

IMAGING OF THE CARDIOVASCULAR SYSTEM



Component parts of medical imaging used for investigation of cardiovascular system

- A. Radiology
- B. Ultrasonography
- C. Magnetic resonance imaging (MRI)
- D. Nuclear medicine
- E. Thermography

Radiology

- Conventional radiography

- Contrast radiography :

 - Angiography

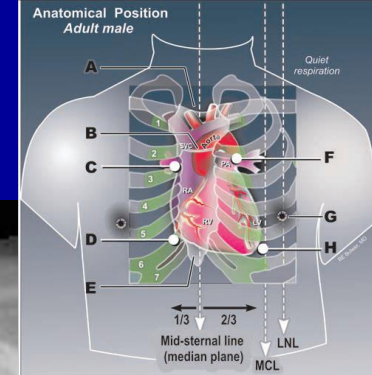
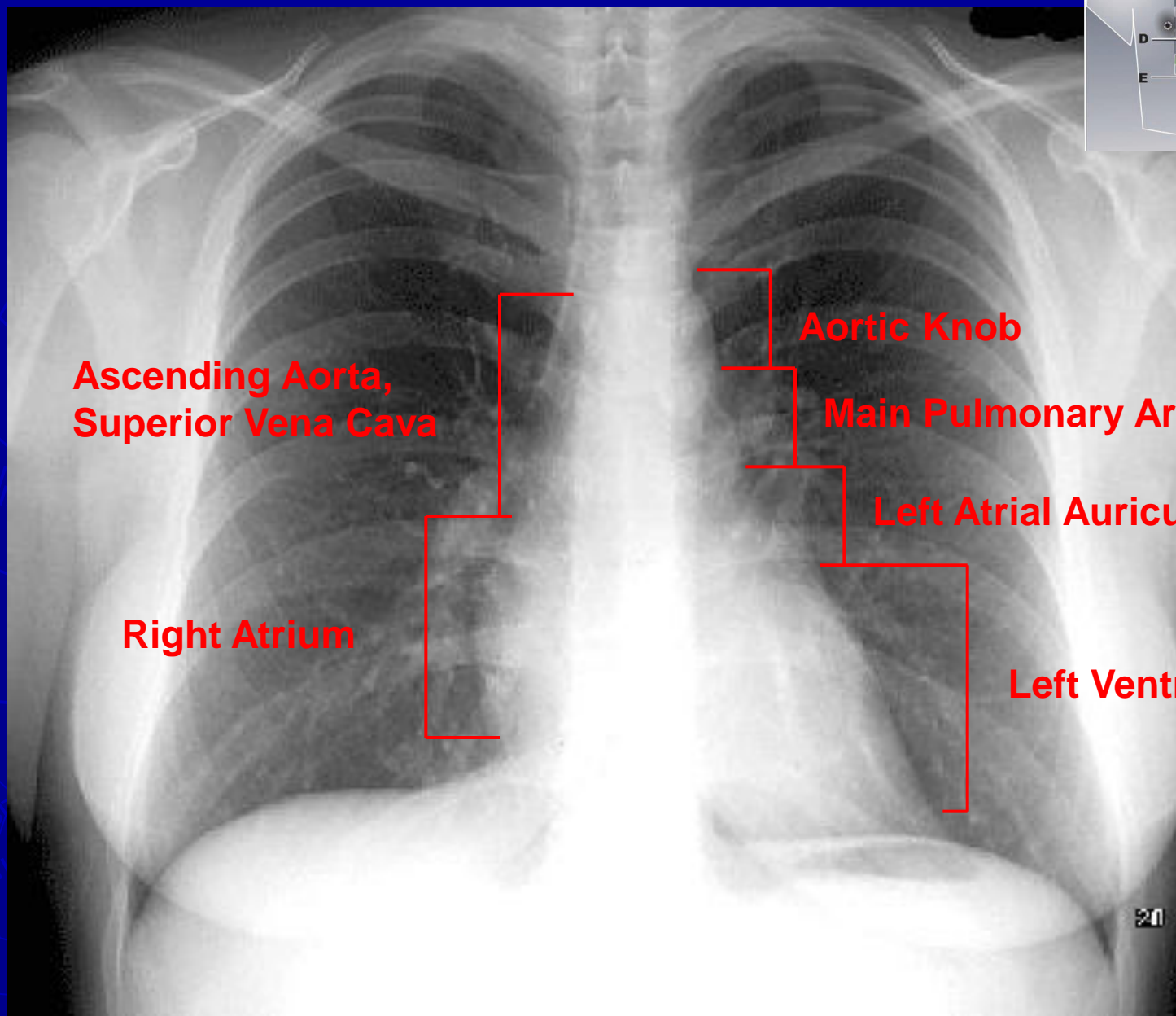
 - Ventriculography (cardiac catheterism)

- Computed tomography

Actually, we use simple chest X-ray for patients with cardiovascular pathology to estimate:

- Heart dimensions (CTR)
- Pulmonary vasculature (pulmonary pattern)
- Mediastinum

Cardiovascular Imaging

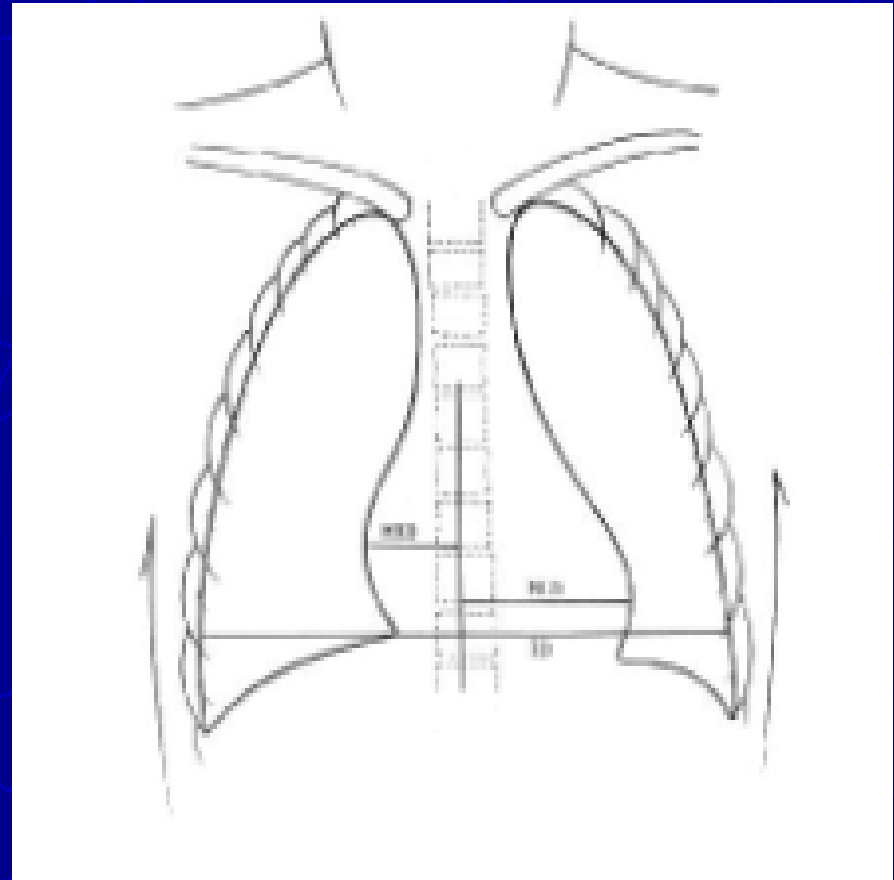


Cardio-toracic ratio (CTR)

CTR is a relation between maximal transverse diameter of the heart shadow and this of the chest (estimated using simple chest X-ray).

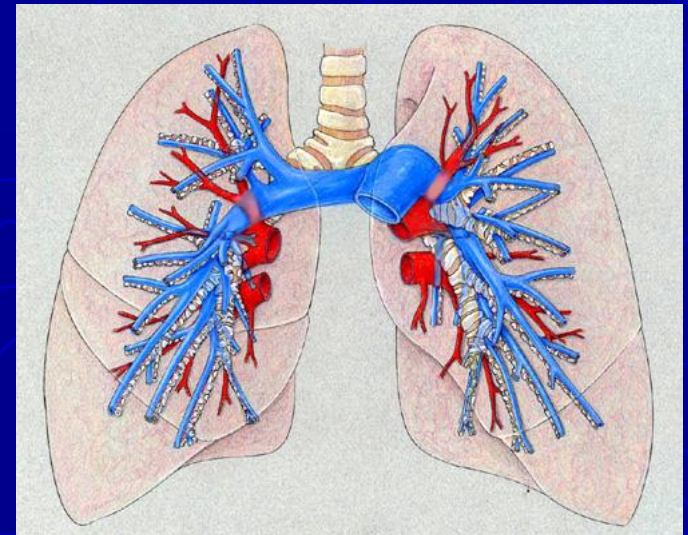
Normal CTR:

- ✓ new-born: $\leq 0,58$
- ✓ teenagers and adults: 0,44-0,48
- ✓ in elderly: 0,50-0,55



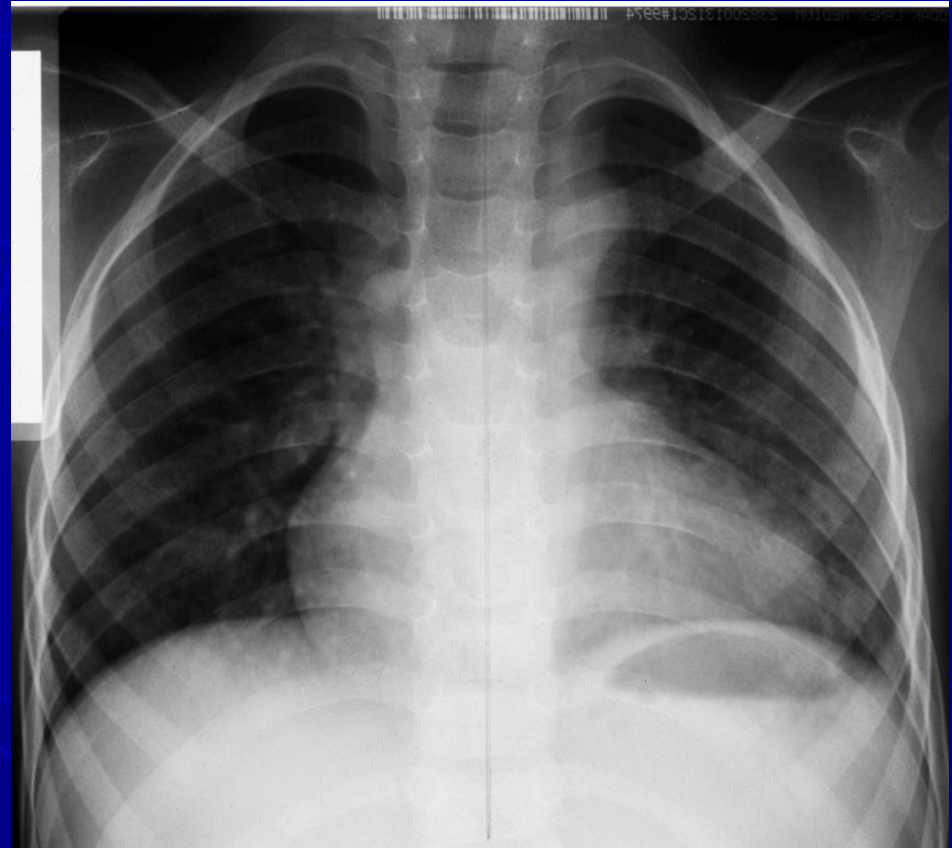
Changes of the pulmonary vasculature (pulmonary pattern) in cardiovascular pathology

- Hypovolemia
- Hypervolemia
- Venous congestion
- Pulmonary hypertension:
 - arterial
 - venous
 - mixt



Pulmonary vasculature: Hypovolemia

- ✓ Pulmonary hyperlucency
- ✓ Narrow peripheral pulmonary arteries
- ✓ Narrow hilum
- ✓ Changes of the PA convexity



Pulmonary vasculature: Arterial hypervolemia

- ✓ Dilated pulmonary arteries
- ✓ Dilated hilum
- ✓ Evident PA convexity



Pulmonary vasculature: Pulmonary arterial hypertension

- ✓ Dilated hilum
- ✓ Narrowed peripheral arteries
- ✓ Evident PA convexity
- ✓ Narrowed pulmonary veins



Pulmonary vasculature: Venous congestion.

Pulmonary edema

Pulmonary venous congestion.

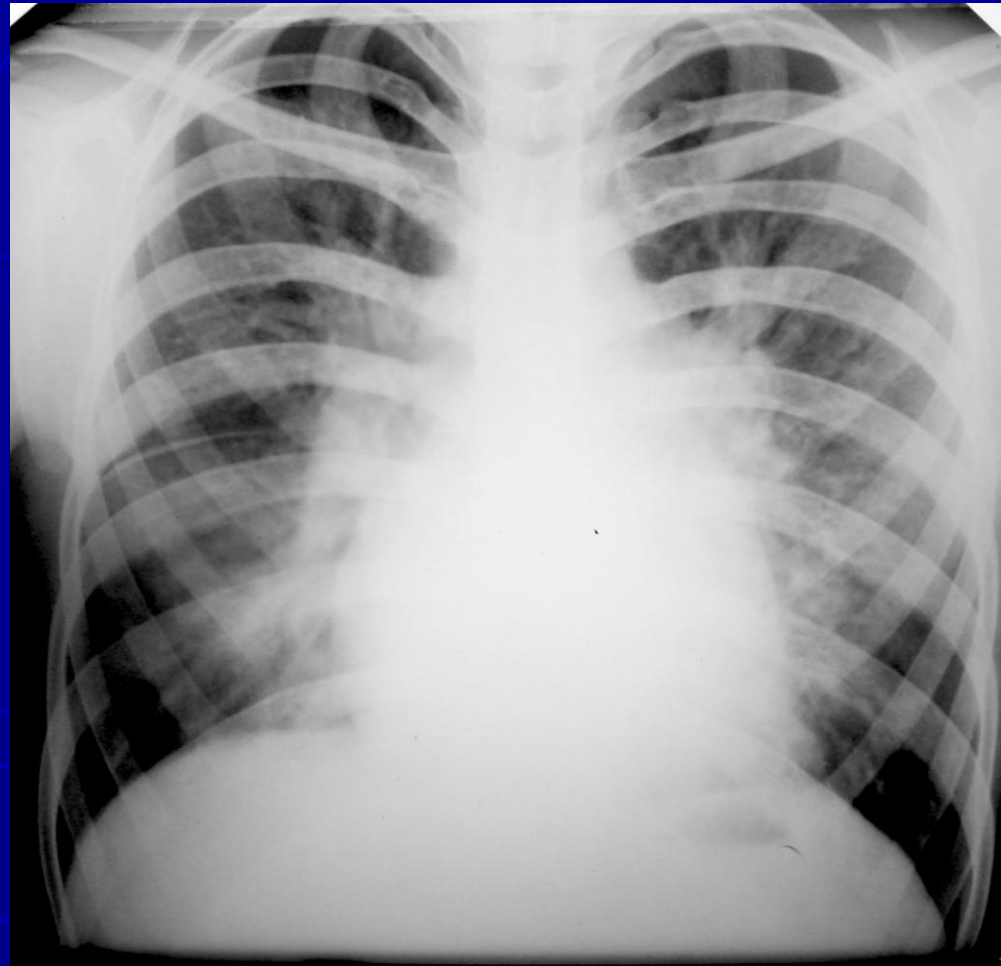
Interstitial edema

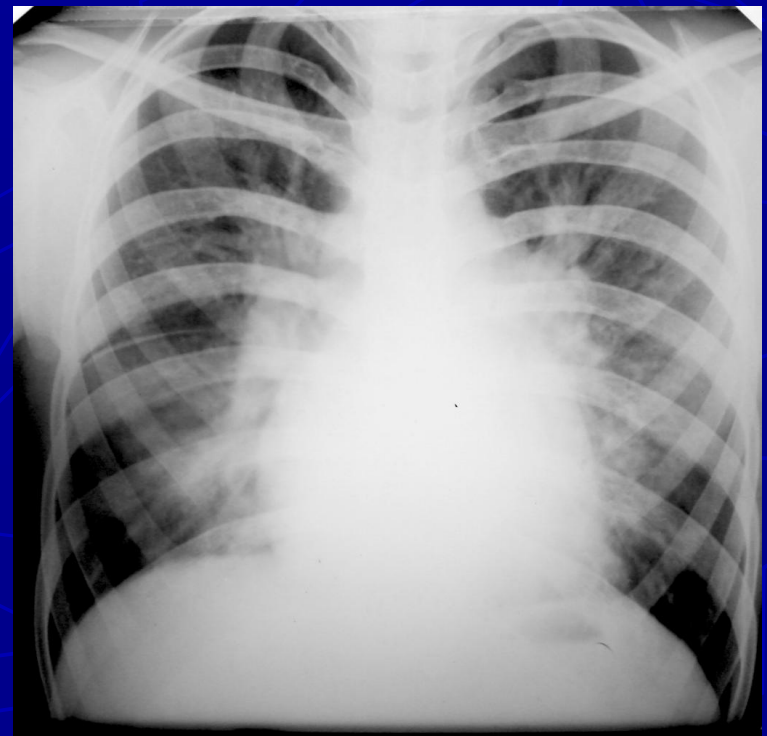
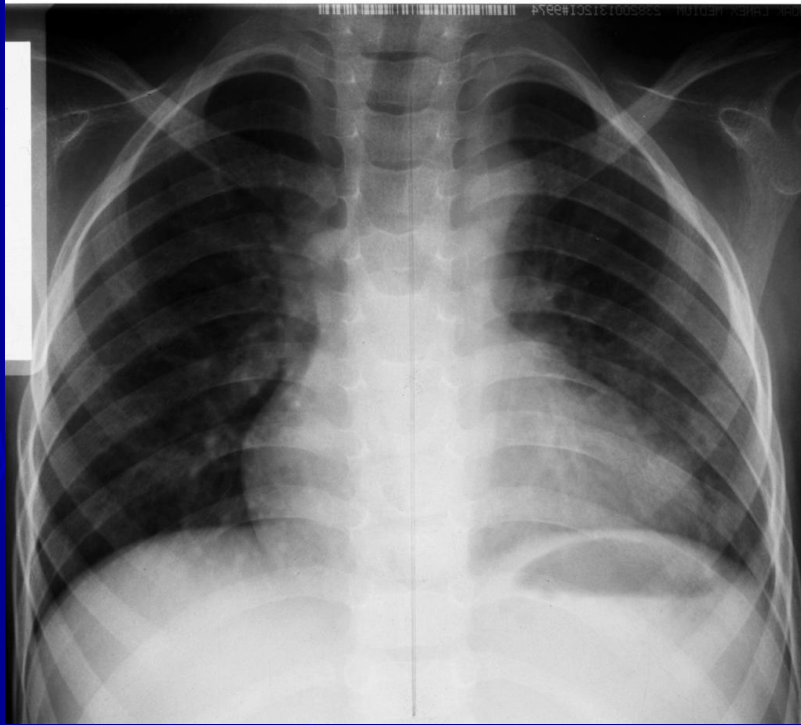
- ✓ Homogenized hilum
- ✓ Diminuation of the pulmonary transparency
- ✓ Unclear contour of blood vessels and bronchial
- ✓ Lines of Kerley

