Role of Echocardiography in pulmonary embolism

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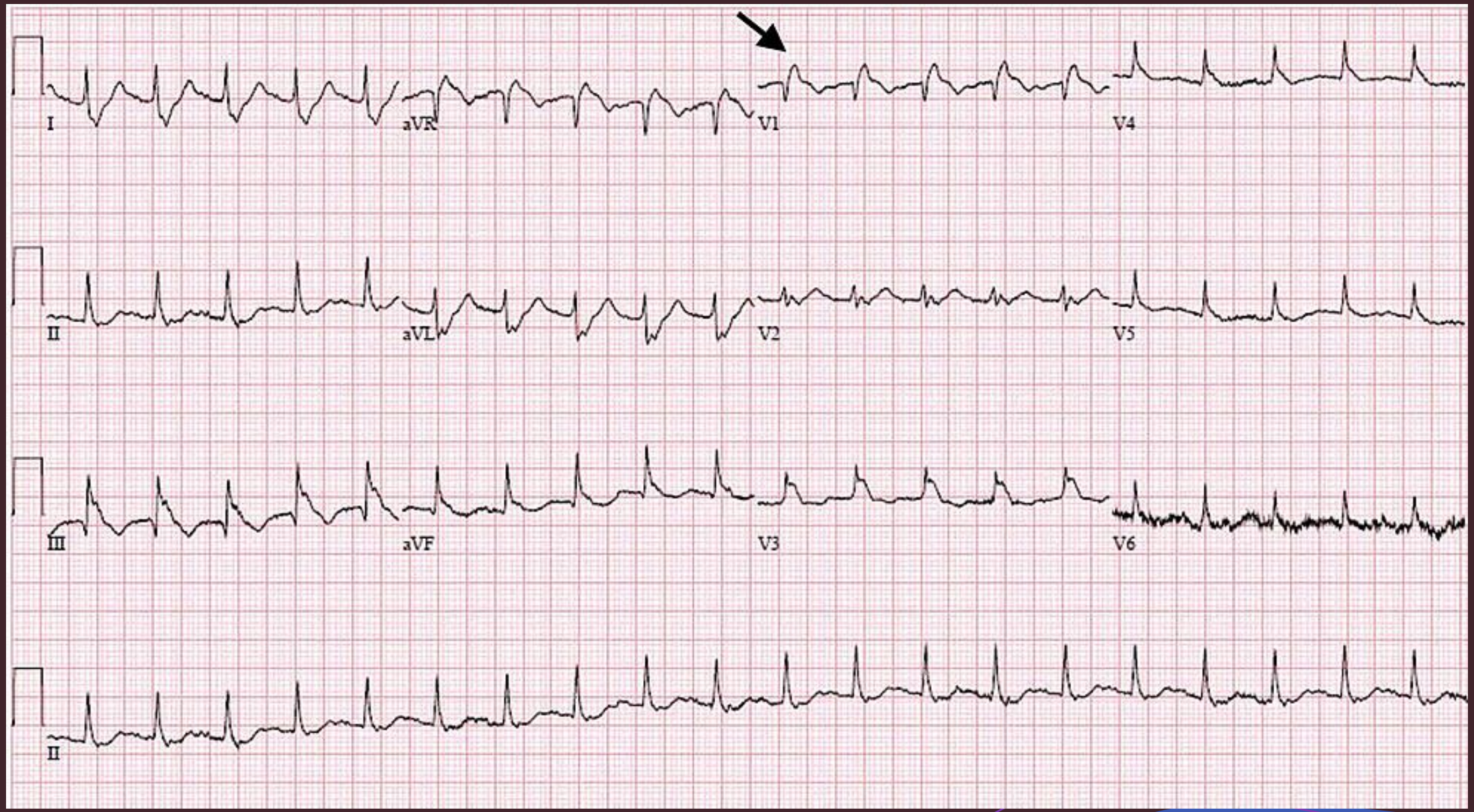
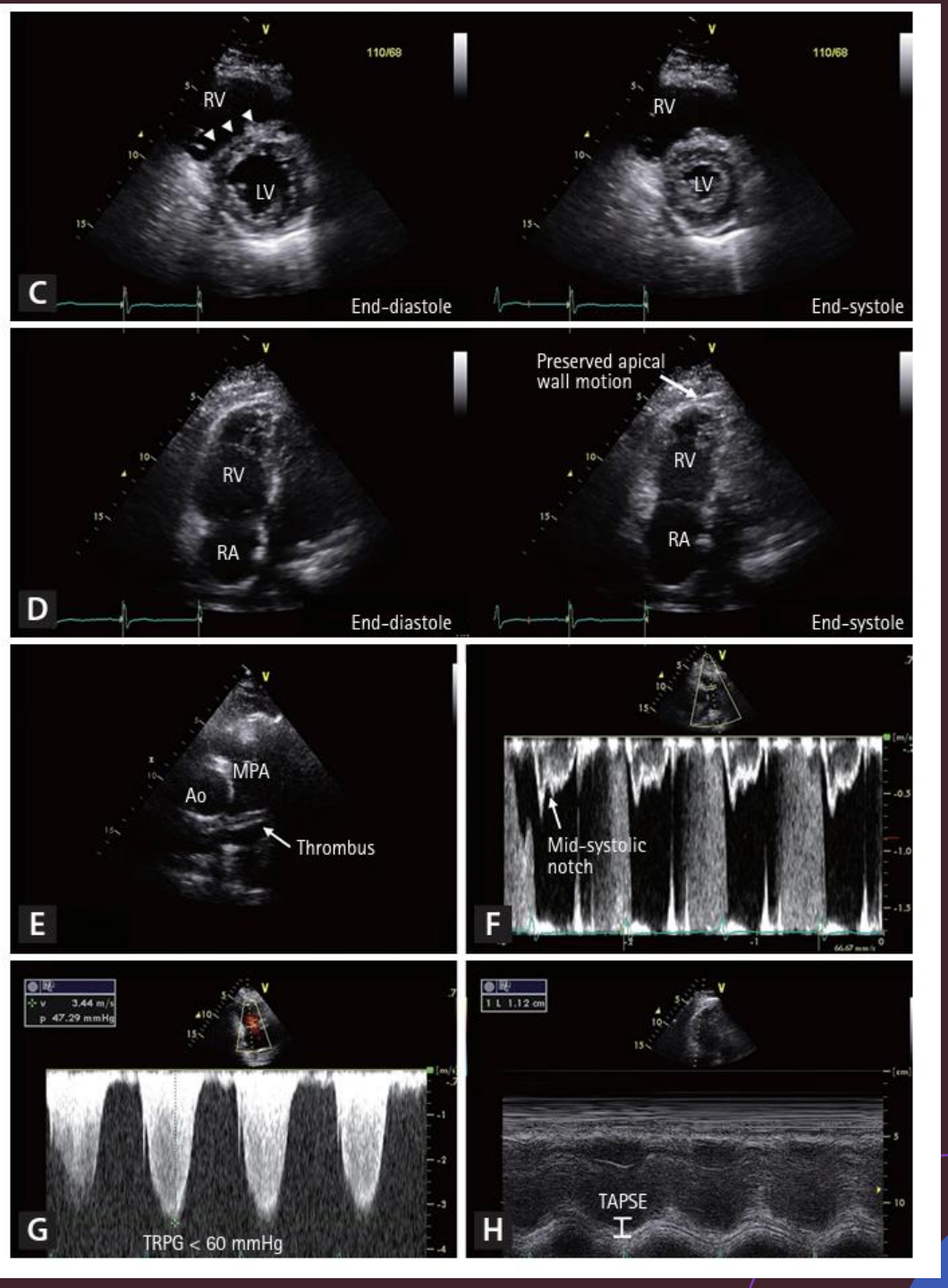
Case presentation

