Cardiovascular imaging and reality

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Learning objectives

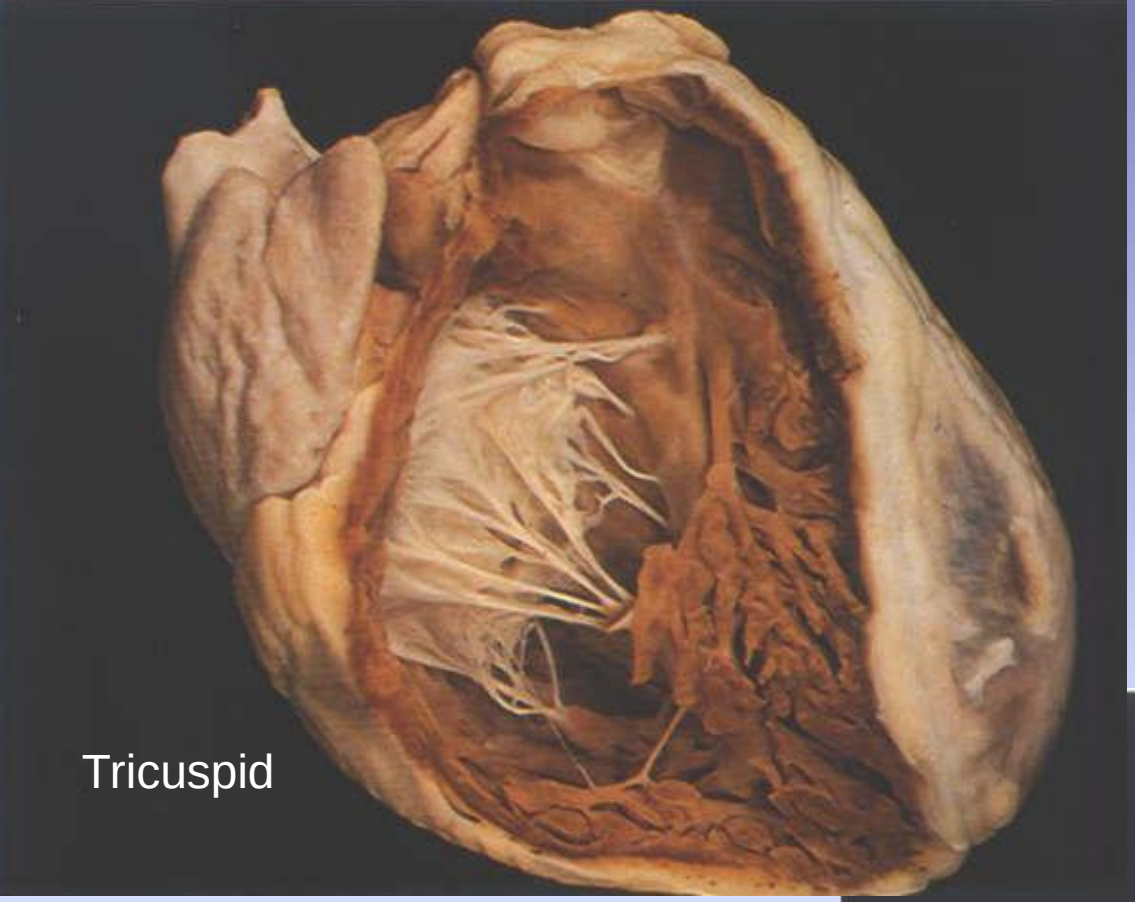
At the end of this lecture you should:

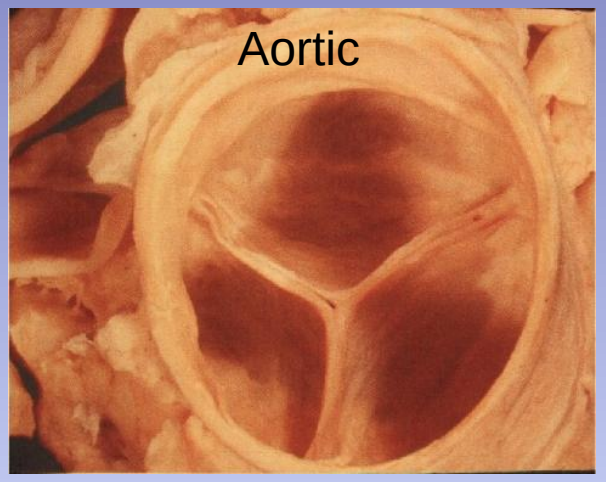
- Appreciate the basic principles, strengths and limitations of **x-ray, computed tomography, ultrasound and MRI approaches to imaging**, particularly of the heart.

- Be ready to approach any medical image (or measurement or trace) with inquisitiveness: 'what can I see and discover?', 'what ***can't*** I see through this approach?', 'why?'…. ignore any sense of ignorance and *engage your observant, inquisitive and critical faculties*.

- Recognize some key imaging features of mitral valve regurgitation.