Normal values of middle capillary pressure:

5-10 mm Hg

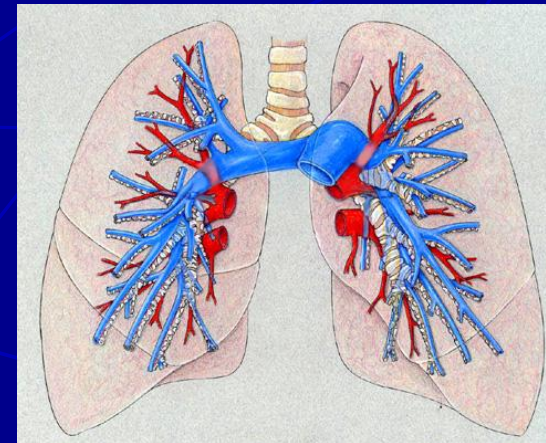
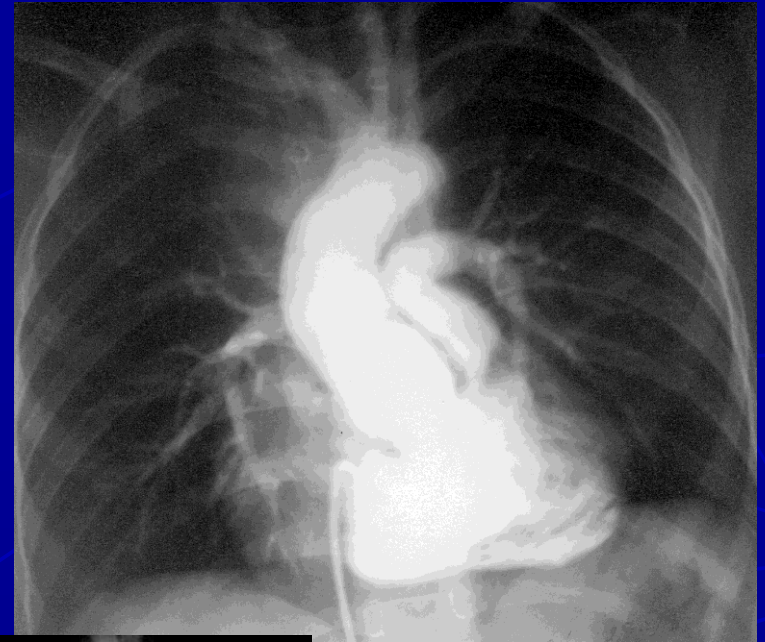
- ✓ If 10-15 mm Hg: there is no more difference between pulmonary pattern in the apical and inferior regions
- ✓ 15-25 mm Hg: venous congestion
- ✓ 25-35 mm Hg: interstitial edema
- ✓ >35 mm Hg: alveolar edema





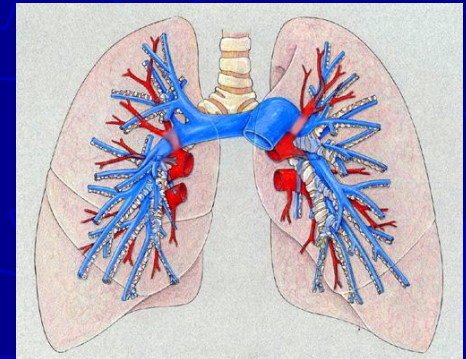
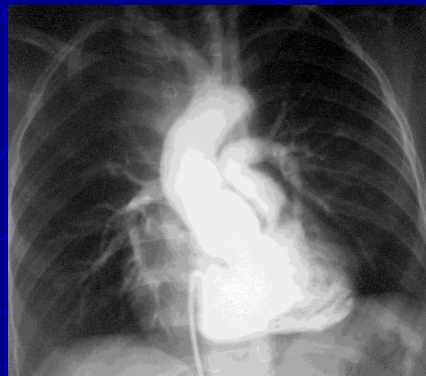
Radiology. Contrast investigation.

- **Ventriculography**
- **Angiography**
 - ▶ **Aortography**
 - ▶ **Angiocoronarography**
 - ▶ **Arteriography**
 - ▶ **Flebography**

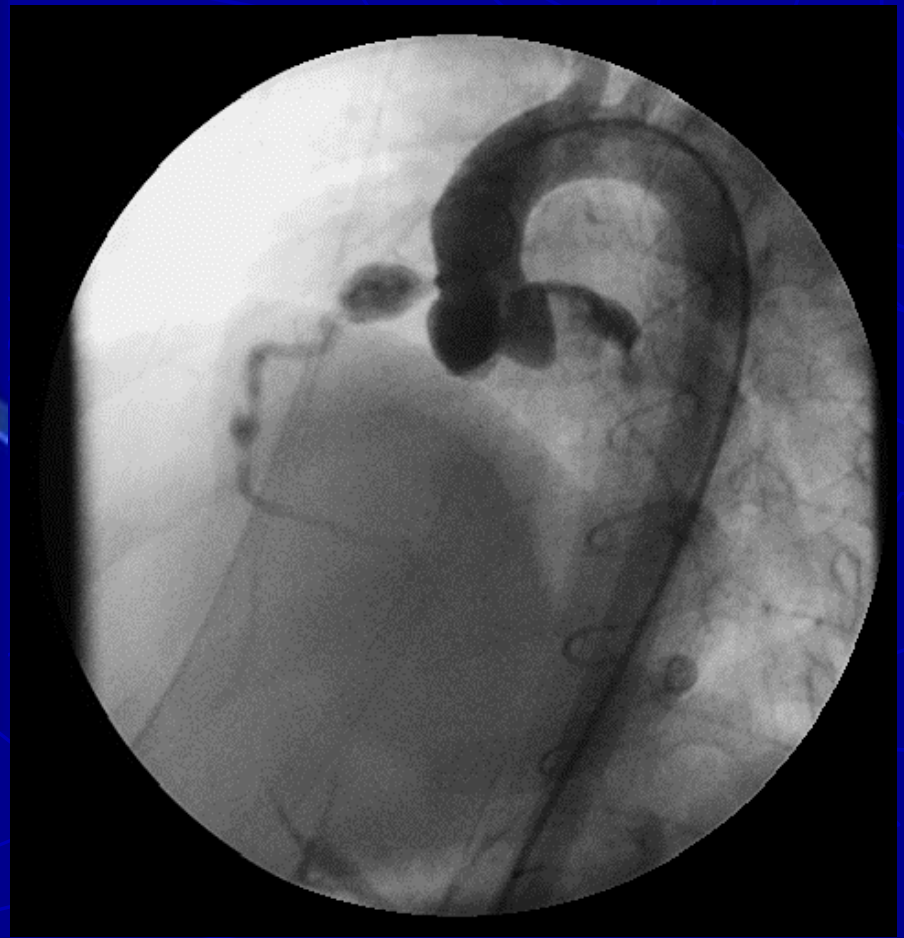


Actual indications for cardiac catheterism and angiography

- Direct estimation of intracardiac and pulmonary blood pressure
- Investigation of aorta and its branches (aortography)
- Investigation of coronary vessels (angiocoronarography)
- Investigation of peripheral pulmonary blood vessels (angiopulmonography)
- Investigation of peripheral systemic blood vessels



Aortography



Radiology. Computed tomography: Indications.

- Investigation of aorta and coronary vessels
- Investigation of peripheral arteries
- Investigation of complex congenital heart diseases
- Investigation of acquired valvular diseases
- Investigation of pericardium



Indications for cardiac CT, 2010 (American College of Cardiology)

Indication		Appropriateness Criteria (Median Score)
Detection of CAD: Symptomatic—Evaluation of Chest Pain Syndrome (Use of CT Angiogram)		
2.	<ul style="list-style-type: none"> • Intermediate pre-test probability of CAD • ECG uninterpretable OR unable to exercise 	A (7)
Detection of CAD: Symptomatic—Evaluation of Intra-Cardiac Structures (Use of CT Angiogram)		
4.	<ul style="list-style-type: none"> • Evaluation of suspected coronary anomalies 	A (9)
Detection of CAD: Symptomatic—Acute Chest Pain (Use of CT Angiogram)		
6.	<ul style="list-style-type: none"> • Intermediate pre-test probability of CAD • No ECG changes and serial enzymes negative 	A (7)
Detection of CAD With Prior Test Results—Evaluation of Chest Pain Syndrome (Use of CT Angiogram)		
16.	<ul style="list-style-type: none"> • Uninterpretable or equivocal stress test (exercise, perfusion, or stress echo) 	A (8)
Structure and Function—Morphology (Use of CT Angiogram)		
28.	<ul style="list-style-type: none"> • Assessment of complex congenital heart disease including anomalies of coronary circulation, great vessels, and cardiac chambers and valves 	A (7)
29.	<ul style="list-style-type: none"> • Evaluation of coronary arteries in patients with new onset heart failure to assess etiology 	A (7)
Structure and Function—Evaluation of Intra- and Extra-Cardiac Structures (Use of Cardiac CT)		
33.	<ul style="list-style-type: none"> • Evaluation of cardiac mass (suspected tumor or thrombus) • Patients with technically limited images from echocardiogram, MRI, or TEE 	A (8)
34.	<ul style="list-style-type: none"> • Evaluation of pericardial conditions (pericardial mass, constrictive pericarditis, or complications of cardiac surgery) • Patients with technically limited images from echocardiogram, MRI, or TEE 	A (8)
35.	<ul style="list-style-type: none"> • Evaluation of pulmonary vein anatomy prior to invasive radiofrequency ablation for atrial fibrillation 	A (8)
36.	<ul style="list-style-type: none"> • Noninvasive coronary vein mapping prior to placement of biventricular pacemaker 	A (8)
37.	<ul style="list-style-type: none"> • Noninvasive coronary arterial mapping, including internal mammary artery prior to repeat cardiac surgical revascularization 	A (8)
Structure and Function—Evaluation of Aortic and Pulmonary Disease (Use of CT Angiogram*)		
38.	<ul style="list-style-type: none"> • Evaluation of suspected aortic dissection or thoracic aortic aneurysm 	A (9)
39.	<ul style="list-style-type: none"> • Evaluation of suspected pulmonary embolism 	A (9)

Cardiac CT : patient must be able:

- To keep immovable
- To perform a breath-holding
- To rise the arms over the head

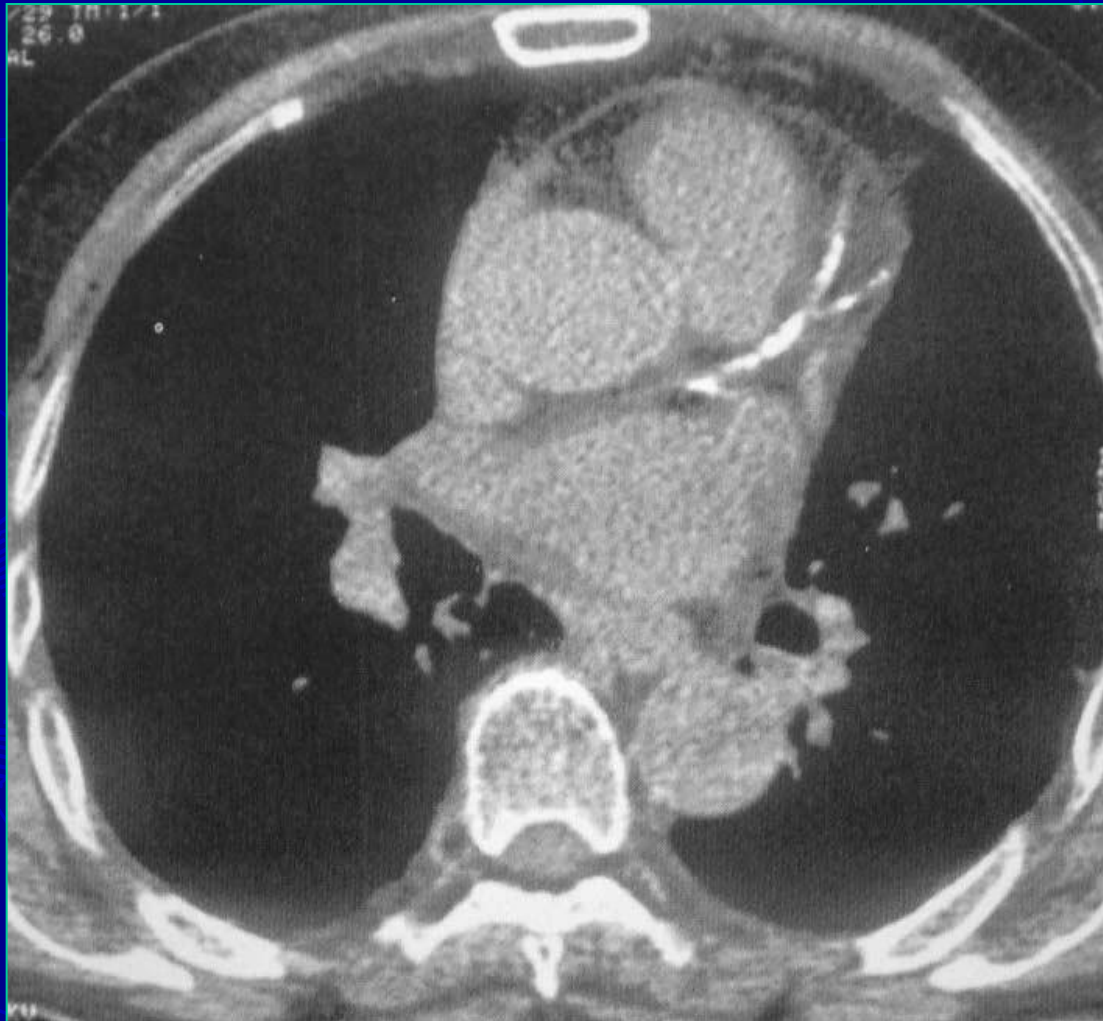


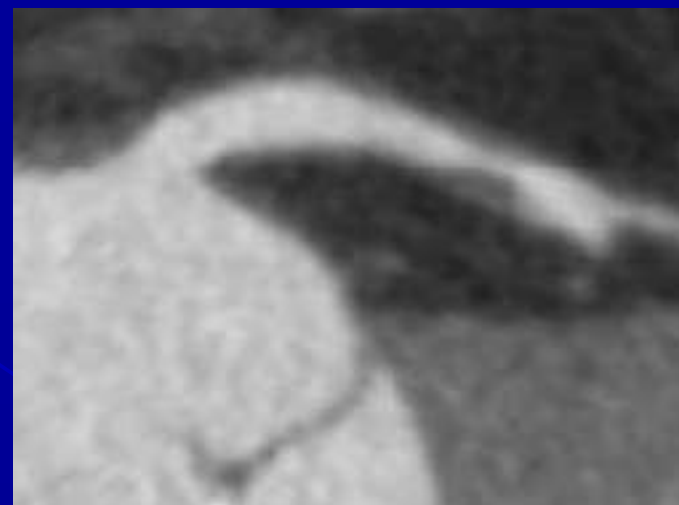
Limitations for cardiac CT

- Insufficient duration of breath-holding (<10-12 sec)
- Severe calcinosis of coronary arteries
- Fragile veins
- Tachycardia >100/min and contraindication for beta-blockers
- Severe arrhythmia (atrial fibrillation, extrasistols)
- Obesity
- Renal failure
- Allergy to contrast media

CT without contrast media.