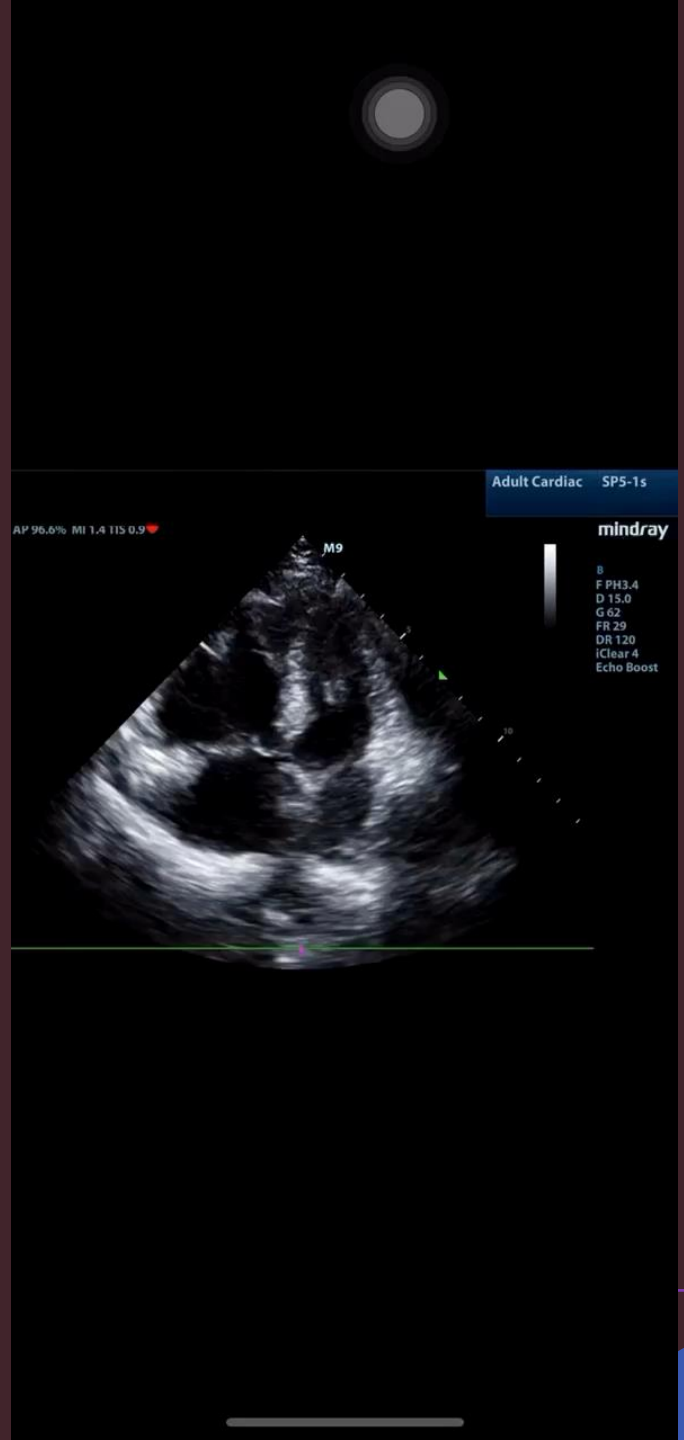
- 33-year-old man with a history of myotonic dystrophy presented with worsening dyspnea for 5 days.
- His initial blood pressure was 108/64 mmHg, heart rate was 120/min, respiratory rate was 25/min, and body temperature was 36.5°C. On physical examination, lung sounds were clear, and no cardiac murmur was found.
- electrocardiogram demonstrated sinus tachycardia and an S wave in lead I (S1), Q wave in lead III (Q3), T wave inversion in lead III (T3), and precordial leads V1-3 .

