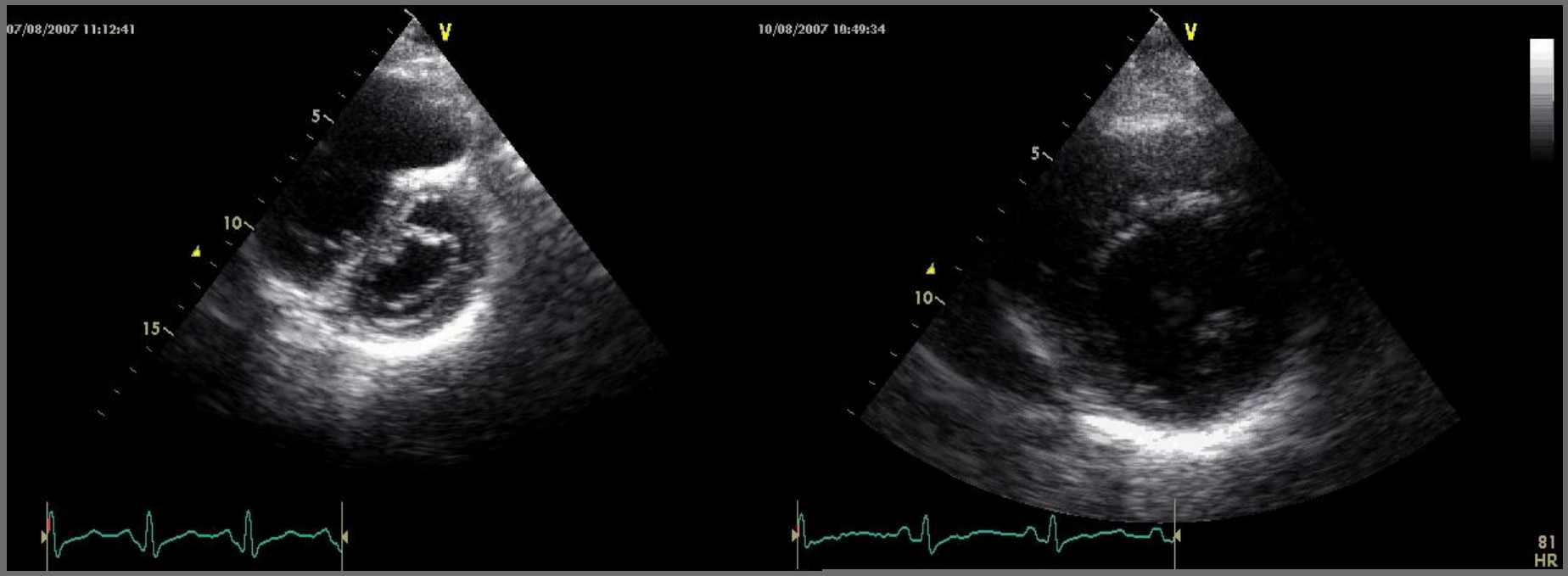
Day 1, before Th

Day 3, after thrombolysis

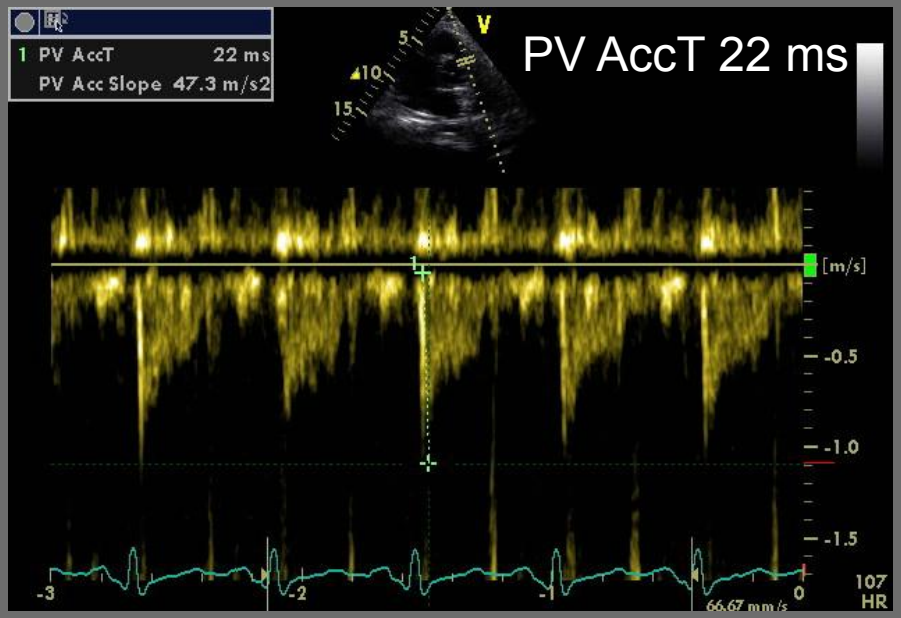


Day 1, before Th

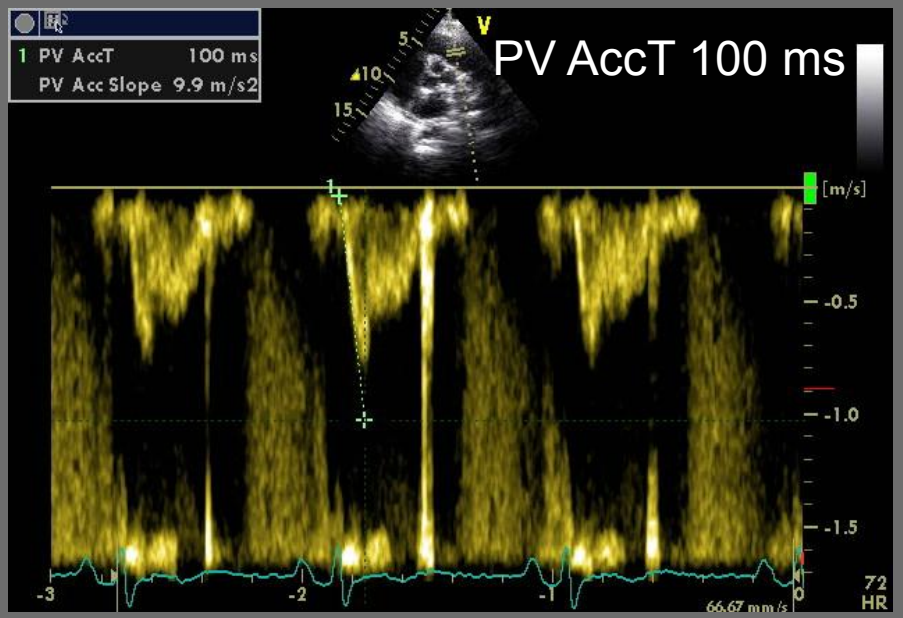
Day 3, after thrombolysis



Day 1, before Th



Day 3, after thrombolysis



Echo in PE

- Should not be used as a screening test for PE due to low sensitivity in unselected pts.
- May be useful in identifying pts with poor prognosis (RV dysfunction, PFO, right heart thrombus).
- TEE allows bedside direct confirmation of PE in selected pts with RV strain (in ~80% of cases).