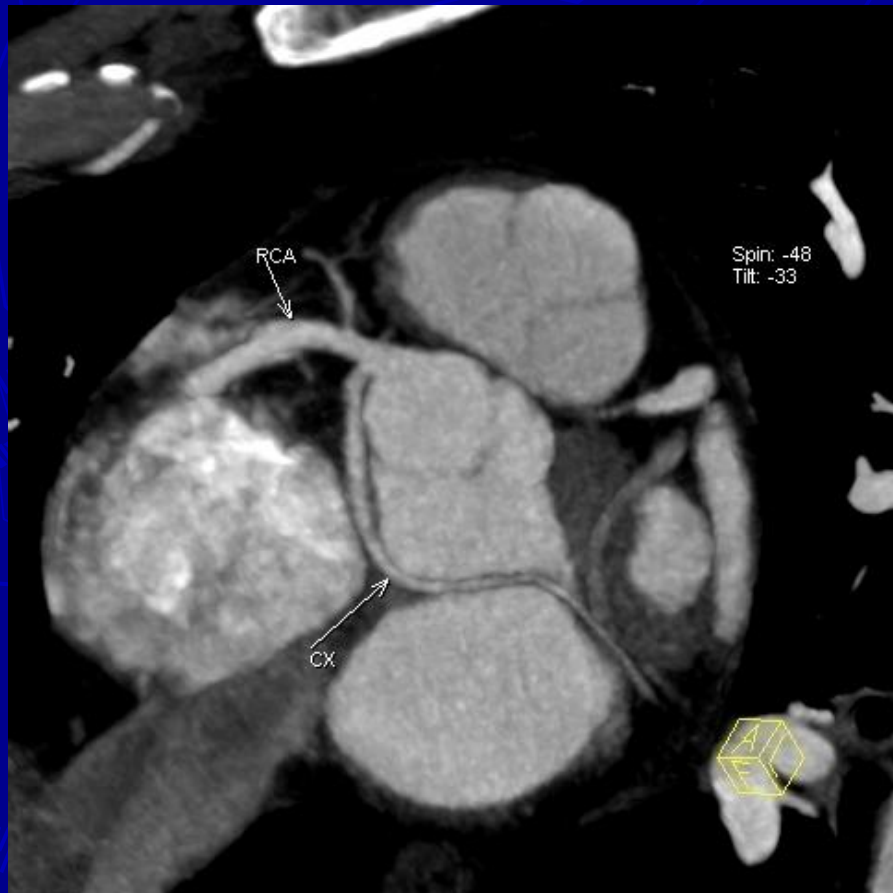
Calcification of coronary artery



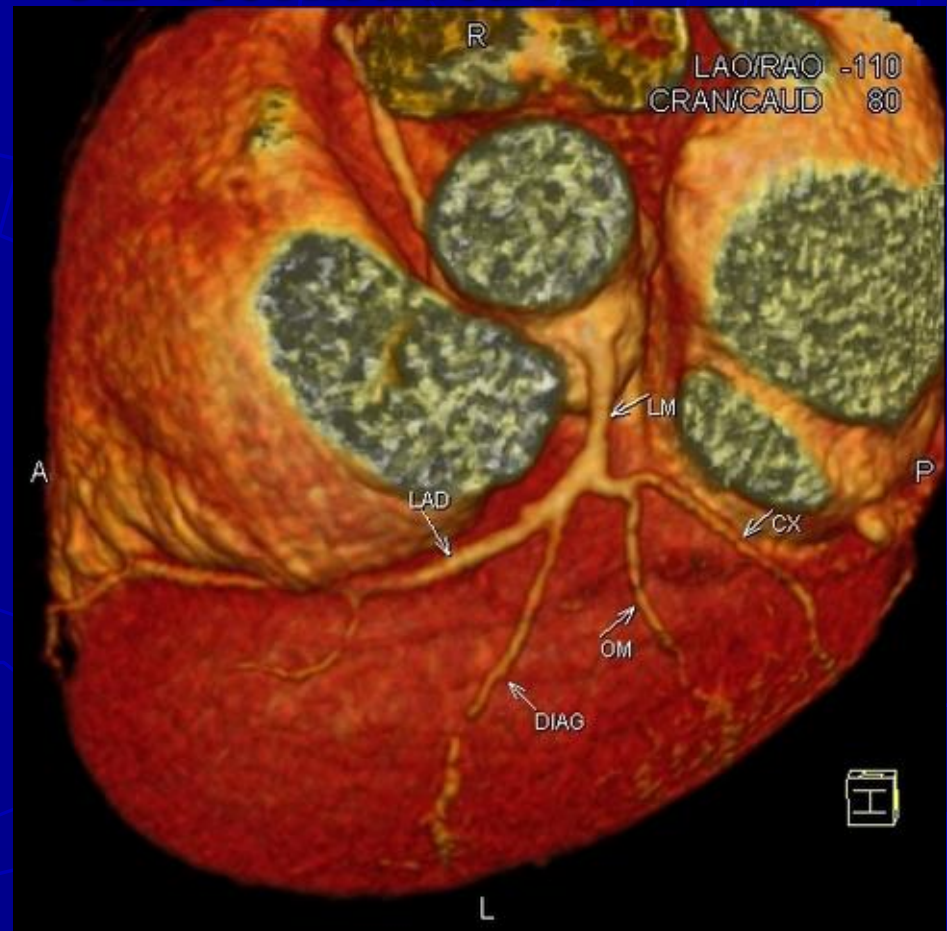


CT

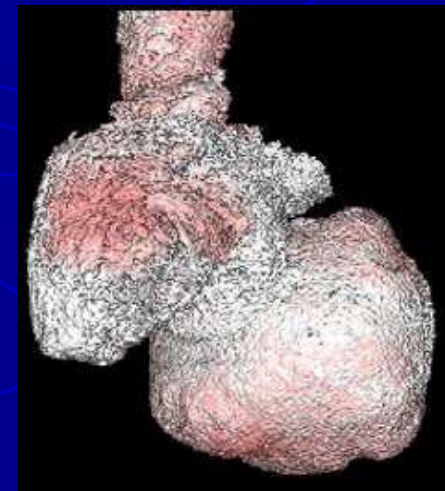
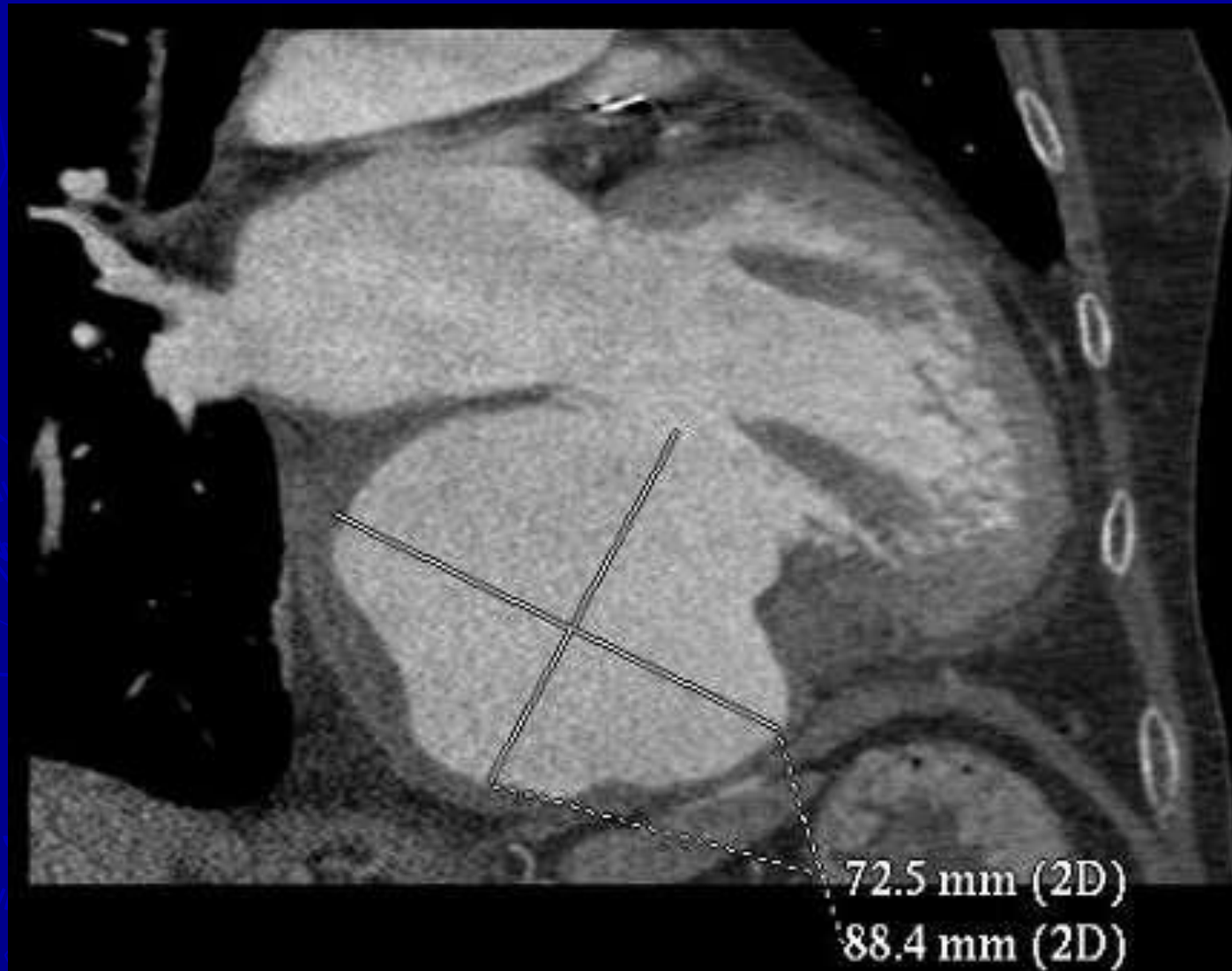
Angiogram

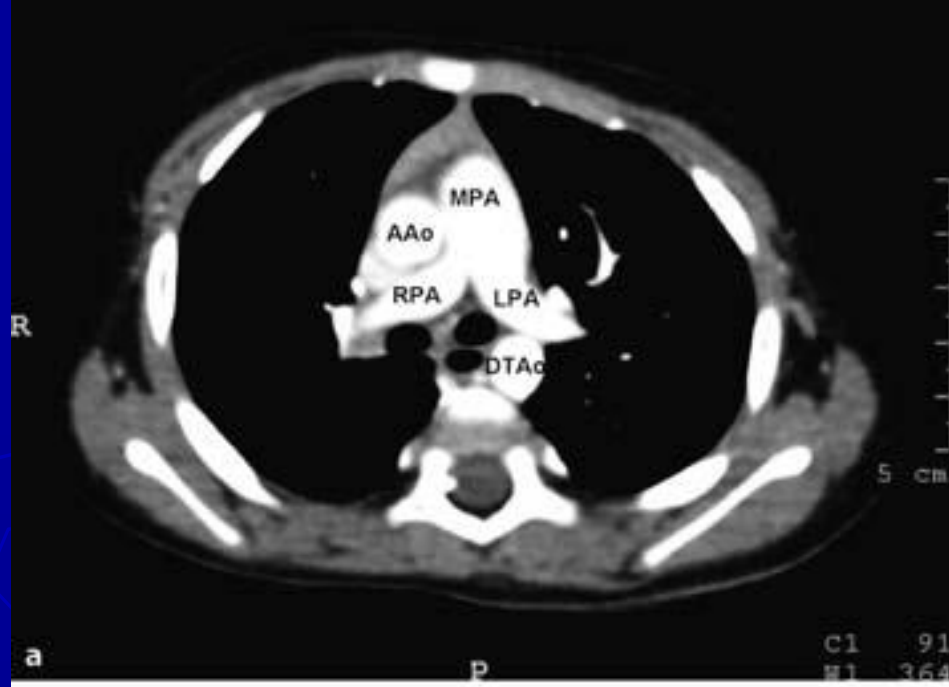


Angiogram: 3D reconstruction



Cardiac CT. Aneurysm of the LV





Cardiac imaging. Ultrasonography

➤ **ECOCG: transthoracic; transesophageal**

mode: M

2D

3D

contrast ECOCG

➤ **Doppler ECOCG**

pulsative Doppler

continual Doppler

color Doppler

tisular Doppler



A standard ECOCG is a transthoracic one and includes

- **ECOCG:** mode: M
2D
- **Doppler ECOCG**
 - pulsative Doppler
 - continual Doppler
 - color Doppler



ECOCG allows:

- Accurate analysis of intracardiac anatomy
- Analysis of haemodynamics, intracardiac and at the level of the great vessels
- Analysis of myocardial contractility
- Investigation of pericardium

Normal values for LV systolic function:

Ejection fraction: at the average, 55-65%

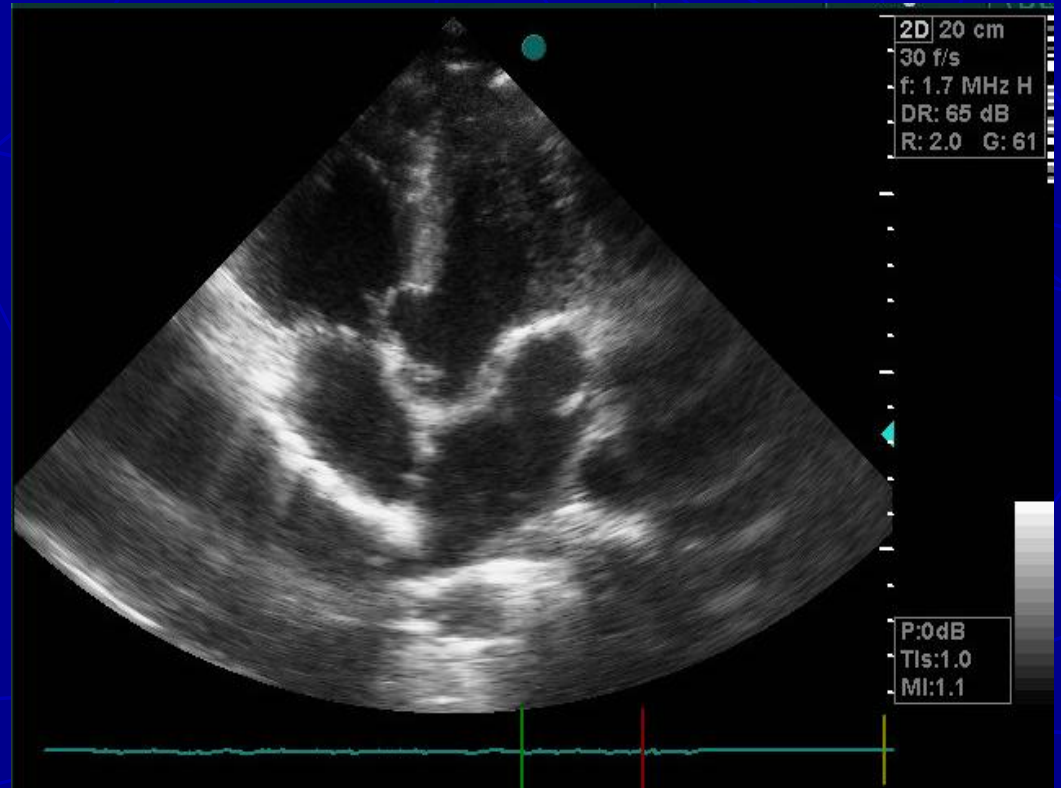
(more general, 50-80%)

Shortening fraction 25-45%

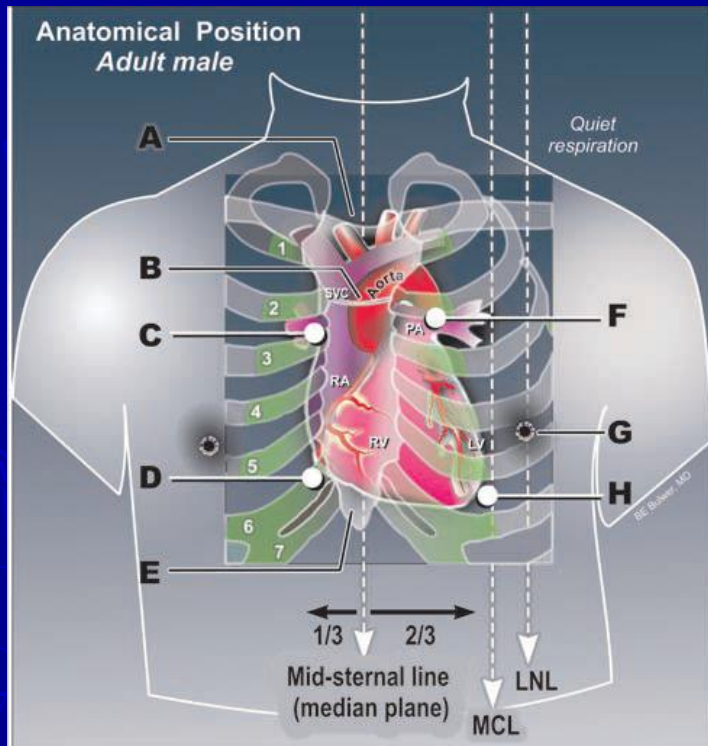


Transthoracic ECOCG: standard views

- Parasternal
- Apical
- Subcostal
- Suprasternal



Transthoracic ECOCG, standard sections



Transthoracic Echocardiography: Windows, Imaging Planes, and Views

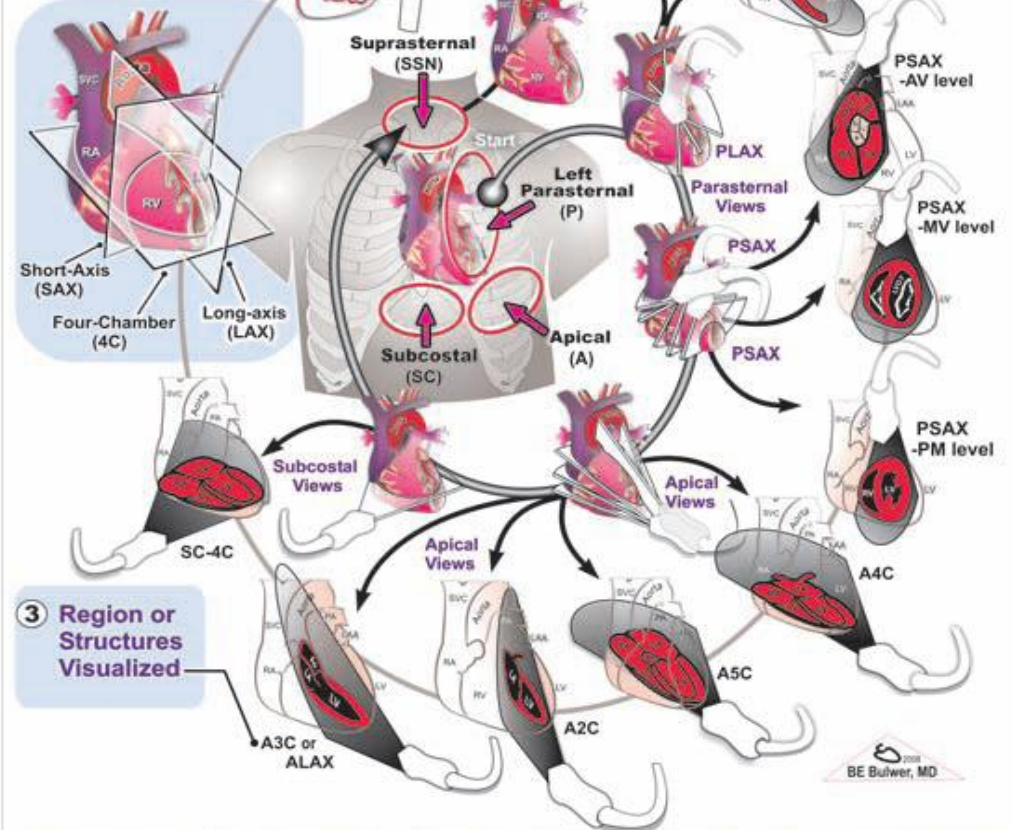
1 Transducer Position or "Window"