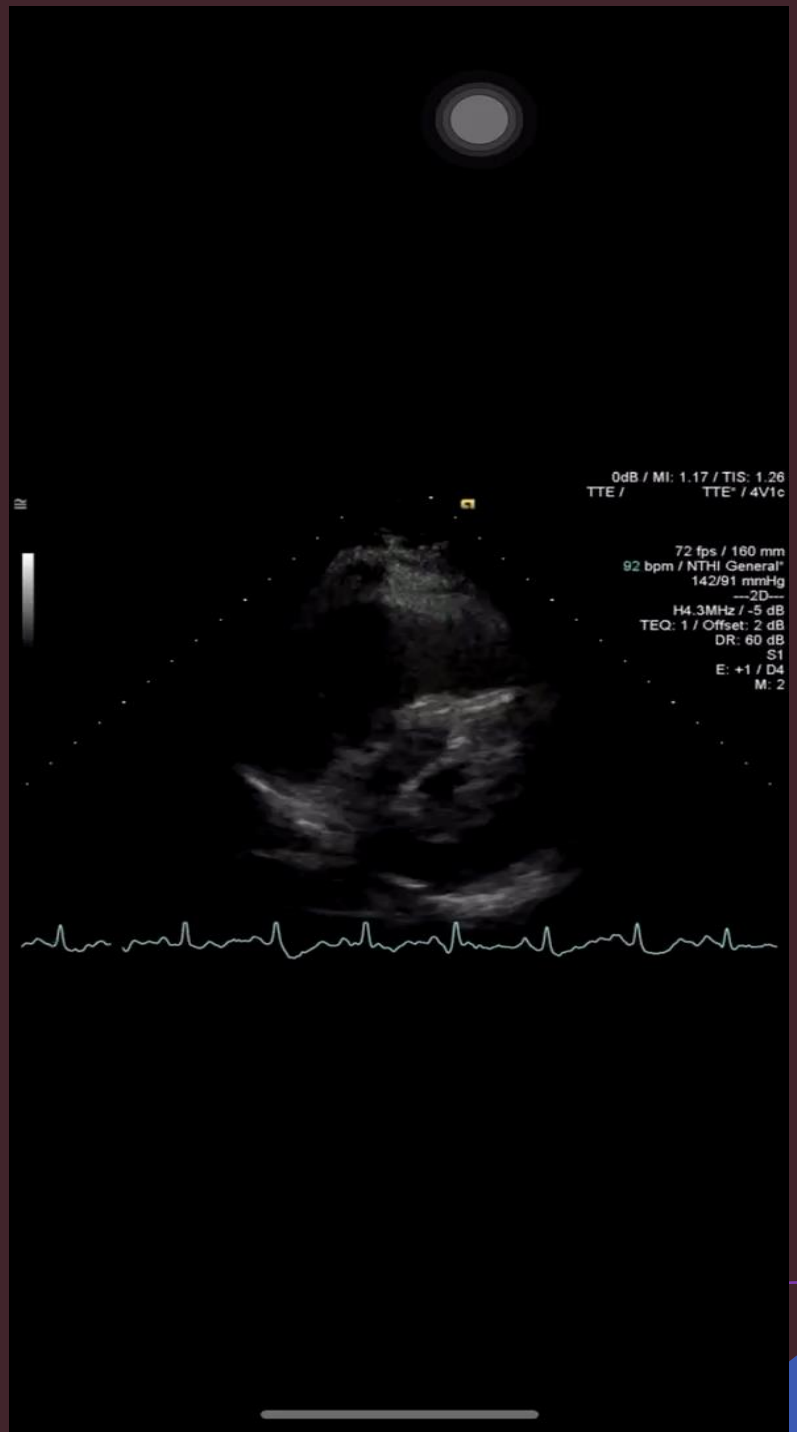

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II

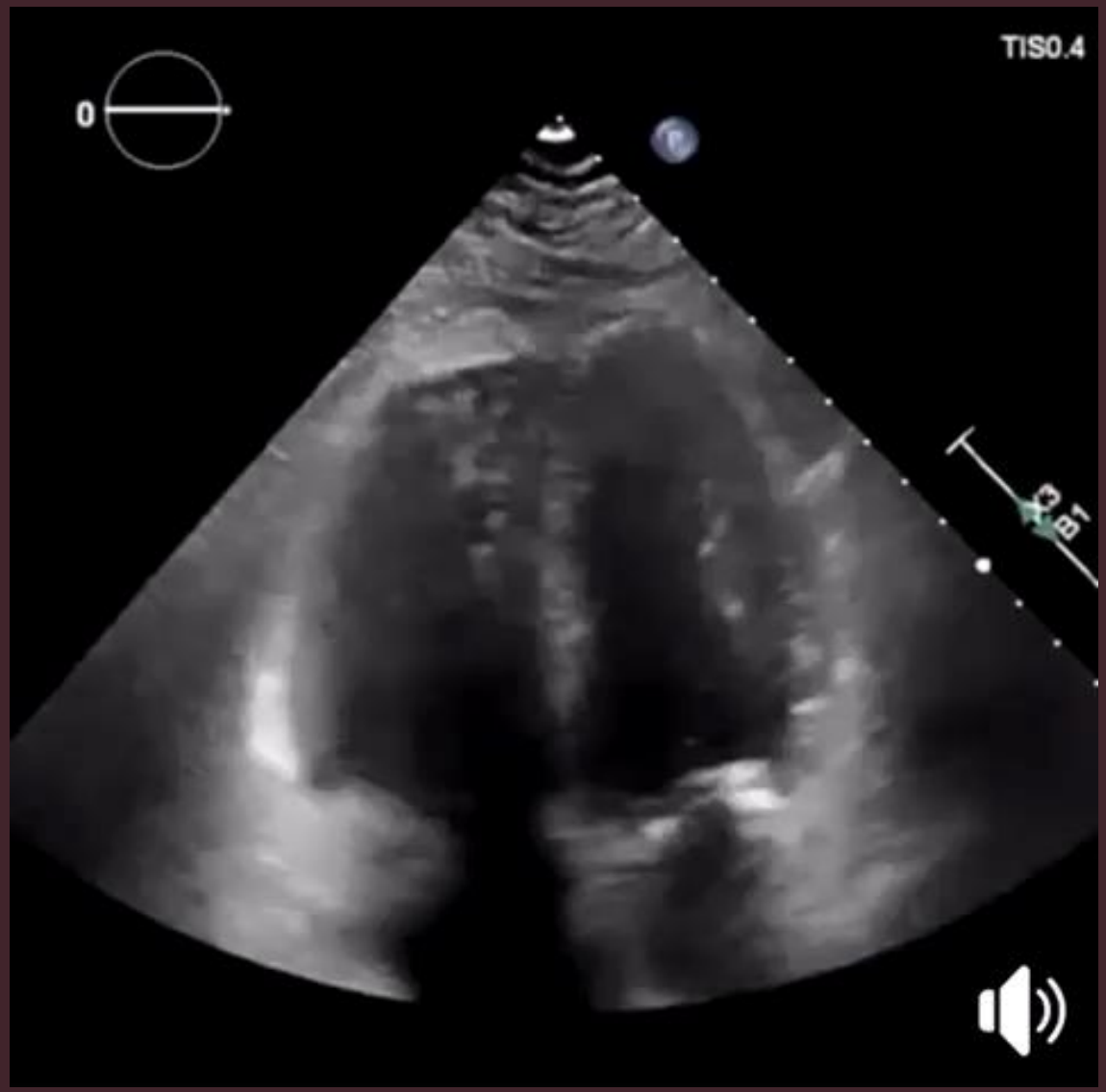
Bed side echocardiography

- Echocardiography showed a D-shaped left ventricle (LV) (Fig. 1C), McConnell's sign (Fig. 1D), linear thrombus in the main pulmonary artery (Fig. 1E), echocardiographic signs of the increased pulmonary arterial systolic pressure (Fig. 1F and 1G), and decreased right ventricular (RV) contractility assessed by tricuspid annular plane systolic excursion (TAPSE) (Fig. 1H).


110/68
RV
LV
C
End-diastole
110/68
RV
LV
End-systole
RV
RA
D
End-diastole
Preserved apical wall motion
RV
RA
End-systole
MPA
Ao
Thrombus
E
Mid-systolic notch
F
3.44 m/s
47.29 mmHg
TRPG < 60 mmHg
G
TAPSE
H


Adult Cardiac SP5-1s
AP 96.6% MI 1.4 TIS 0.9
M9
mindray
B
F PH3.4
D 15.0
G 62
FR 29
DR 120
iClear 4
Echo Boost


0dB / MI: 1.17 / TIS: 1.26
TTE /
TTE* / 4V1c
72 fps / 160 mm
92 bpm / NTHI General*
142/91 mmHg
---2D---
H4.3MHz / -5 dB
TEQ: 1 / Offset: 2 dB
DR: 60 dB
S1
E: +1 / D4
M: 2


TIS0.4
0


Cardio
S5-1
24 Hz
22,0cm
2D
HGen
Gn 56
C 50
3/2/0
75 mm/s


HESHMAT
Adult Echo
FR 70Hz
P2-4BA
AR/FSI 1
MLine Position

RECOMMENDATION OF ECHOCARDIOGRAPHY IN RECENT TREATMENT GUIDELINES

BOX 33.1 Potential Roles of Echocardiography for Evaluation of Known or Suspected Pulmonary Emboli

1. Contribute to the diagnosis.
2. Evaluate the hemodynamic consequences.
3. Assess the cardiopulmonary responses to therapeutic interventions.
4. Determine management.
5. Exclude other entities that may present like pulmonary emboli.

ECHOCARDIOGRAPHIC FINDINGS IN PATIENTS WITH PE

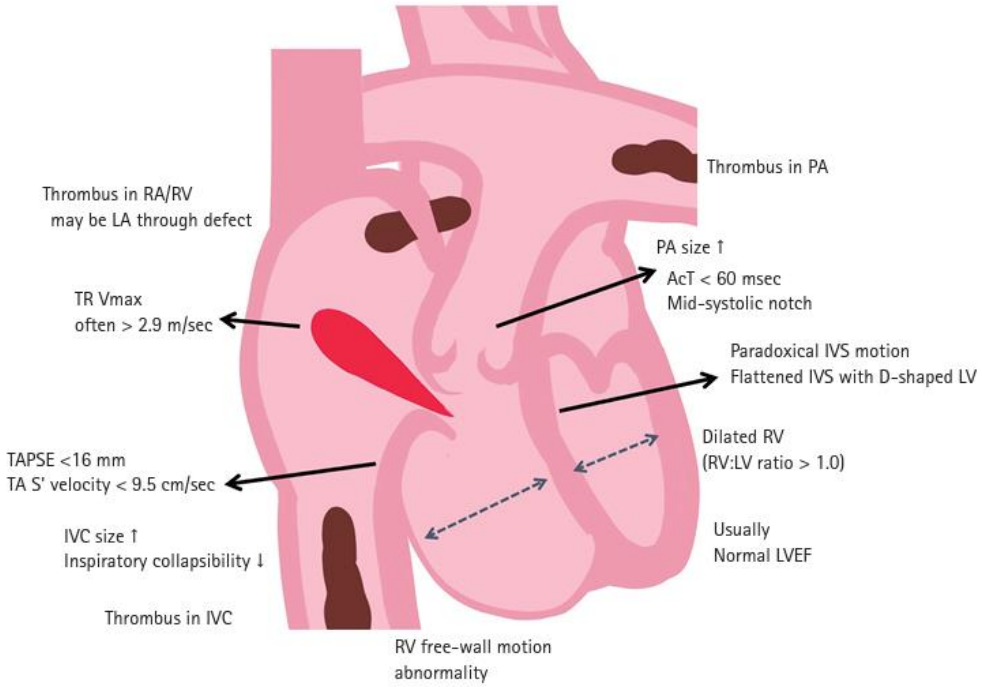
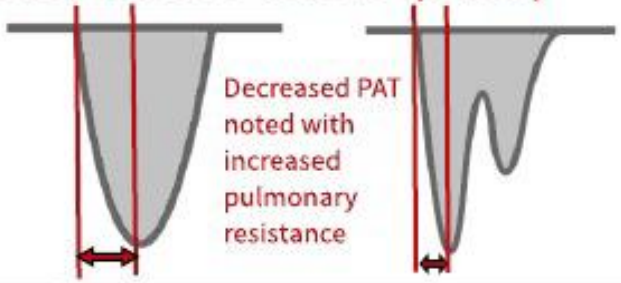


Figure 2. Schematic illustration of echocardiographic findings can be found in acute pulmonary embolism. RA, right atrium; RV, right ventricle; LA, left atrium; TR Vmax, maximal velocity of tricuspid regurgitation; TAPSE, tricuspid annular plane systolic excursion; TA, tricuspid annulus; IVC, inferior vena cava; PA, pulmonary artery; AcT, acceleration time of right ventricular outflow tract; IVS, interventricular septum; LV, left ventricle; LVEF, left ventricular ejection fraction.

The “60/60” sign

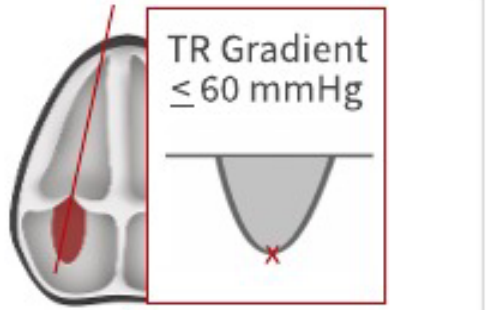
- The “60/60 sign” is defined as a pulmonary flow acceleration time < 60 ms in the presence of a tricuspid regurgitation (TR) pressure gradient of < 60 mmHg or a TR velocity < 3.9 m/sec, a Doppler echocardiographic PE sign based on a distorted RV ejection pattern.

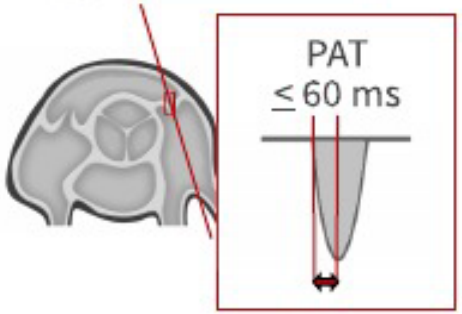
Pulmonary Acceleration Time (PAT)



- Parasternal Short-Axis
- PW Doppler
- Align Doppler with Flow
- Sample Volume at the Annulus

- Increase Sweep Speed
- Measure interval between:
  Onset of Pulmonary Flow & Peak Velocity





60/60 Echo Sign

TR Pressure Gradient

≤ 60 mmHg

AND

Pulmonary Acceleration Time (PAT)