P: Parasternal
A: Apical
SC: Subcostal
SSN: Suprasternal Notch

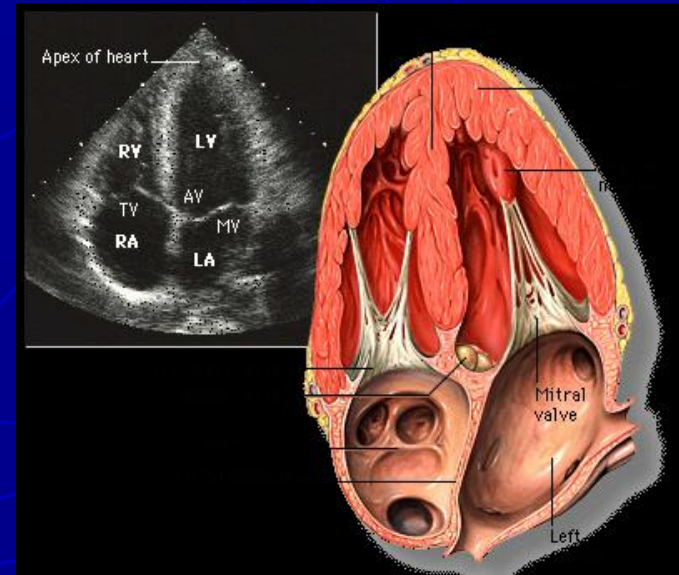
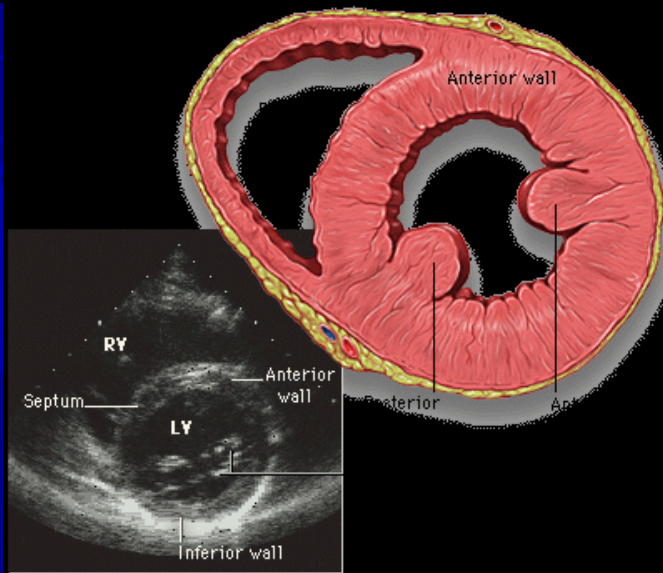
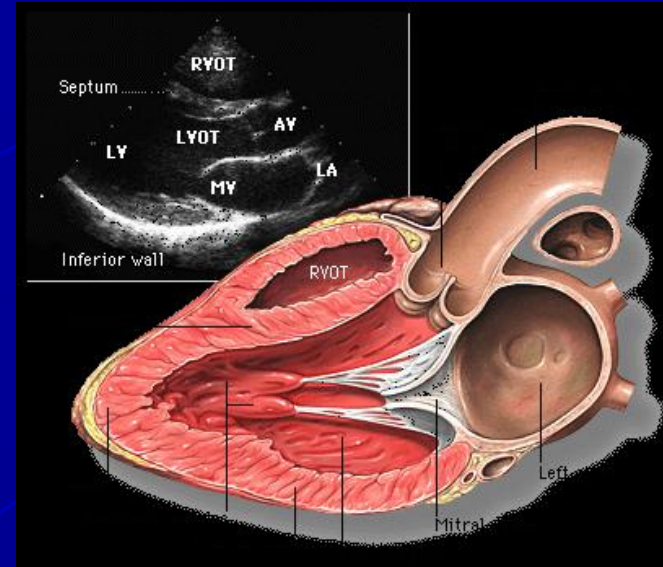
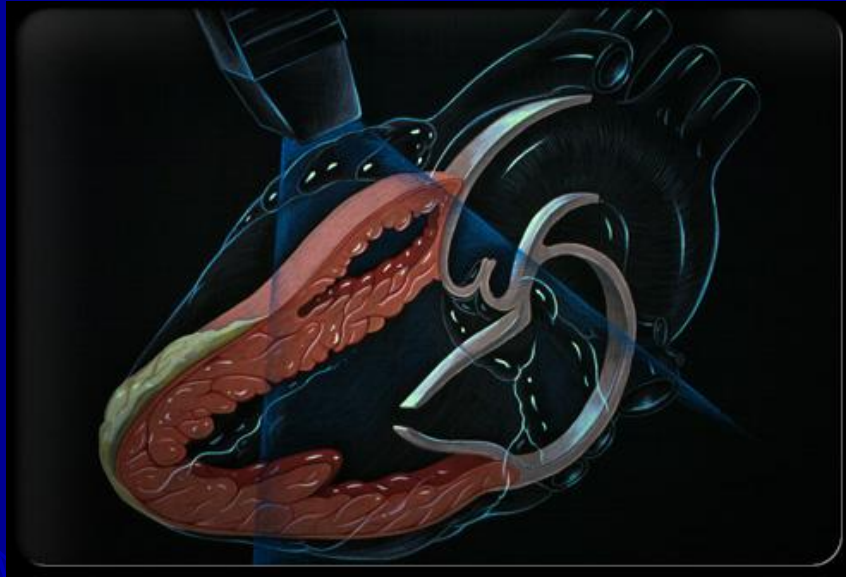
Each view is described using three (3) components:

- 1. Transducer Position or "Window", e.g. Parasternal, Apical, or Subcostal
- 2. Echocardiographic Imaging Plane, e.g. LAX, SAX, or 4C
- 3. Region or Structures visualized, e.g. Aortic valve (AV) level, Two-Chamber

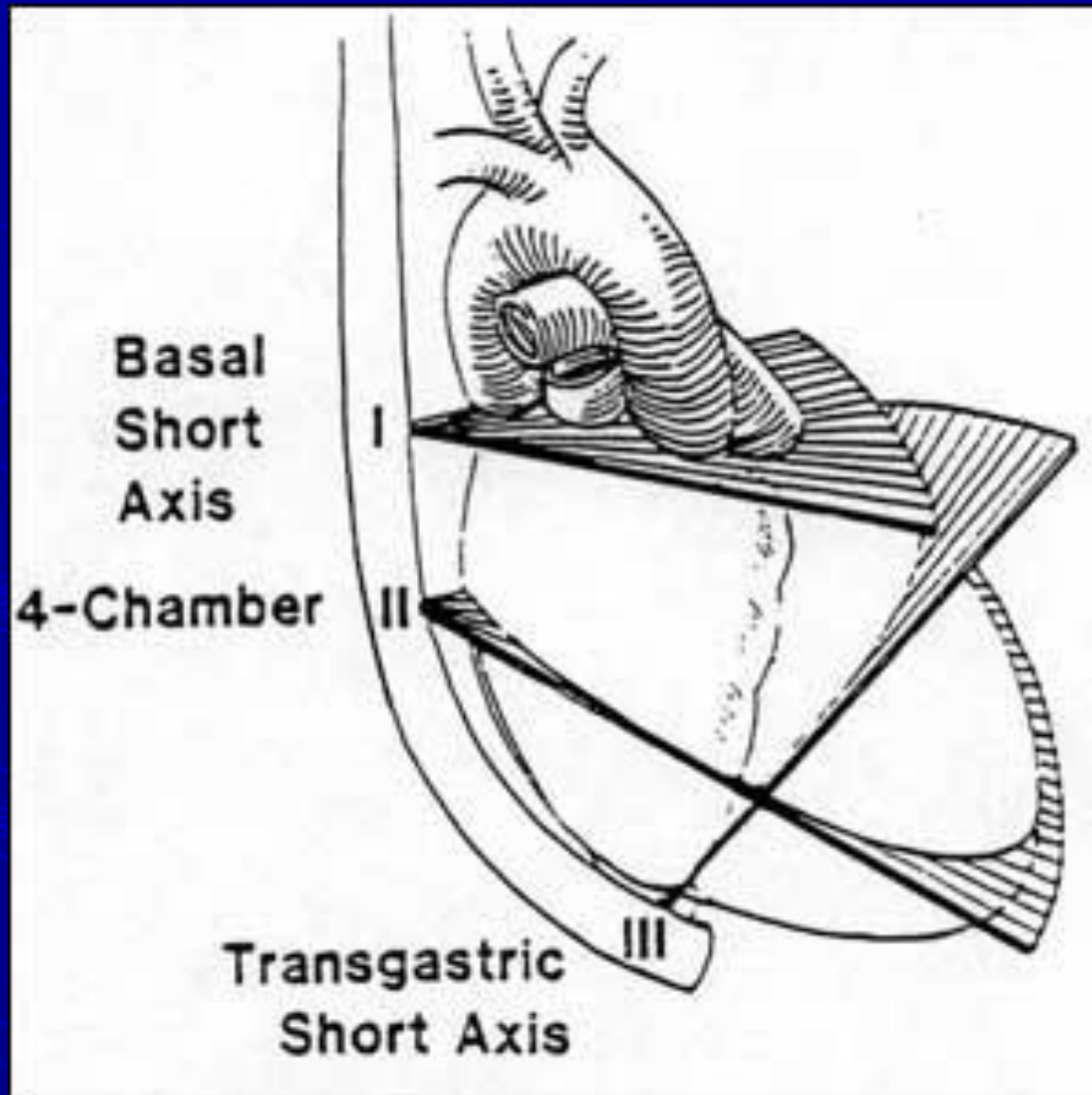
2 Echocardiographic Imaging Planes - LAX; SAX; 4C



Transthoracic ECOCG



Transesophageal ECOCG

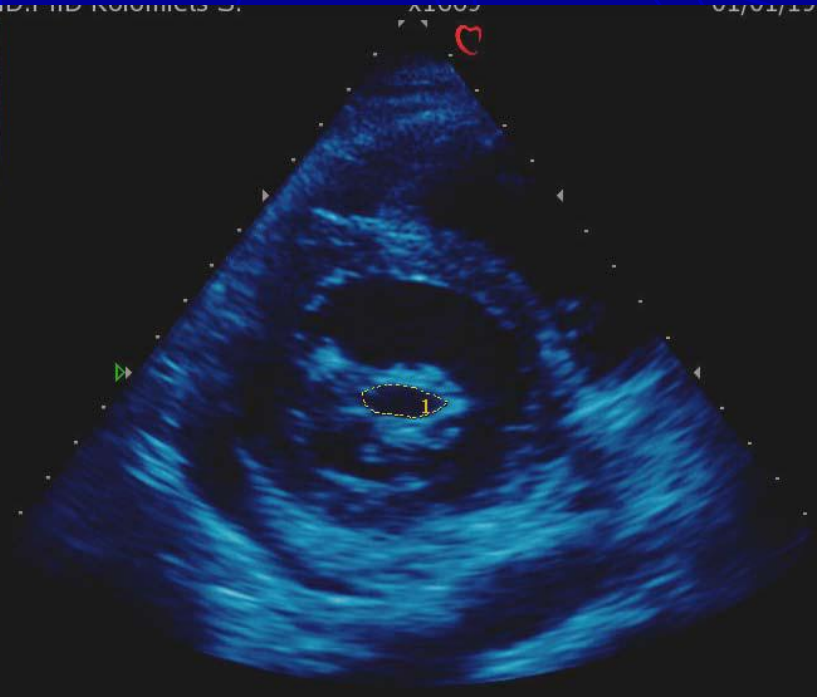


2D ECOCG



2-4PA 79 fps
Heart
2D BGain 19
15 cm Smooth 2
High H Rej 4
Enh -1 Rainb 5
Gamma 4

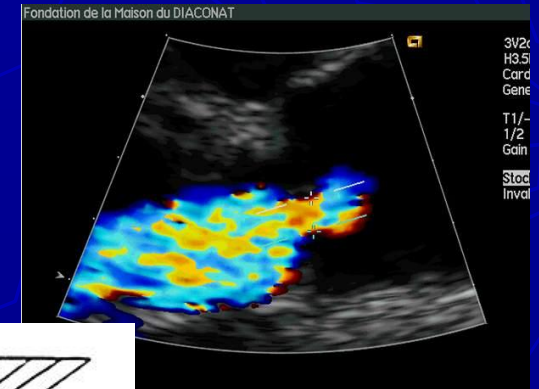
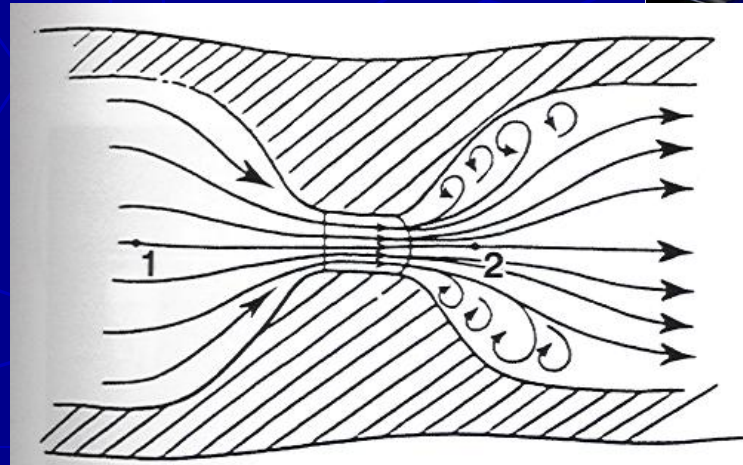
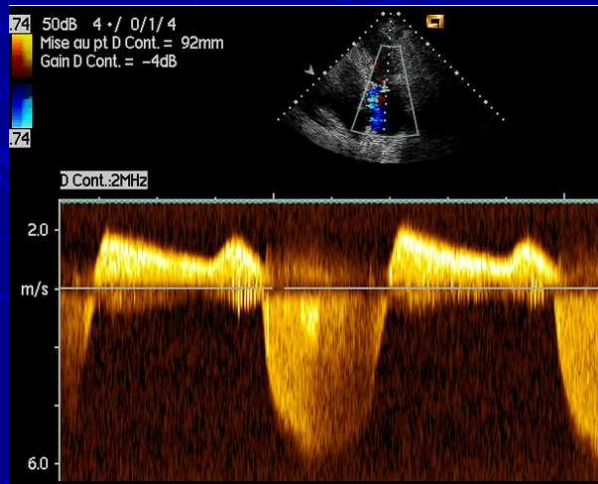
1A 1.0 cm2
C 4.3 cm



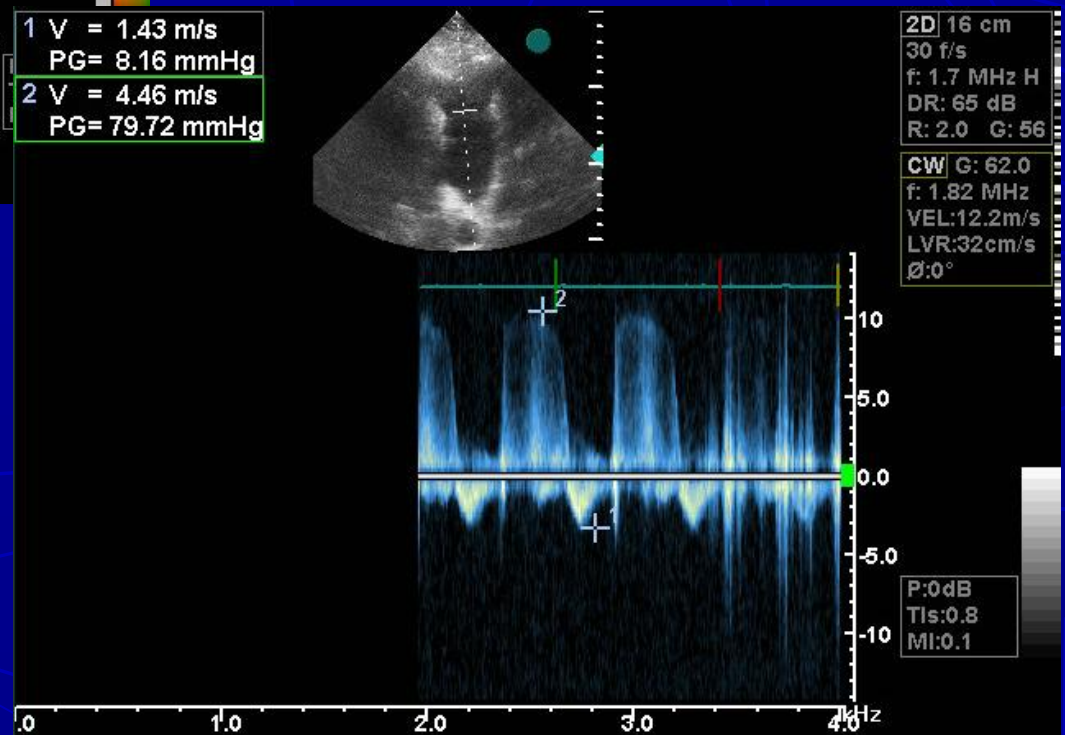
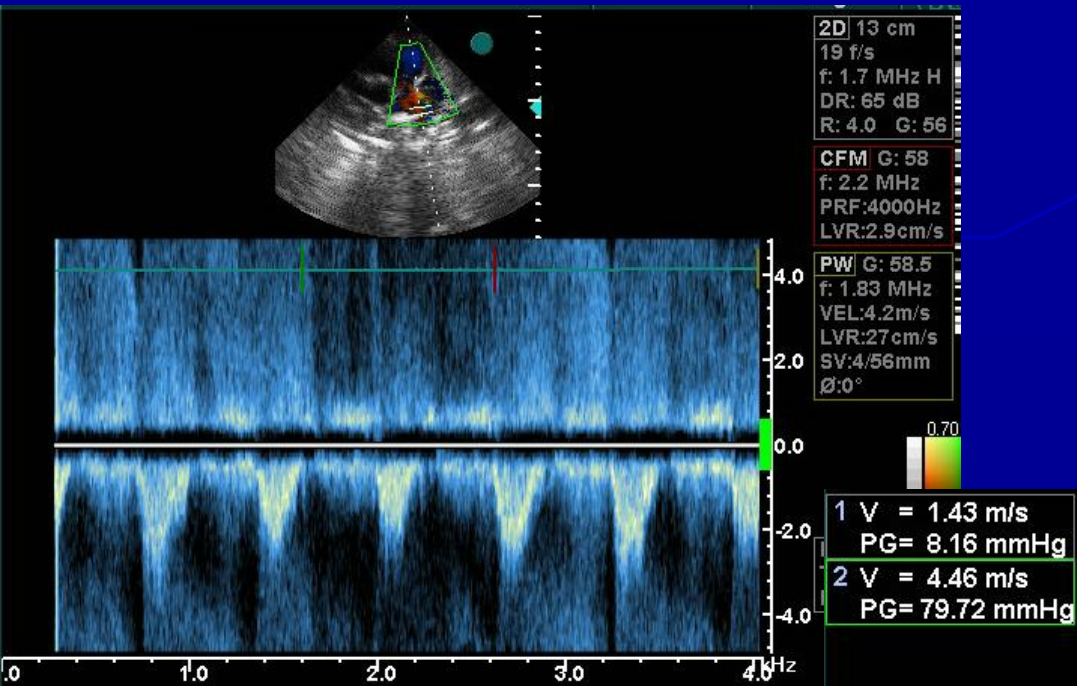
Doppler ECOCG