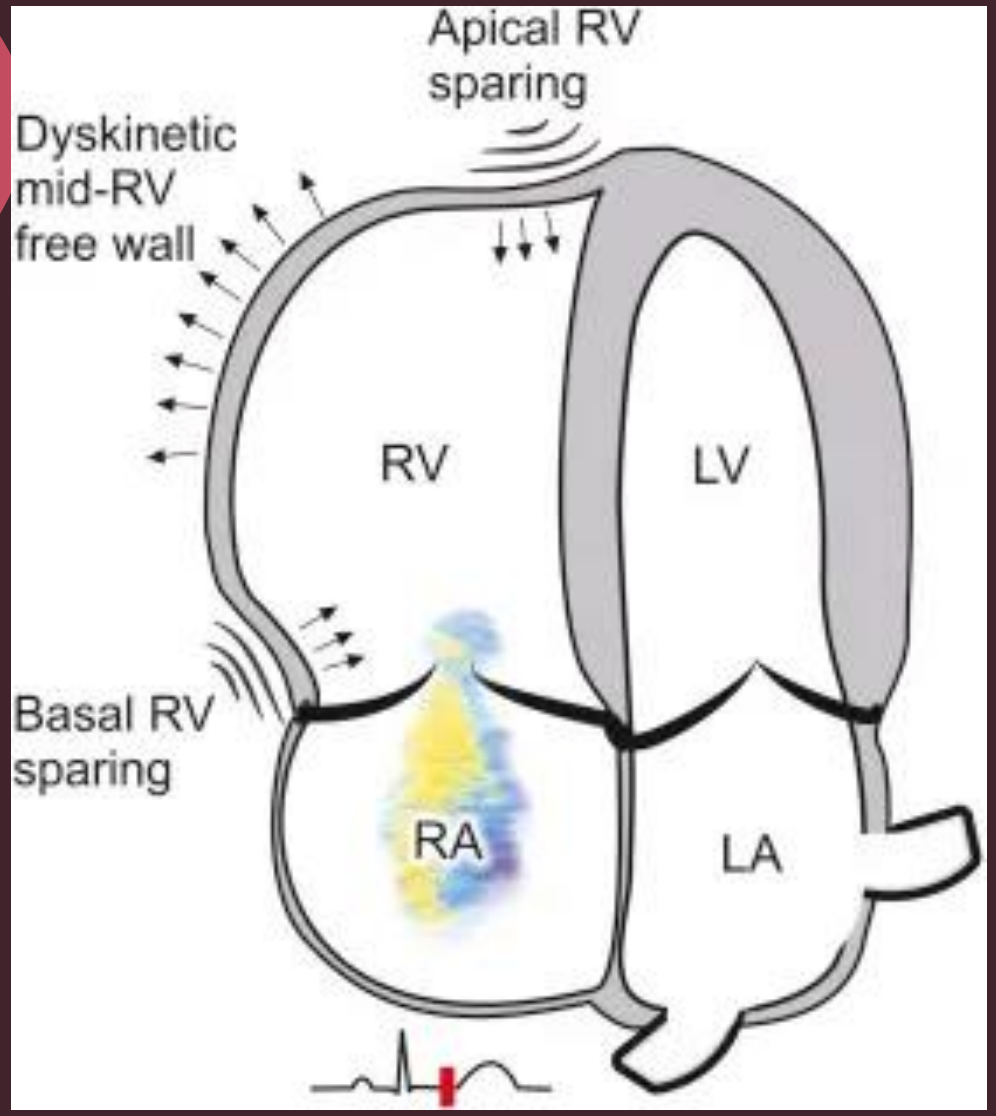
≤ 60 ms

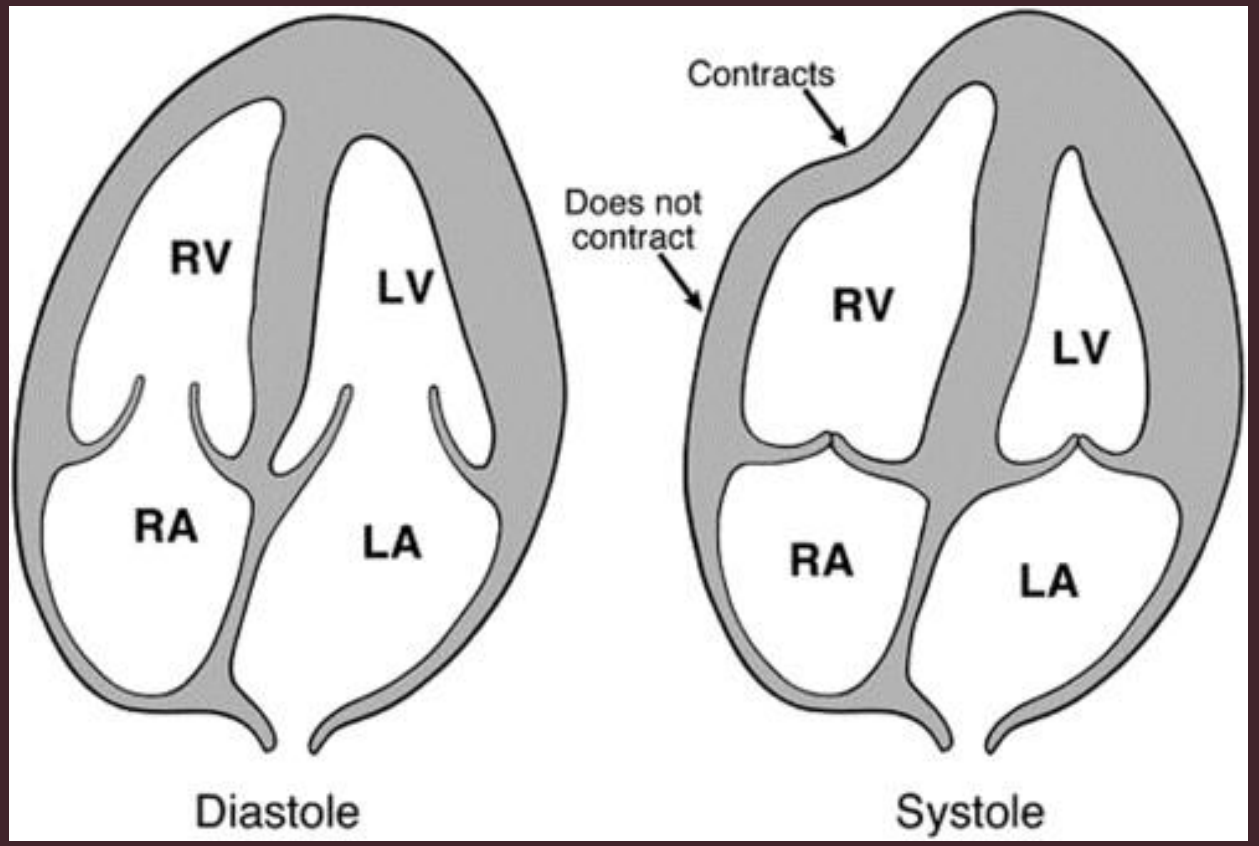
- short acceleration time and
- mid-systolic deceleration with a notched pattern is considered diagnostic of severe pulmonary hypertension
- Early systolic notching on the pulmonary Doppler flow tracing was found in 92% of patients with **massive or submassive** PE, and it was superior to McConnell's sign in PE diagnosis

Decreased RV free wall motion and systolic dysfunction

- In patients with acute PE, RV **hypokinesis** can be observed.
- It can also be observed in patients with **RV infarction**.
- The presence of **pulmonary hypertension** in patients with acute PE helps to distinguish this finding from that in RV infarction

- Patients with acute PE show decreased RV free wall motion with preserved RV apical motion (McConnell's sign), which is suggestive of acute PE .
- Initially, McConnell et al. reported that McConnell's sign could diagnose acute PE with a sensitivity of 77% and a specificity of 94%.

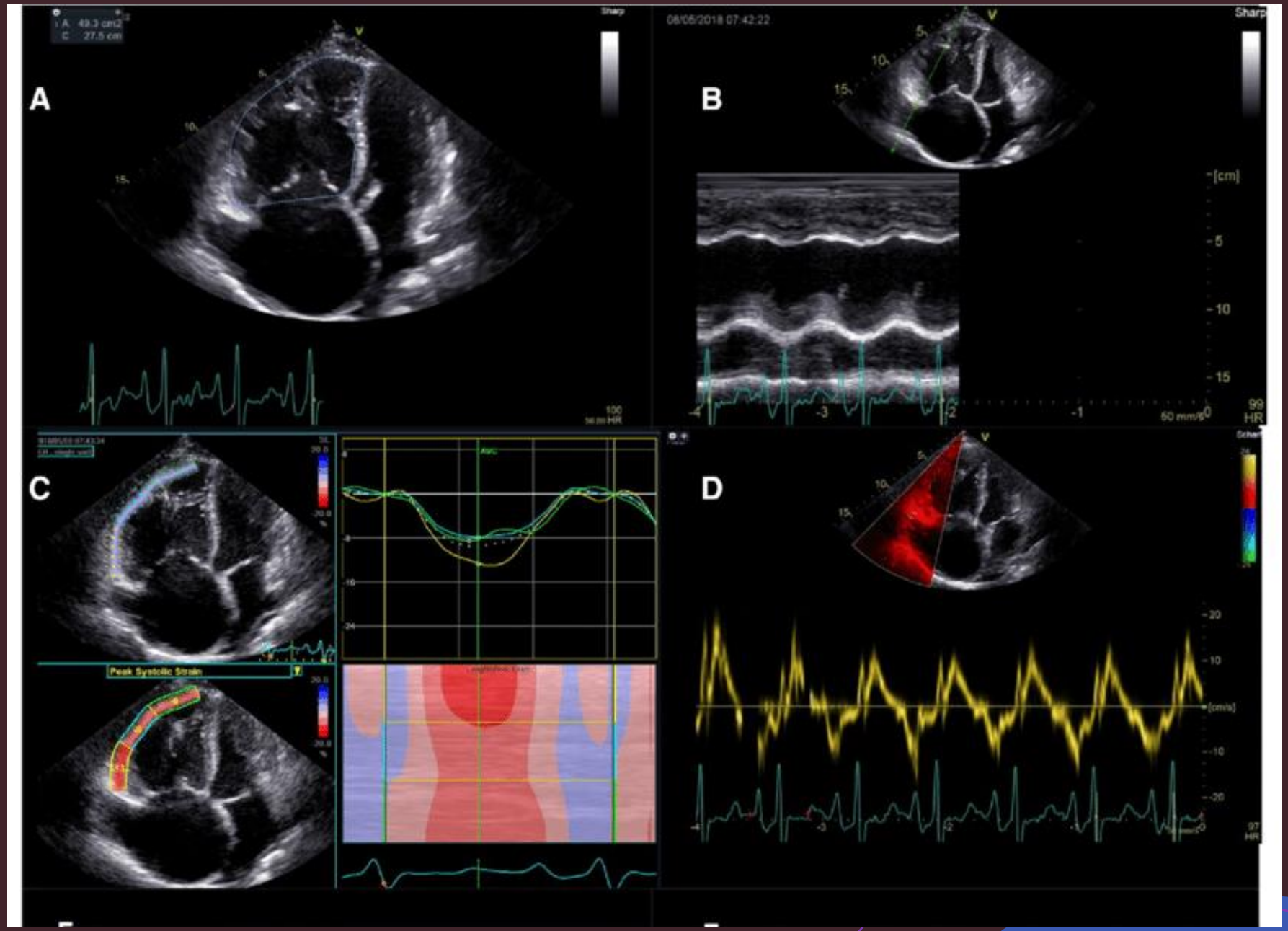




The combination of the “60/60” and McConnell signs increased the sensitivity without compromising the specificity

Other signs of RV dysfunction

- There are several echocardiographic markers of RV systolic dysfunction. Decreased TAPSE may be present in patients with acute PE
- A TAPSE < 1.6 cm was associated with higher pulmonary arterial pressure, higher incidence of RV dilatation and free wall hypokinesis
- . In addition, a tricuspid annular systolic velocity < 10 cm/sec, derived from Doppler tissue imaging of the lateral tricuspid annulus, is another RV systolic dysfunction marker
- Mid ventricular peak systolic strains of RV using speckle-tracking echocardiography provide objective findings of decreased RV free wall motion


A
B
C
D
Peak Systolic Strain

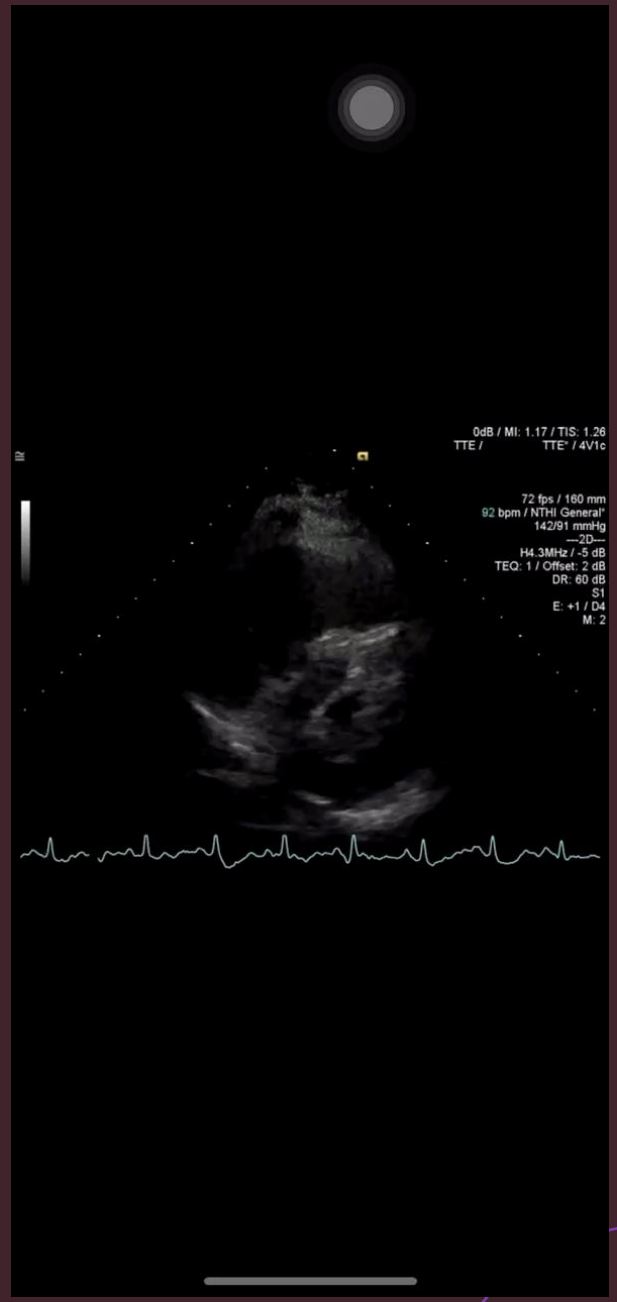
RV dilatation

- RV dilatation could occur due to increased RV afterload; it can be diagnosed when the RV basal diameter is > 42 mm and the RV diameter at the midlevel is > 35 mm
- RV/LV ratio > 1.0 indicates RV dilatation
- ilt can be found in about 27.4% of patients with acute PE
- In one prospective study with 146 patients, RV dilatation on bedside echocardiography had high specificity (98%) and poor sensitivity (50%) in detecting PE