Analysis of intracardiac blood flows:

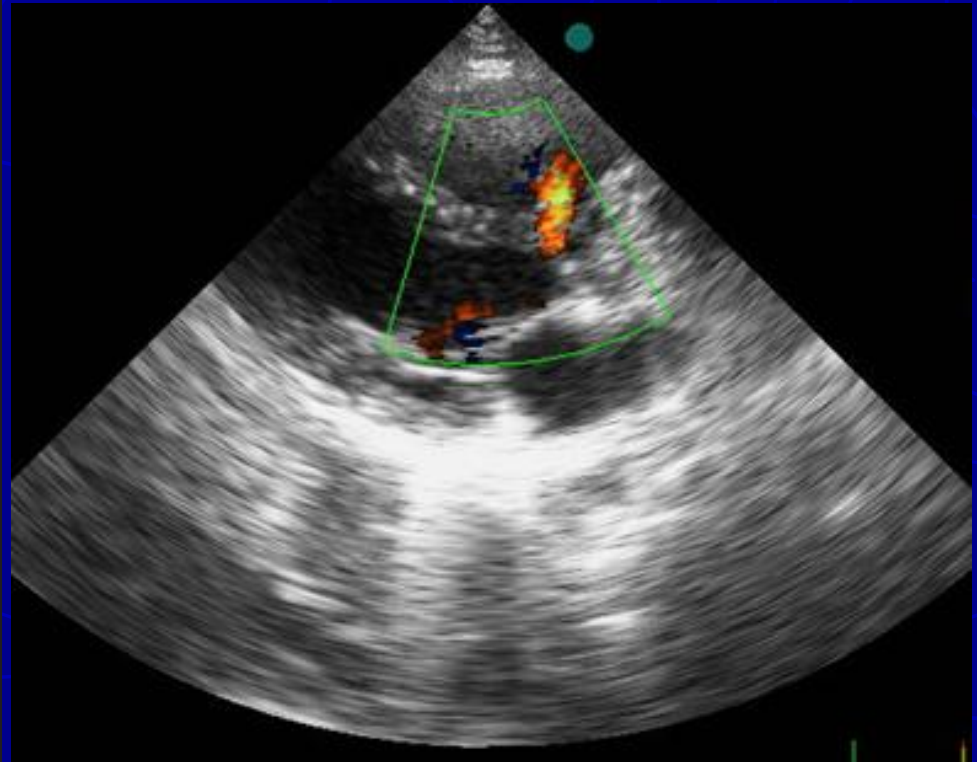
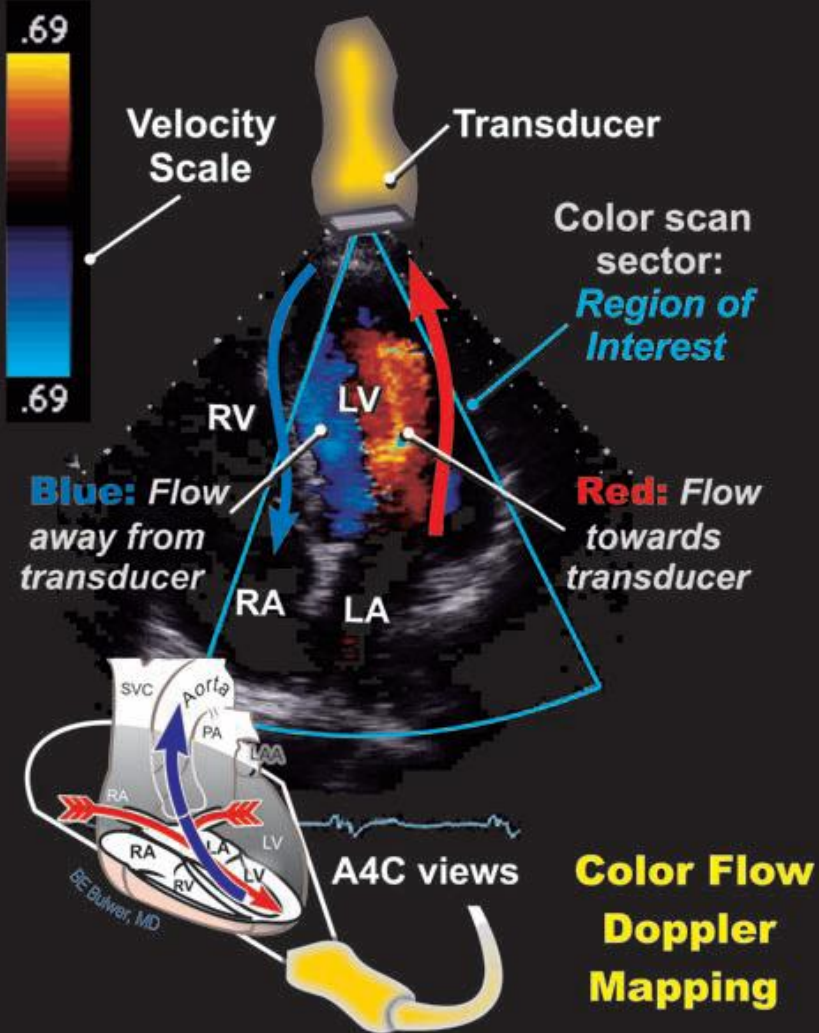
- ✓ Direction
- ✓ Blood velocity and pressure gradients
- ✓ Output

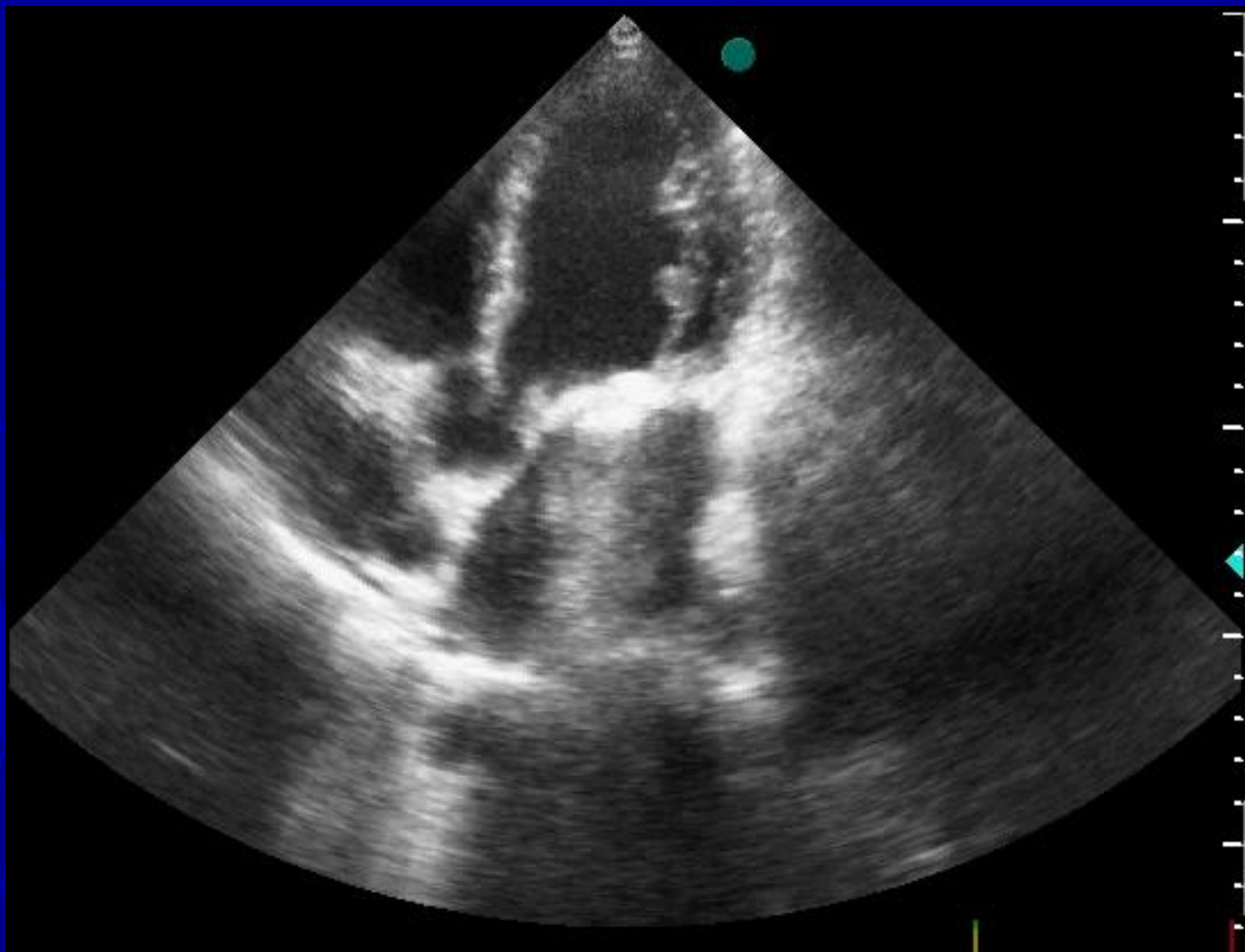


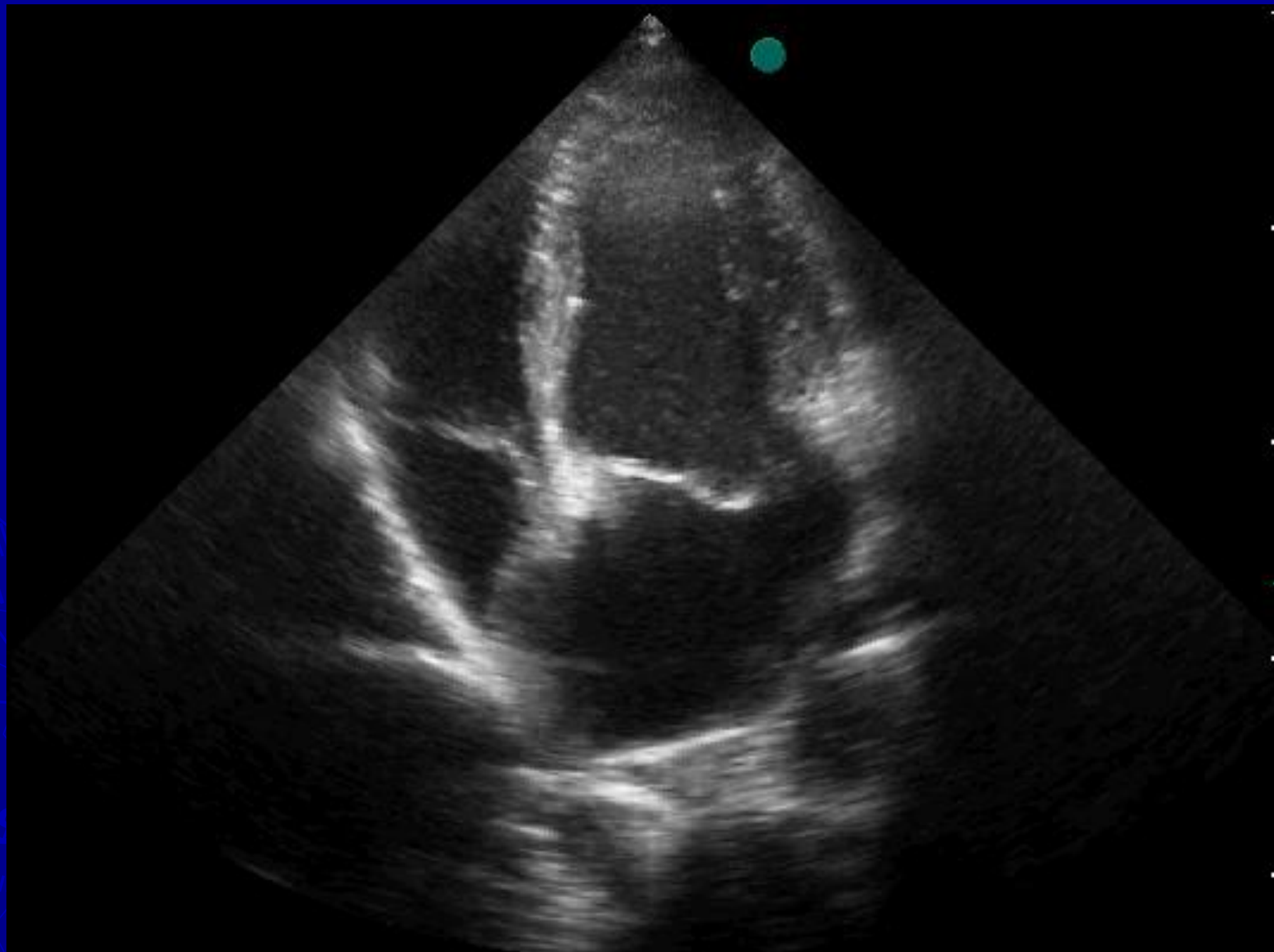
Doppler ECOCG

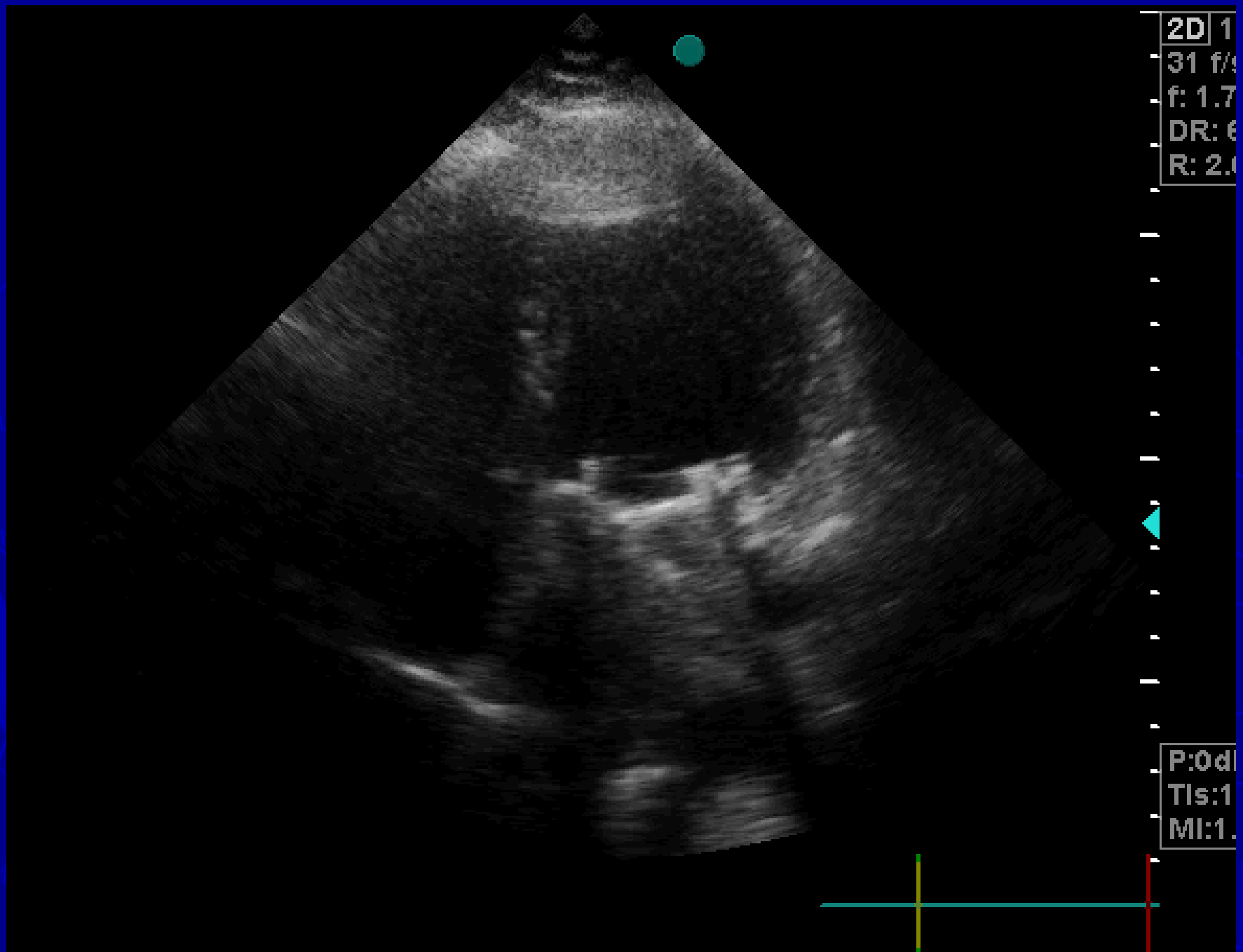


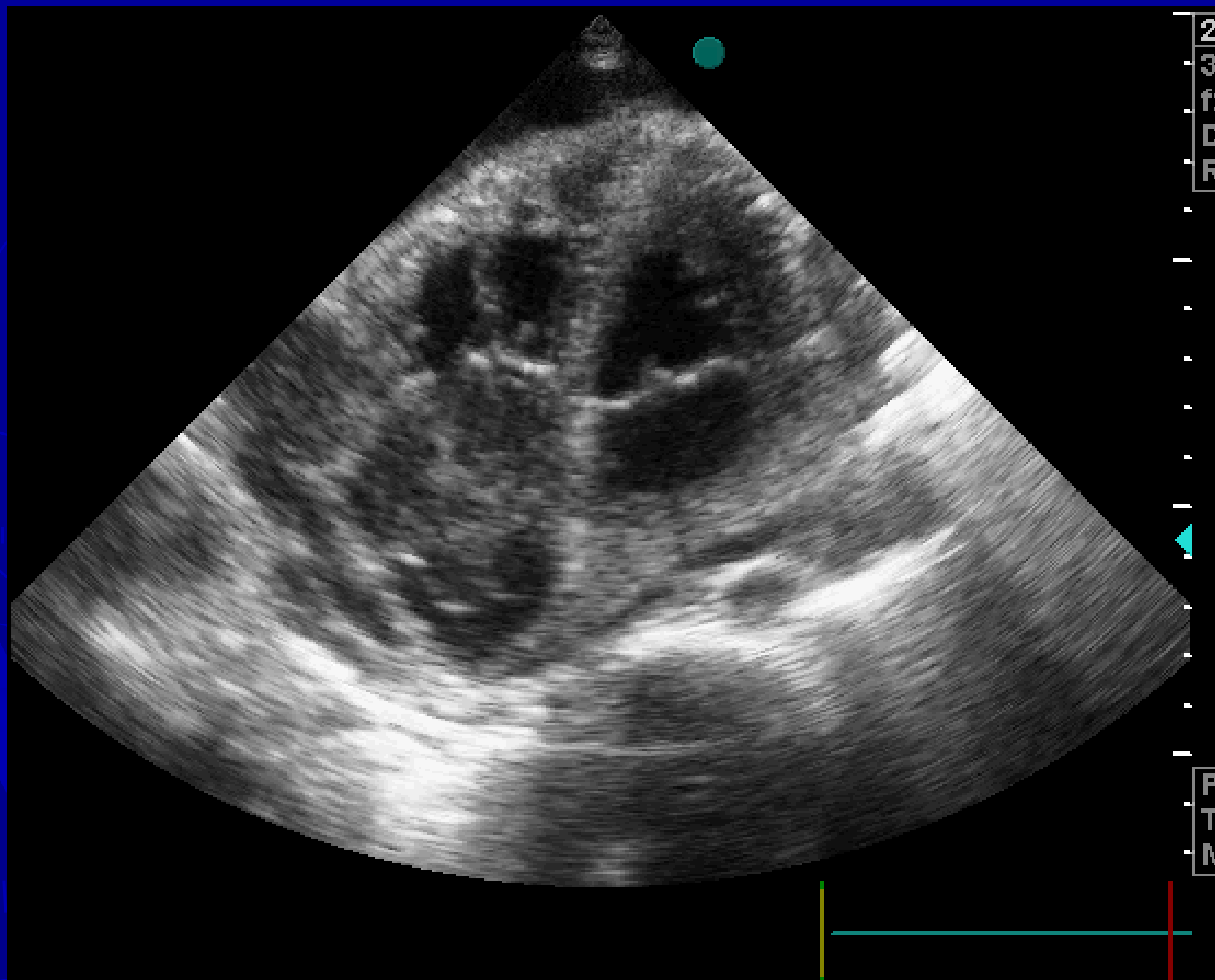
Color Doppler

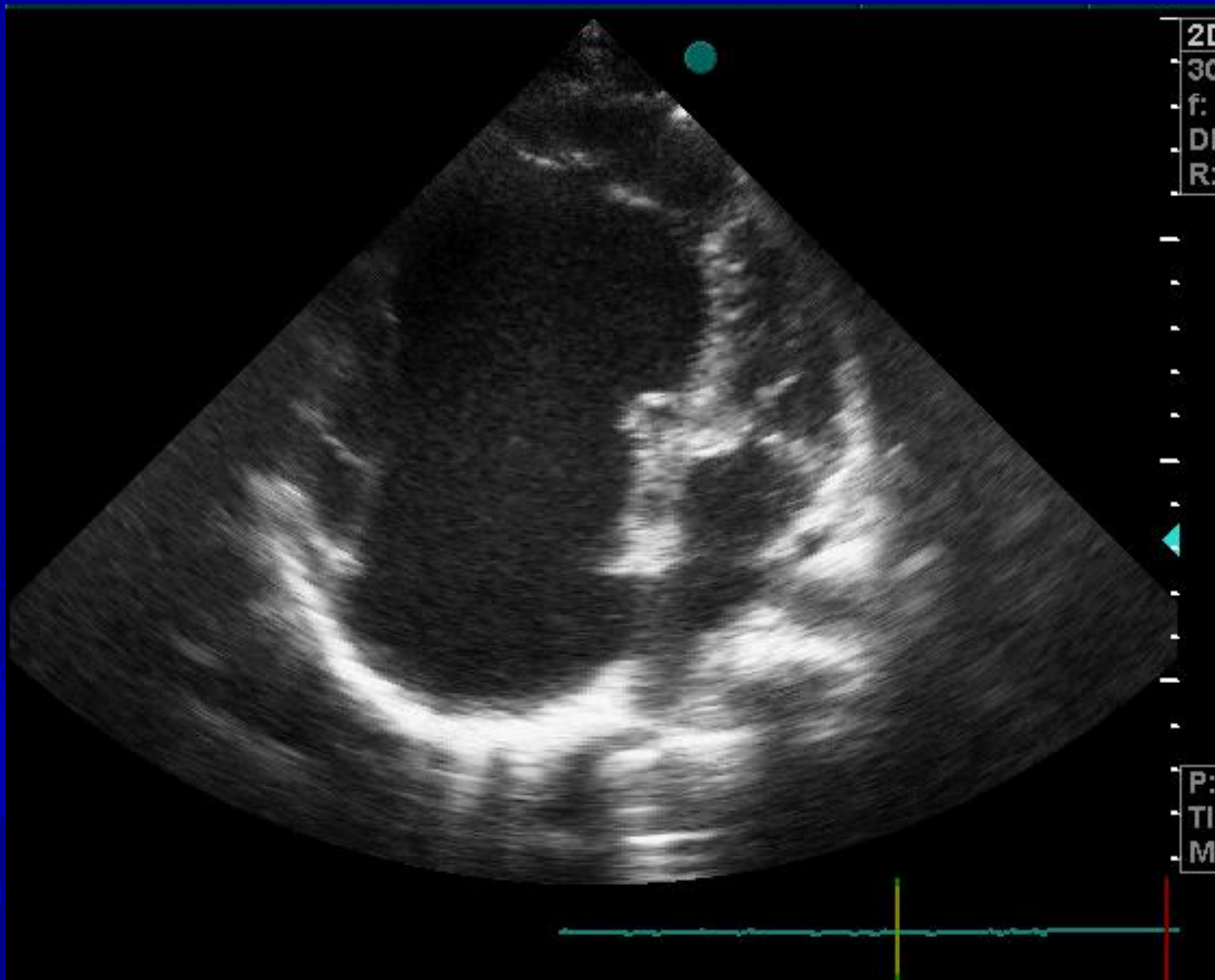






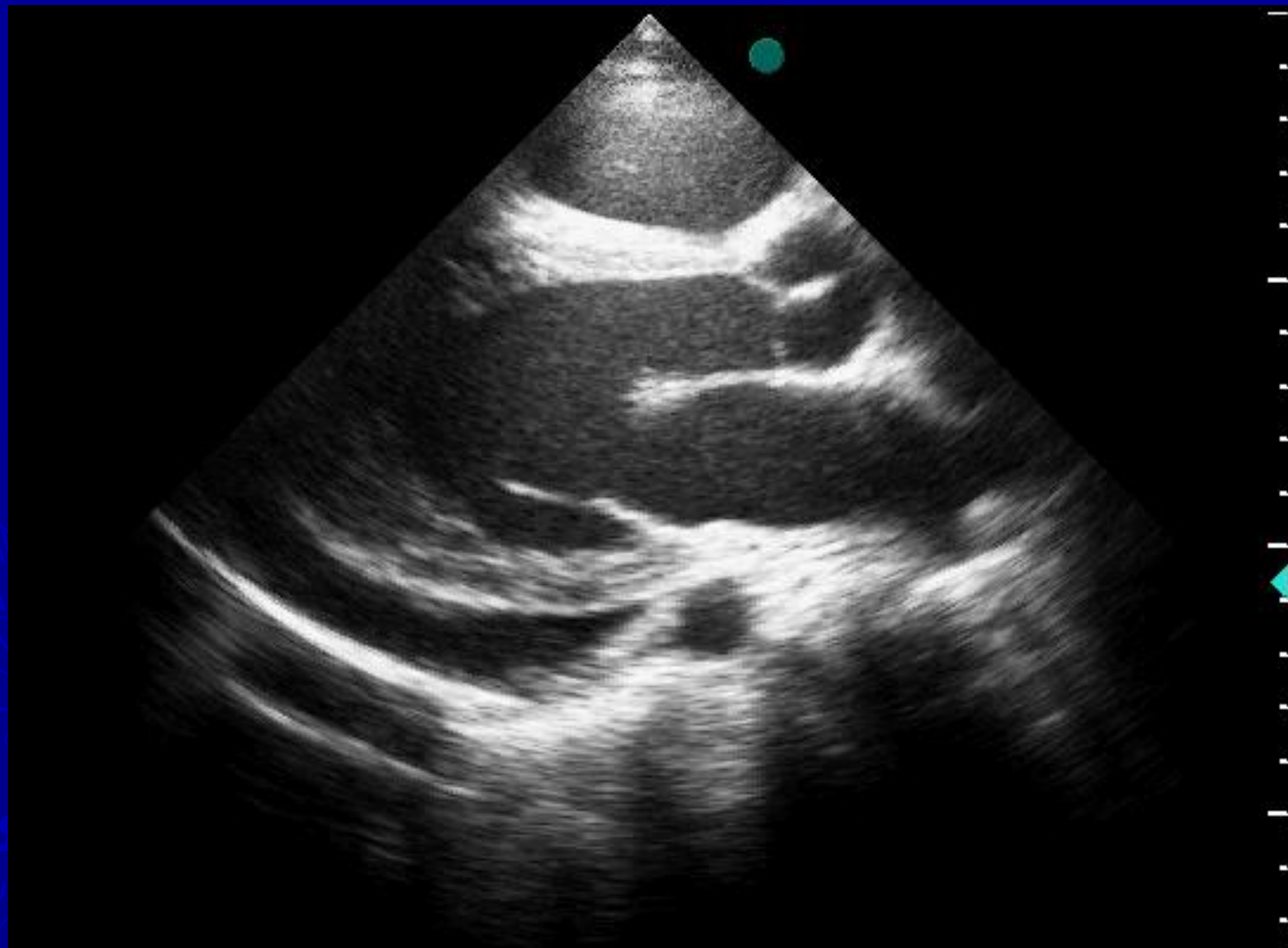






2D
30
f:
DI
R:

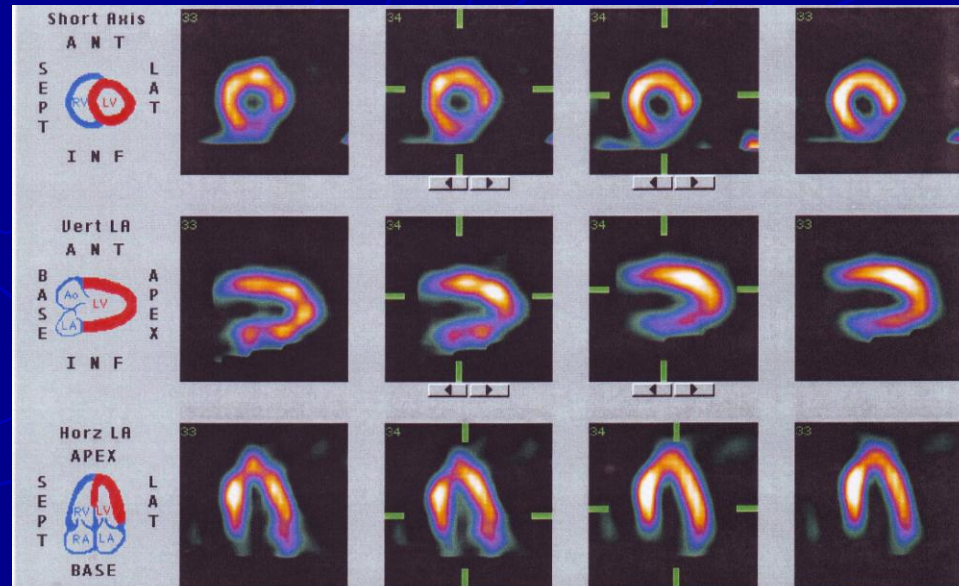
P:
TI
M



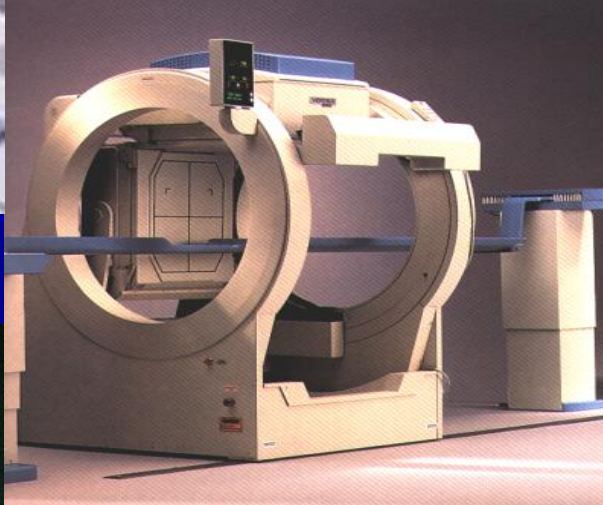
Cardiovascular Imaging.

Nuclear medicine: methods

- Nuclear angiocardiology
- Myocardial perfusion scintigraphy
- Tomographic methods: SPECT, PET
- Hybride methods (SPECT-CT)

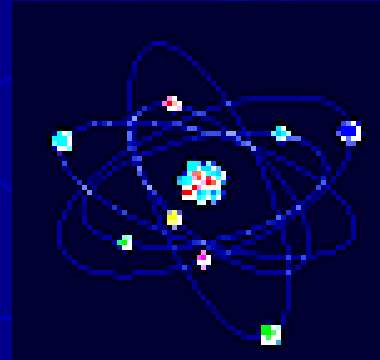


Cardiac scintigraphy



SPECT: indications

- Coronary disease, especially if:
 - *Left bundle branch block*
 - *Typical clinical picture but normal ECG*
 - *ECG changes present but no clinical signs*
 - *Impossibility to perform tests with physical effort*
 - *Estimation of haemodynamic significance of coronary stenosis*
- Identification of viability of myocardium:
 - *Differential diagnosis ischemia-necrosis*
 - *Prediction of the function of LV after revascularization*
- Control of quality of treatment



Radionuclides

► Thallium 201

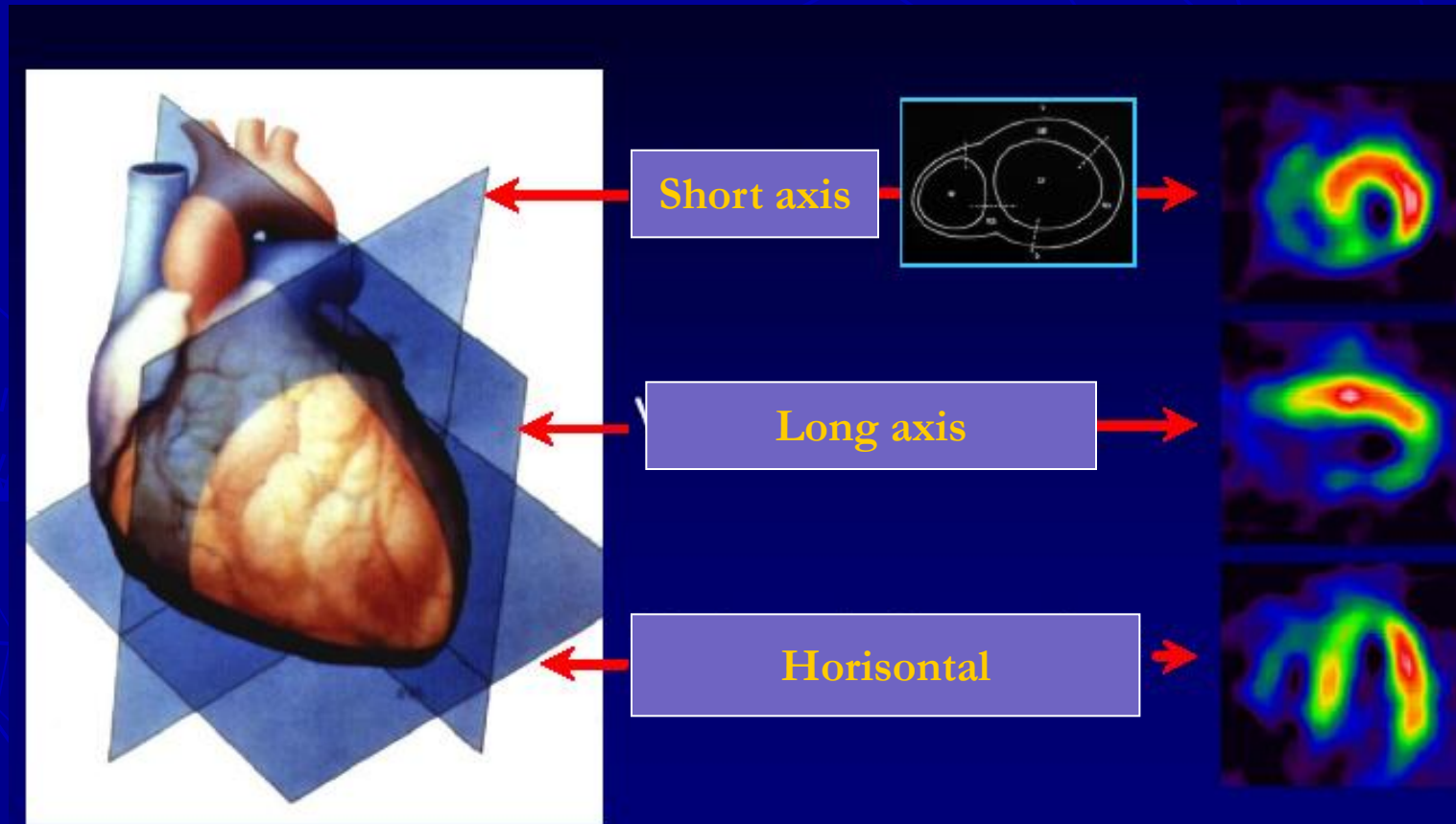
- *Half-life period 73 hours*
- *Analog of K: penetrate inside the cell due to Na/K pump*
- *Each **viabil** myocardial cell will capture thallium 201*