Morphology and motion of the interventricular septum

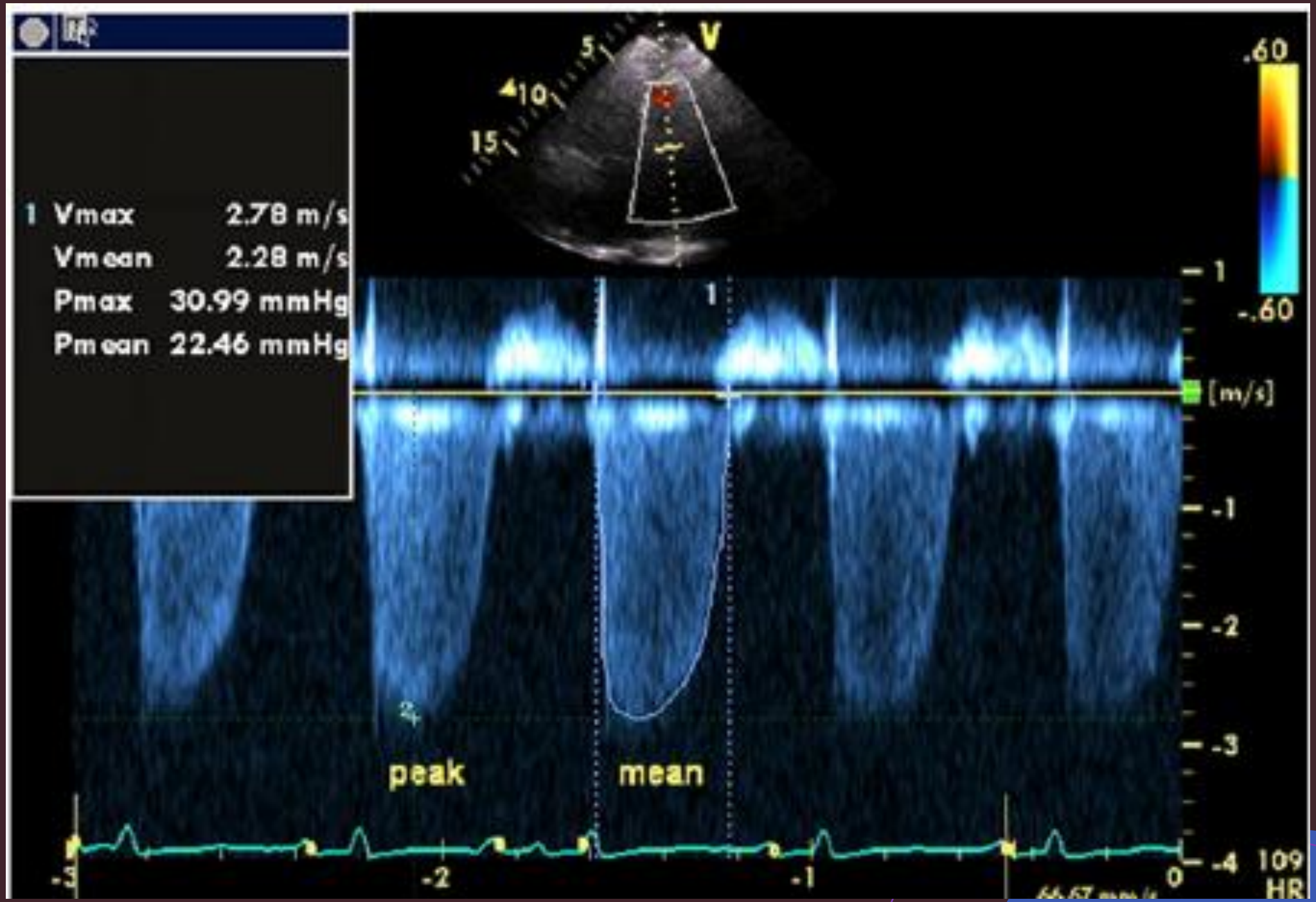
- Patients with RV pressure overload can have a flattened or bowed interventricular septum (IVS) toward the LV at end-diastole and end-systole.
- In the parasternal short axis view, the LV becomes a D-shaped cavity as the IVS flattens and loses its convexity due to increased RV pressure during diastole
- Paradoxical septal motion on echocardiography, along with RV dilatation, RV hypokinesis, McConnell's sign (RV free wall hypokinesis with apical sparing), and increased TR velocities, are evidences of RV dysfunction
- **signs of advanced RV dysfunction were associated with a higher thrombus burden**. These findings were more significant in patients with more proximal emboli, such as the saddle, lobar, and mainstem emboli in the pulmonary arterial bed


mindray


0dB / MI: 1.17 / TIS: 1.26
TTE /
TTE* / 4V1c
72 fps / 160 mm
92 bpm / NTHI General*
142/91 mmHg
---2D---
H4.3MHz / -5 dB
TEQ: 1 / Offset: 2 dB
DR: 60 dB
S1
E: +1 / D4
M: 2

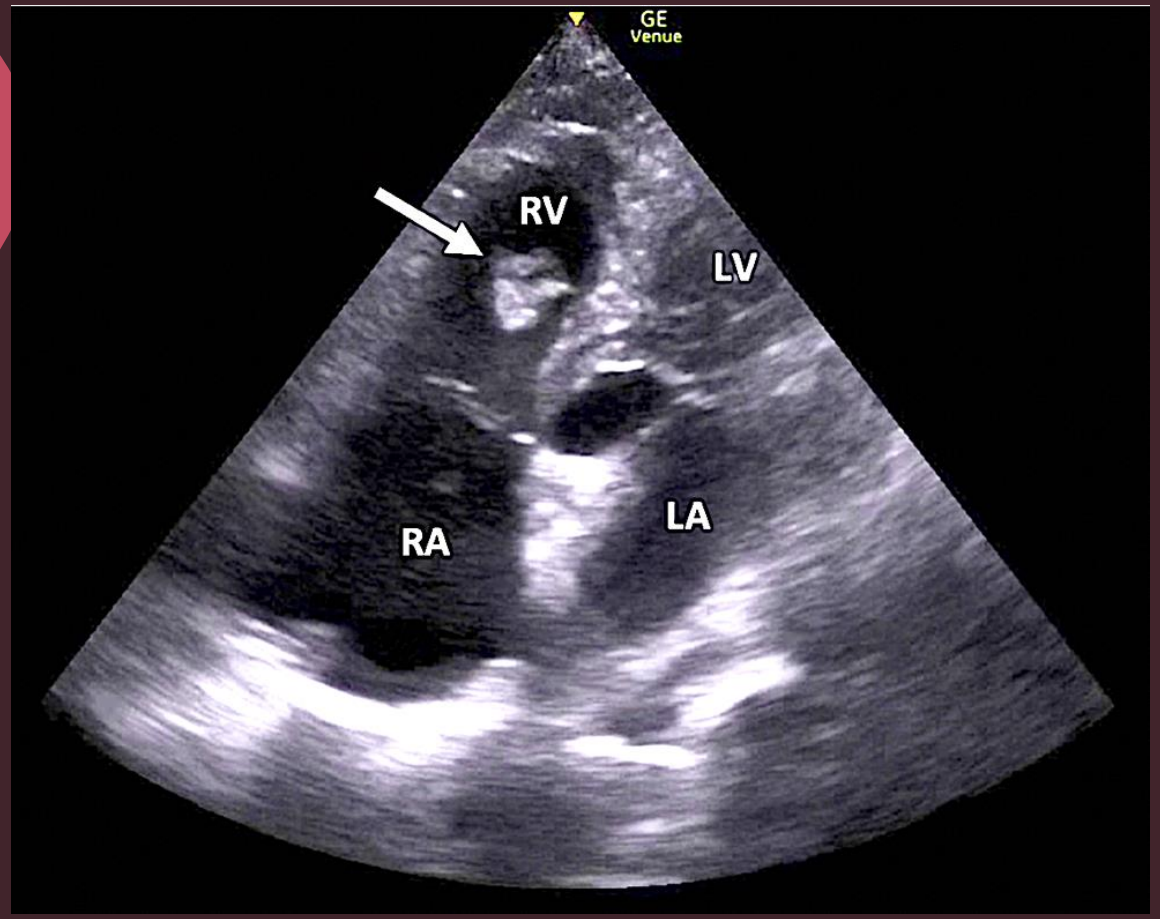
Pulmonary hypertension

- Pulmonary hypertension is high blood pressure affecting the pulmonary arteries. In patients with acute PE, increased total pulmonary resistance originates from mechanical obstruction of the pulmonary arteries and humoral factors secreted due to hypoxia
-
- The method of choice for noninvasive estimation of pulmonary arterial pressure is continuous wave Doppler measurement of the peak velocity of the regurgitant jet across the tricuspid valve (maximal velocity of tricuspid regurgitation [TR Vmax]).


1 Vmax 2.78 m/s
Vmean 2.28 m/s
Pmax 30.99 mmHg
Pmean 22.46 mmHg
5
10
15
V
.60
-.60
1
[m/s]
-1
-2
-3
-4
peak
mean
-3
-2
-1
0
109
HR

Visualization of emboli in the right heart and pulmonary arteries

- Emboli, usually originating from deep vein thrombi, can be found anywhere in the inferior and superior venae cavae, right atrium (RA), RV, and pulmonary arteries. Since thrombi form in deep veins, emboli are usually elongated in shape. Sometimes, emboli from tumors or myxomas can be round in shape


GE
Venue
RV
LV
LA
RA


Auto
5
10

Echocardiographic signs of RV strain

- Echocardiographic RV strain parameters include RV dilatation (RVEDD > 30 mm at the apical four-chamber view),
- McConnell's sign,
- paradoxical interventricular septal motion, and
- visible thrombi in the right heart or pulmonary arteries

Diagnostic power of echocardiographic findings

- right heart strain was the most common sign (sensitivity 73%, specificity 75%)
- echocardiographic signs showed a low negative predictive value; therefore, none of them can rule out PE except the presence of clots in the right heart chambers and pulmonary arteries.

- Signs of RV overload or dysfunction may be observed even in the absence of acute PE with concomitant cardiac or respiratory disease condition.
- echocardiography is **limited as a potential gold standard** for ruling in or out a PE diagnosis, and clinicians should consider further advanced imaging tests in case of a discordance between clinical judgement and the echocardiographic parameters

ROLE OF ECHOCARDIOGRAPHY IN THERAPEUTIC STRATEGIES

- early identification of RV systolic dysfunction in high-risk patients with acute PE is essential in promptly deciding whether to administer thrombolytic therapy

- **Many critically ill patients cannot undergo more advanced imaging; therefore, bedside echocardiography should be performed at an emergency department or intensive care unit to identify RV systolic dysfunction**

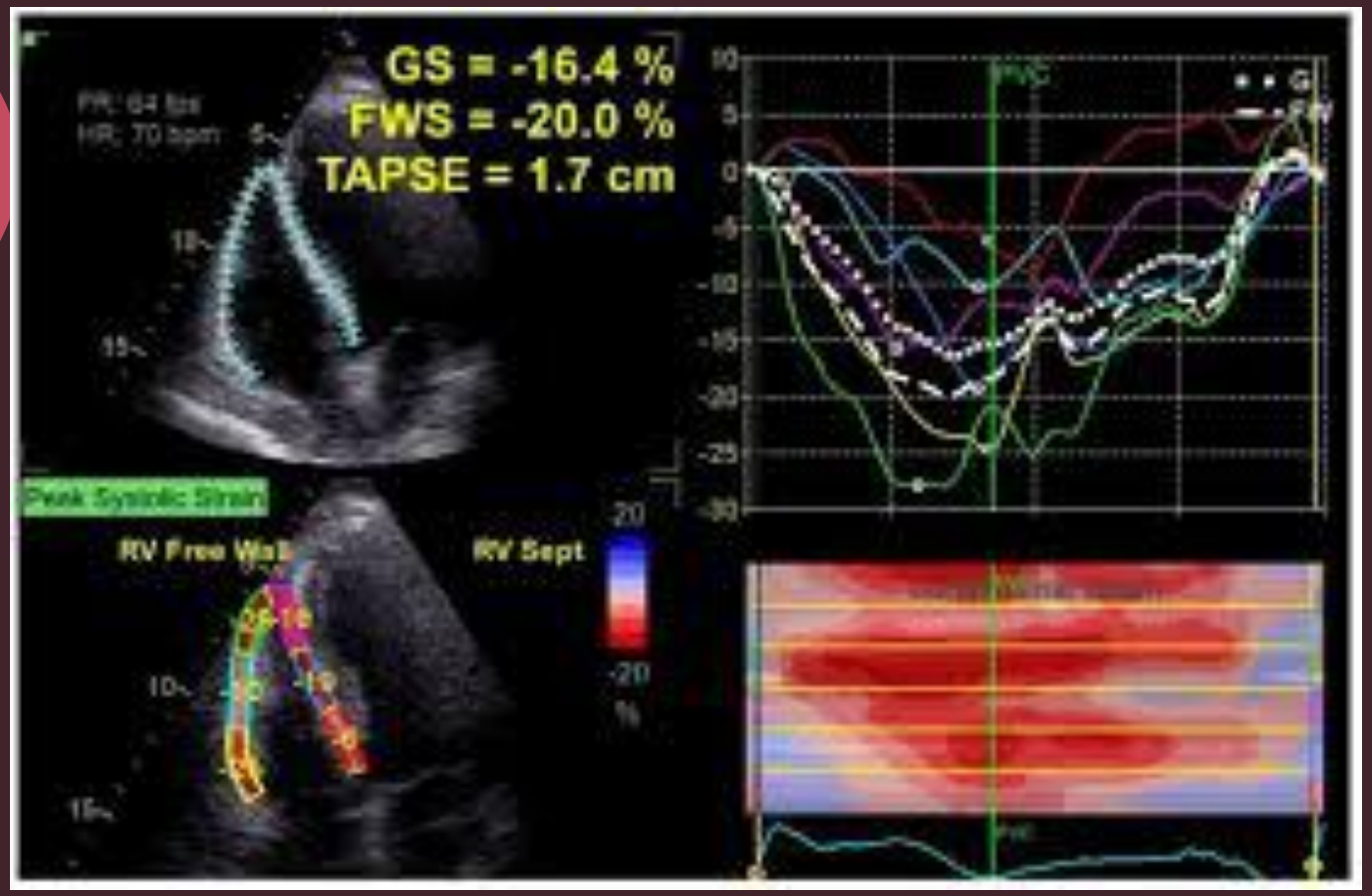
PROGNOSTIC VALUE OF ECHOCARDIOGRAPHIC PARAMETERS IN ACUTE PE

- **Presence of RV systolic dysfunction :**RV dysfunction was associated with an increased risk of short-term mortality, even in hemodynamically stable patients with acute PE
- **Decreased TAPSE**:TAPSE < 16 mm is regarded as decreased RV systolic function and is the most frequently reported finding associated with unfavorable prognoses in acute PE
- **TAPSE is a better predictor of acute PE-related outcomes than the RV/LV diameter ratio in normotensive patient**s
- Patients with TAPSE > 20 mm can be considered very low-risk patients who may be candidates for a short hospital stay or even outpatient treatment.

- **Presence of thrombi in the right heart:**Prevalence of right heart thrombi may reach 18% among patients with PE in the intensive care setting.
- rarely found in normotensive patients without echocardiographic evidence of RV dysfunction (1.0%)
- In low risk patients without hemodynamic instability or RV systolic dysfunction, the presence of right heart thrombi had no impact on mortality.
- In particular, the prognosis was more related to the hemodynamic status than to thrombi characteristics

- **Decreased RV longitudinal strain:**RV mid free wall longitudinal strain and 3-dimentional RV EF were independently associated with 6-month adverse outcomes

- RV free wall and global wall strain is an independent prognostic marker for inhospital events in patients with acute nonmassive PE.



RV longitudinal strain measured by two-dimensional speckle-tracking echocardiography can assess RV myocardial systolic function without the confounding effect of angle dependency and tethering.


THANK YOU
For Your Attention!