► Tc99m

- *Half-life period 6 hours*



SPECT: standard sections



Nuclear medicine: SPECT

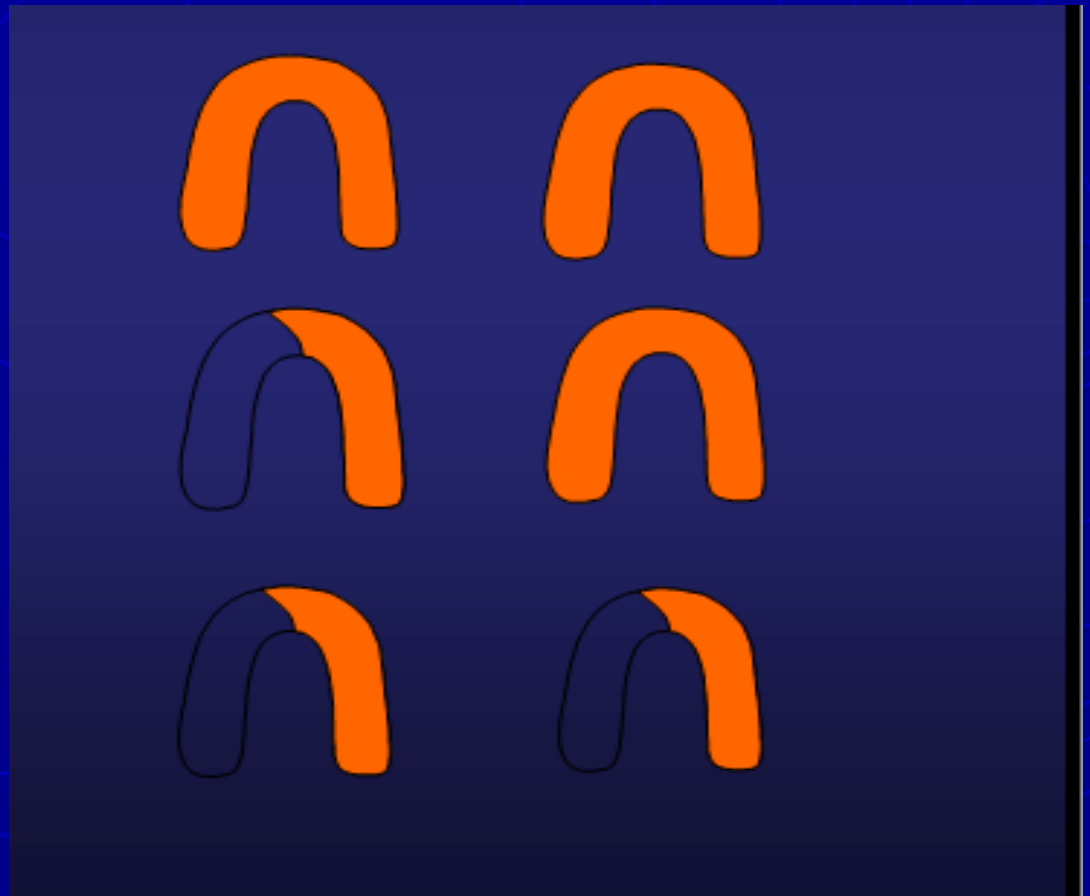
At physical effort

At rest

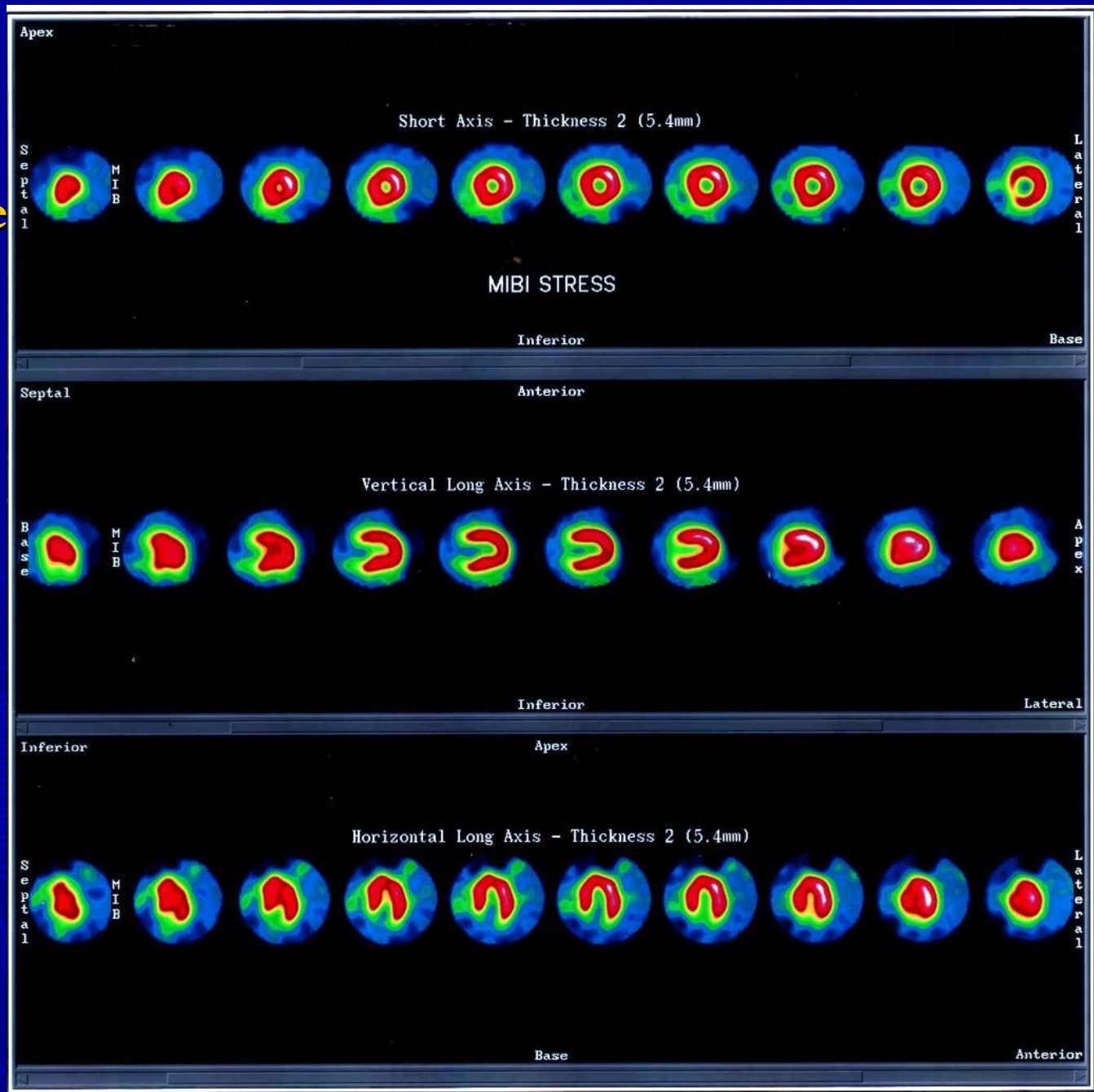
Normal

Ischemia

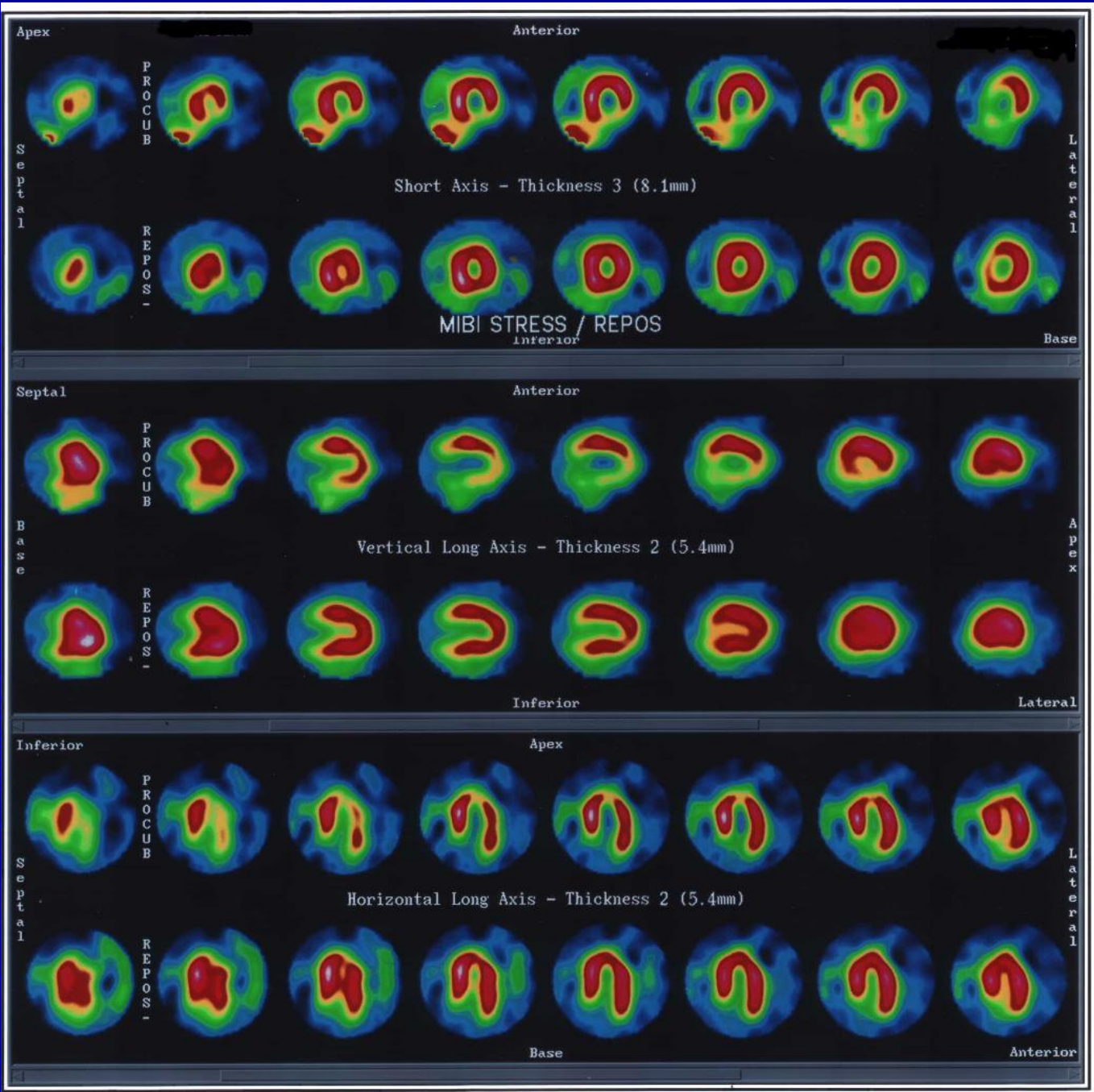
Cicatrix



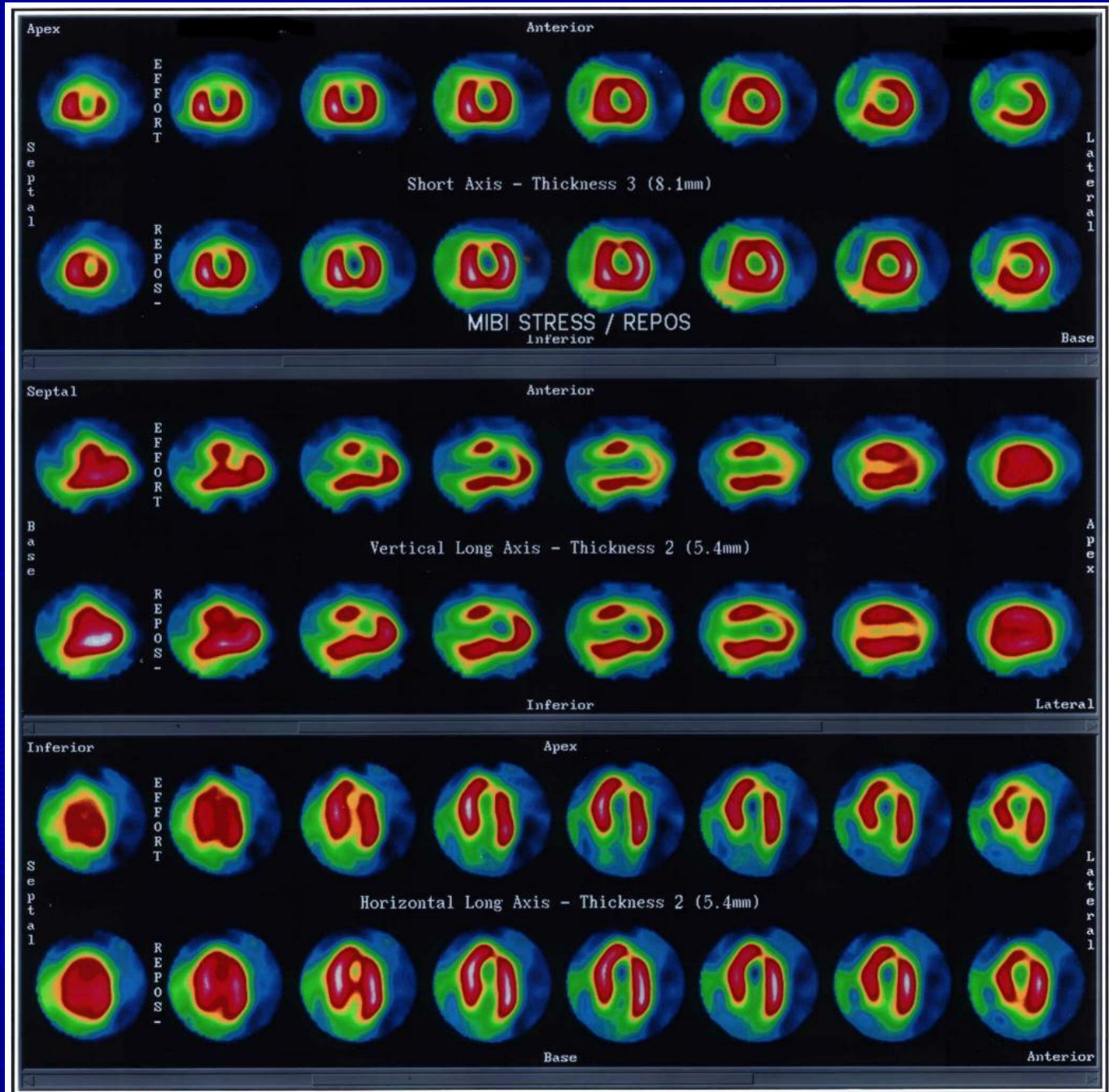
Myocardial scintigraphy— normal picture



Myocardial scintigraphy– Ischemia

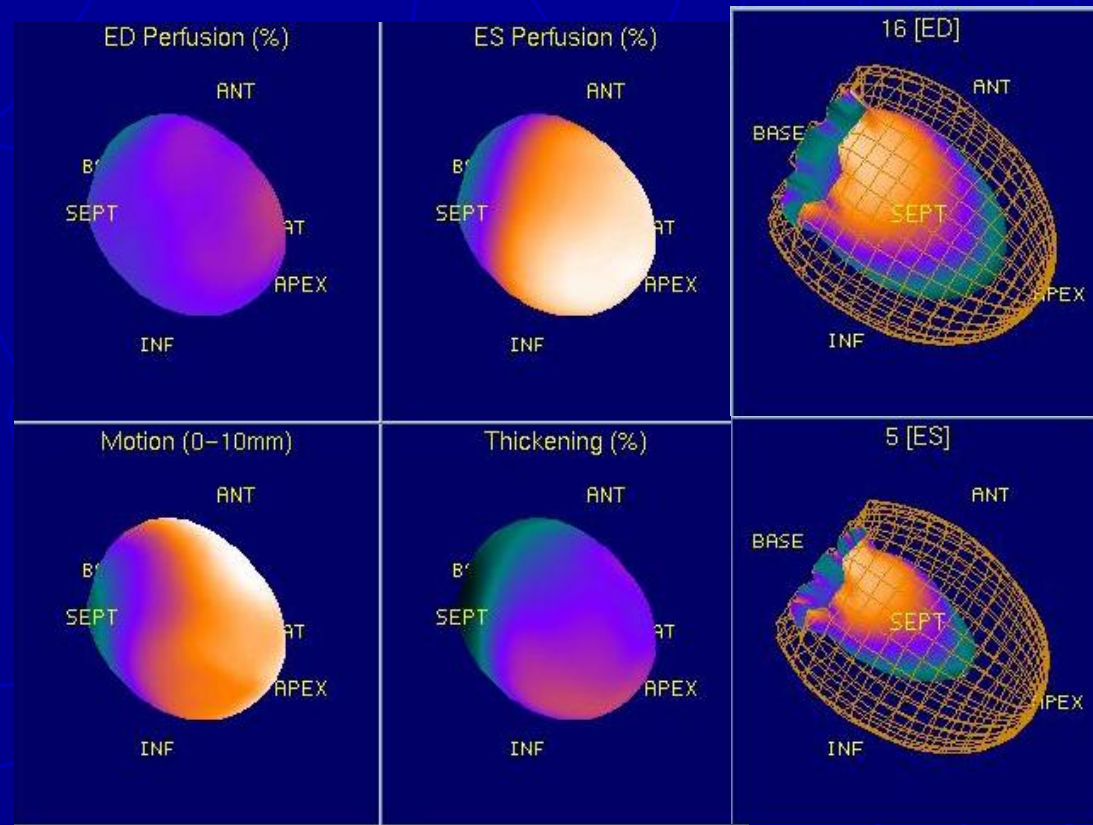


Myocardial scintigraphy- necrosis



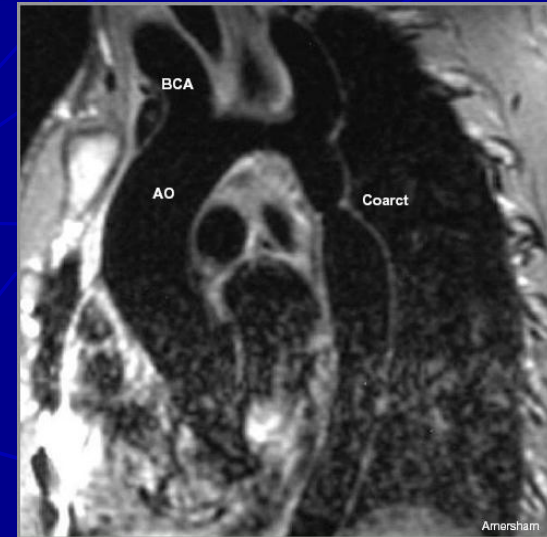
“Gated” SPECT

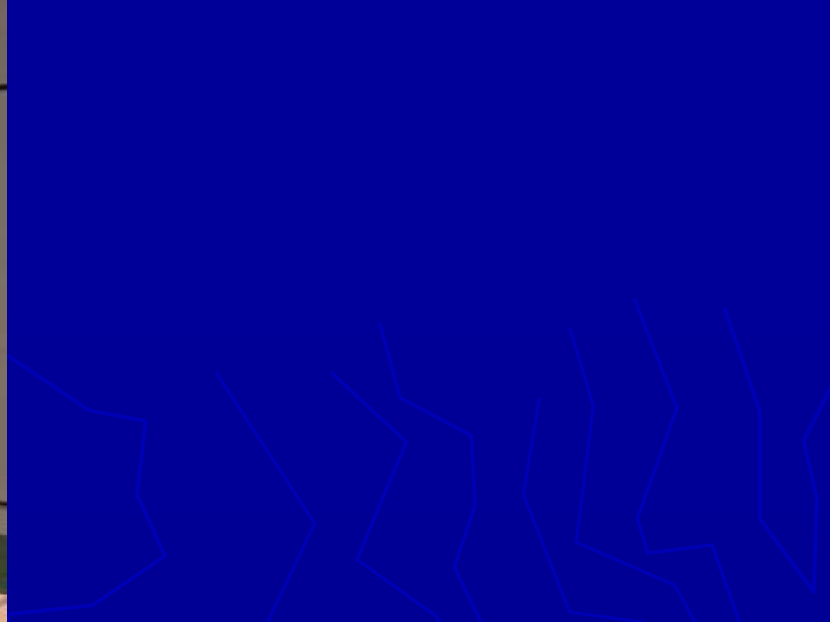
- ✓ Synchronization with R-wave ECG during all the time of recording
- ✓ Permits 3D reconstruction of the image and gives the possibility to turn or to move it
- ✓ Permits a quantitative estimation of myocardial contractility



MRI permits

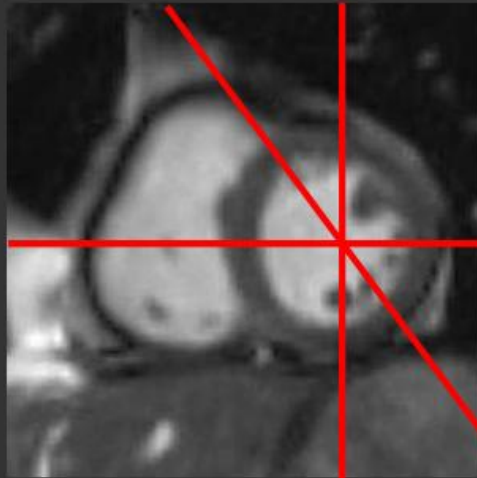
- Global and segmental analysis of myocardial function, myocardial mass, perfusion
- Differential diagnosis of cardiomyopathies
- Analysis of intracardiac anatomy (in complex congenital heart diseases)
- Investigation of intra- and paracardiac tumours
- Investigation of pericardium



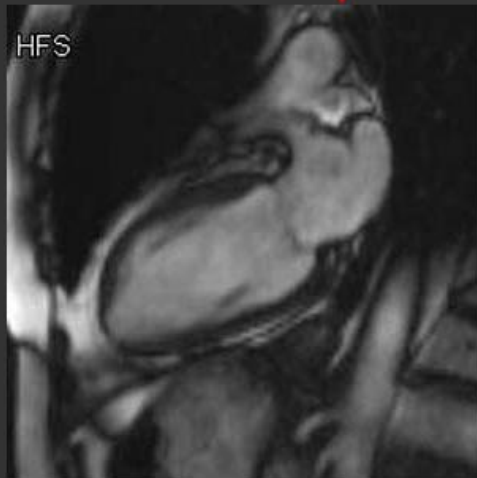
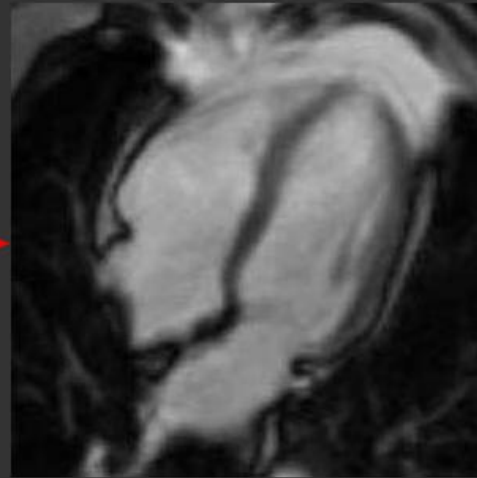


MRI views

Short axis



4 chamber view



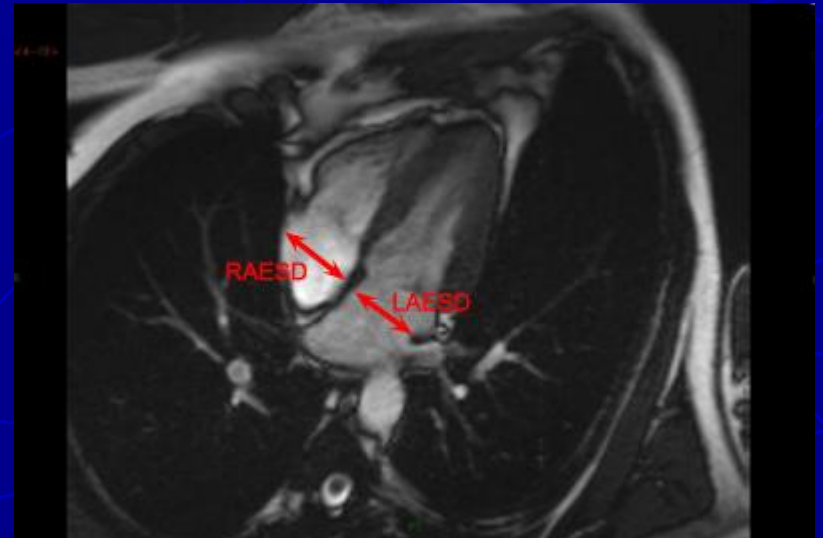
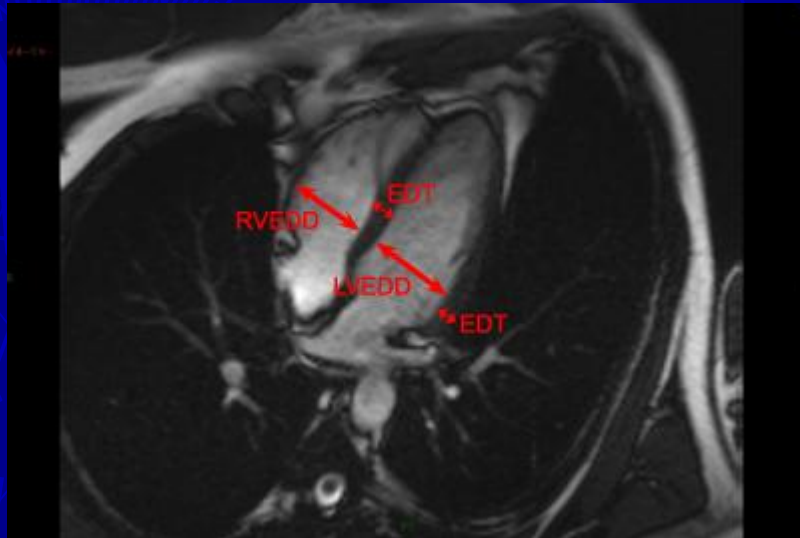
Vertical long axis



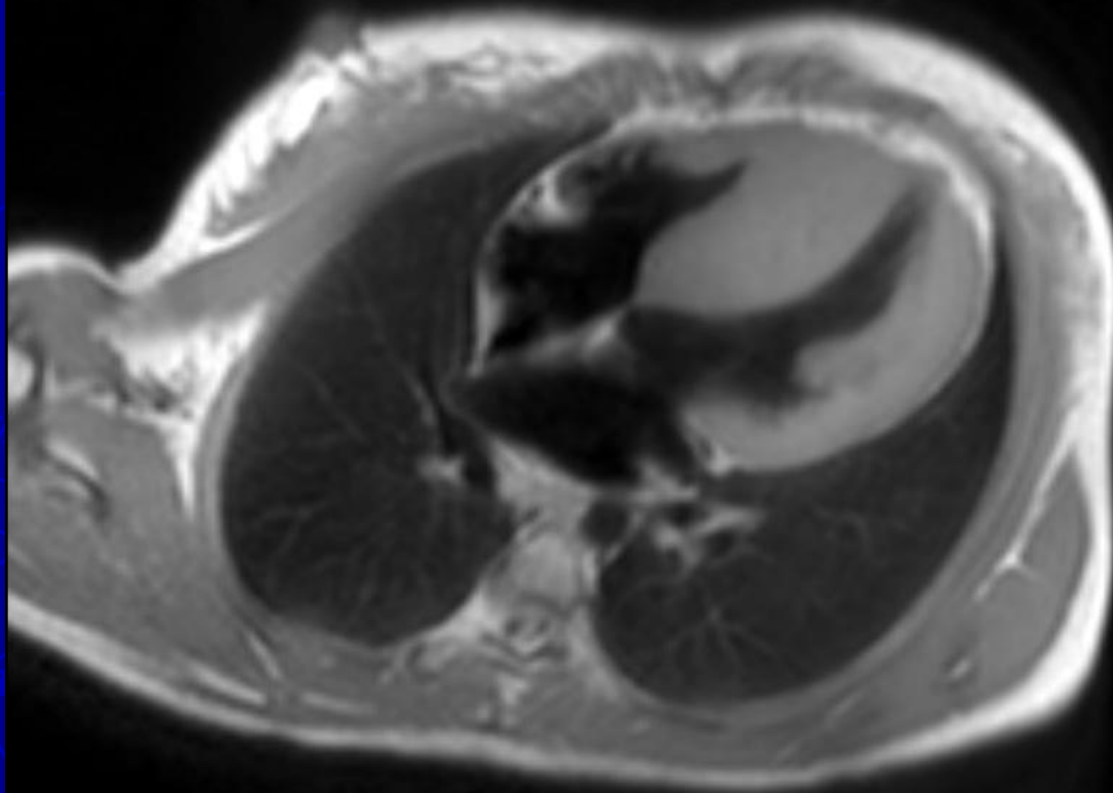
3 chamber view

MRI measurements

Measurement	Normal range
Left Ventricular End Diastolic Diameter (LVEDD)	<5.6 cm
Right Ventricular End Diastolic Diameter (RVEDD)	<LVEDD
End Diastolic Thickness (EDT)	<1.1 cm
Right Atrial End Systolic Diameter (RAESD)	<4.0 cm
Left Atrial End Systolic Diameter (LAESD)	<4.0 cm



Acq5/5
TSE / M
Td 694 ms



G

DG 35
PT 39
AP 15°
DG 44°
PT -14°

MRI: contraindications

Absolute

- Patients with pacemakers
- Patients with implanted ferromagnetic devices
- Patients who are intubated and mechanically ventilated

Relative

- Claustrophobia
- Severe arrhythmias

Information value of imaging methods in the diagnosis of cardiovascular pathology

	Methods					Method of choice
	Radiography using contrast media	CT	ECOCG	IRM	Nuclear medicine	
Heart						
Morphological changers	++	+++	+++	+++	+	ECOCG
Functional changers	++	++	+++	++	++	ECOCG
Heart valves	+	+	+++	+	-	ECOCG
Coronary arteries	+++	++	-	+	-	Angio-coronarography
Myocardial perfusion and metabolism	-	+	-	+	+++	Nuclear medicine, MRI
Thoracic aorta	++	+++	++	+++	+	CT, MRI

Imaging of peripheral blood vessels

Radiology:

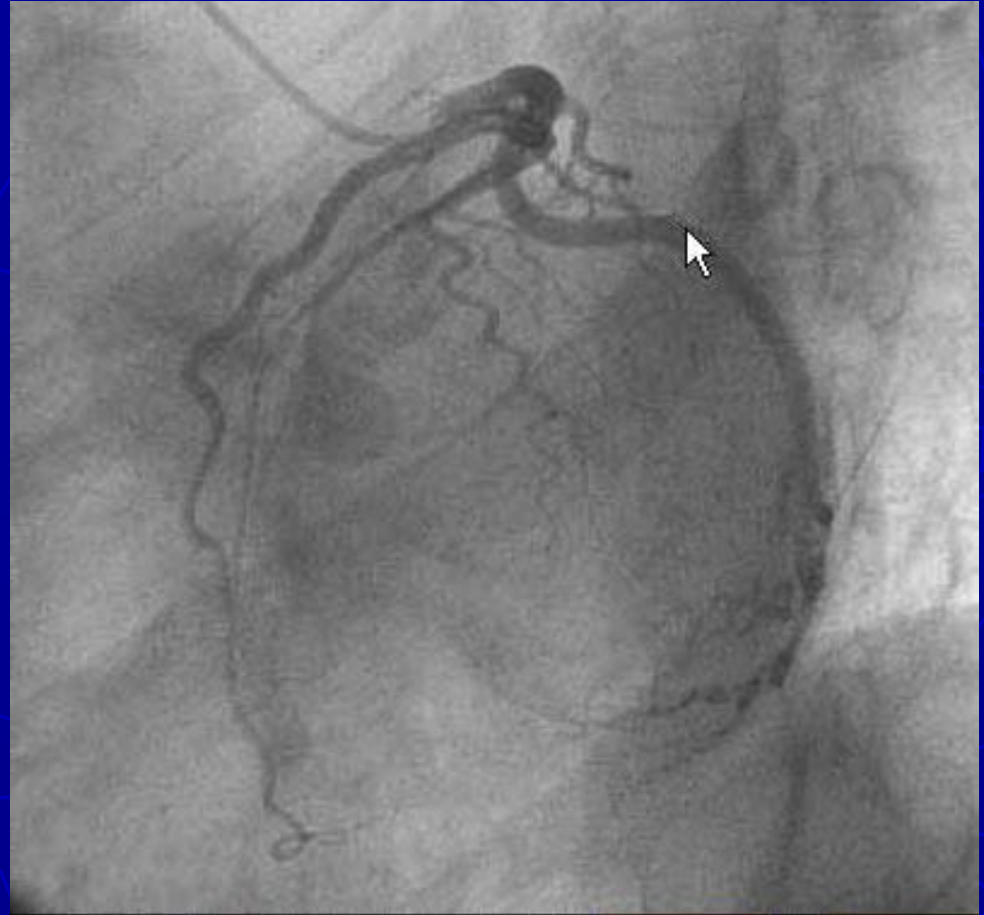
Angiography:

- ✓ aortography
- ✓ coronarography
- ✓ angiopulmonography
- ✓ arteriography
- ✓ flebography

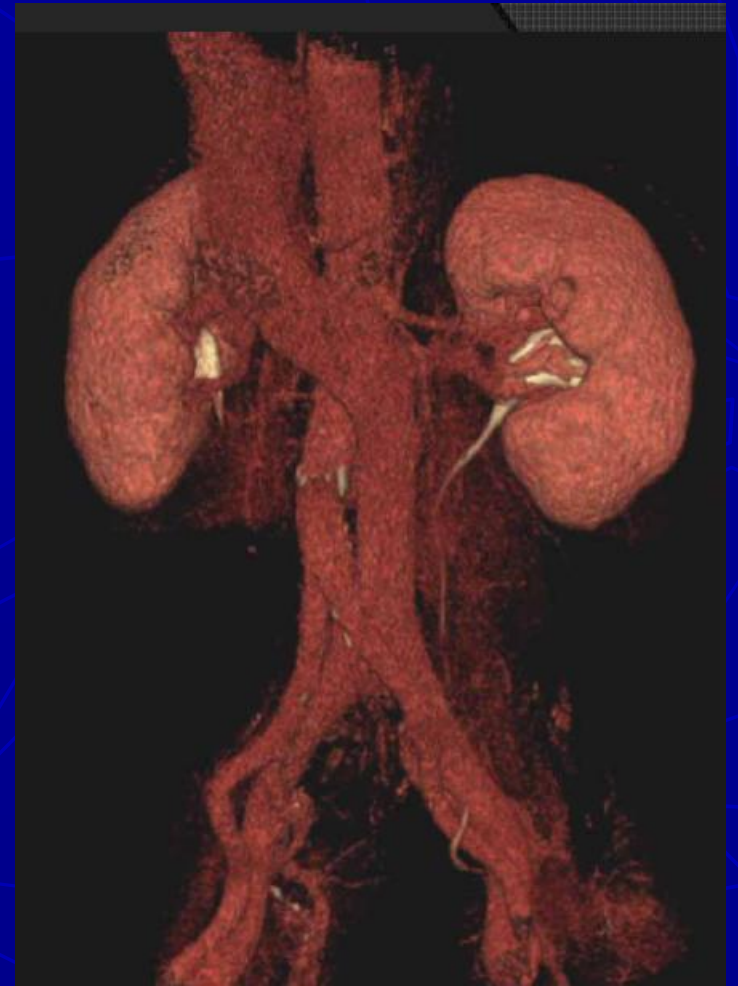
Angio-CT

USG:

- ✓ 2D
- ✓ Doppler:
 - ✓ pulsative
 - ✓ continuus
 - ✓ color



Imaging of blood vessels



USG imaging of peripheral blood vessels