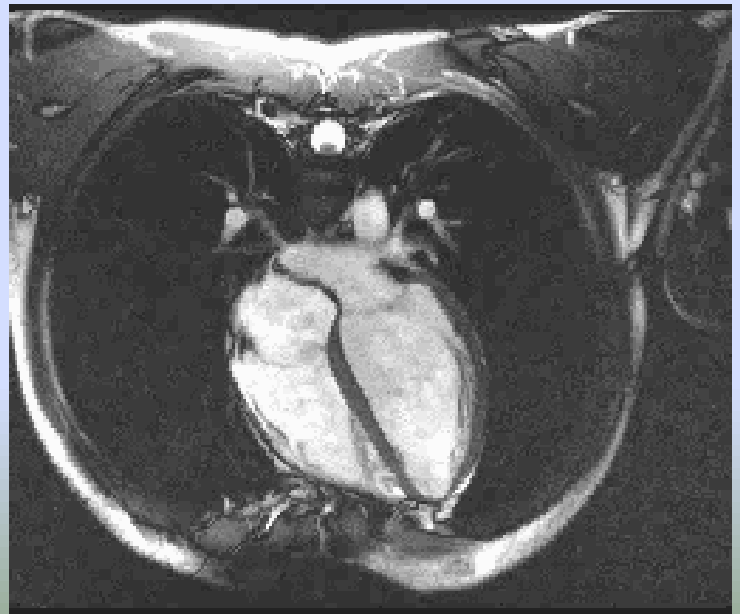
All medical images are limited and selective relative to living reality

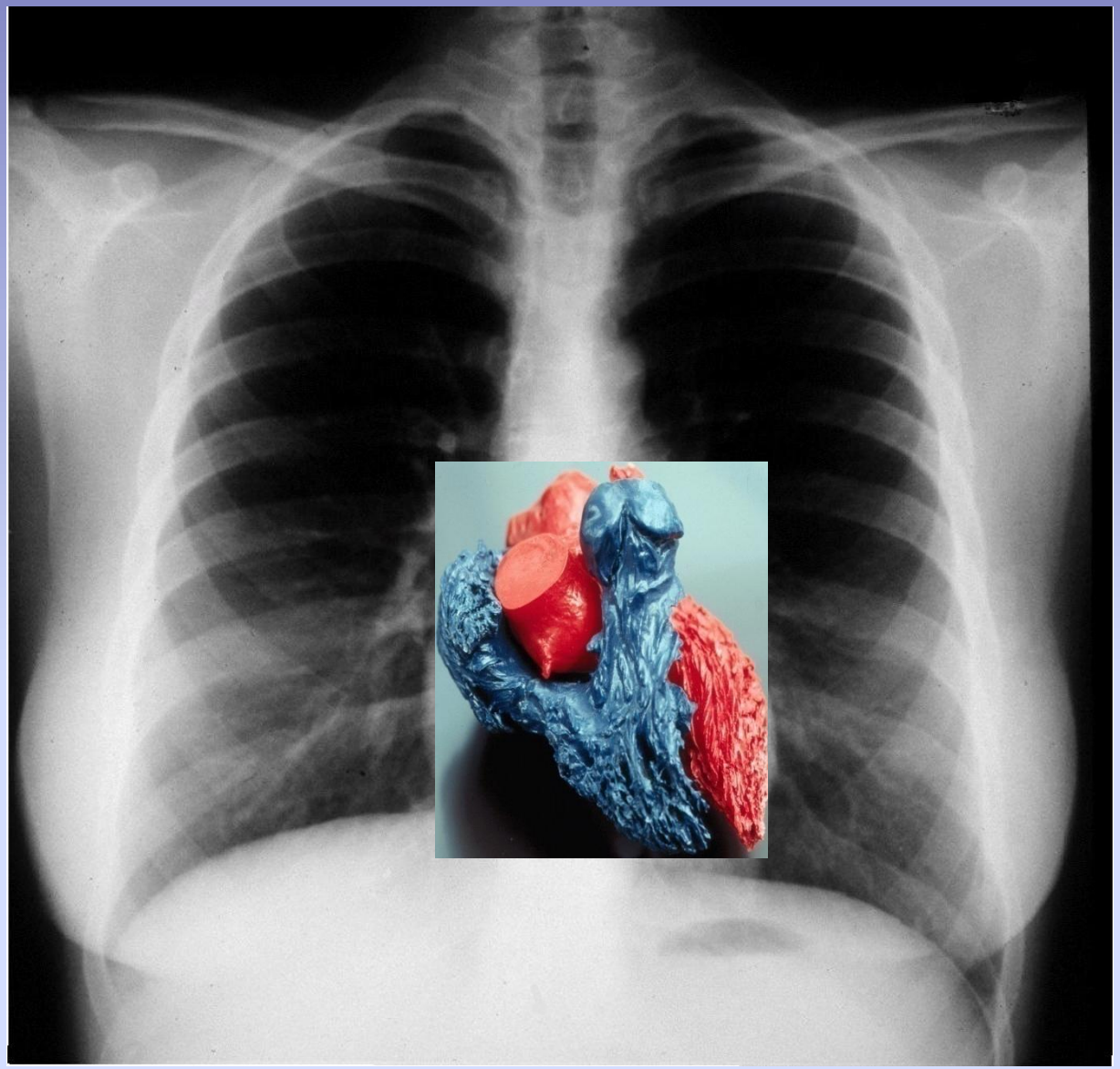

Tricuspid


Aortic


Mitral

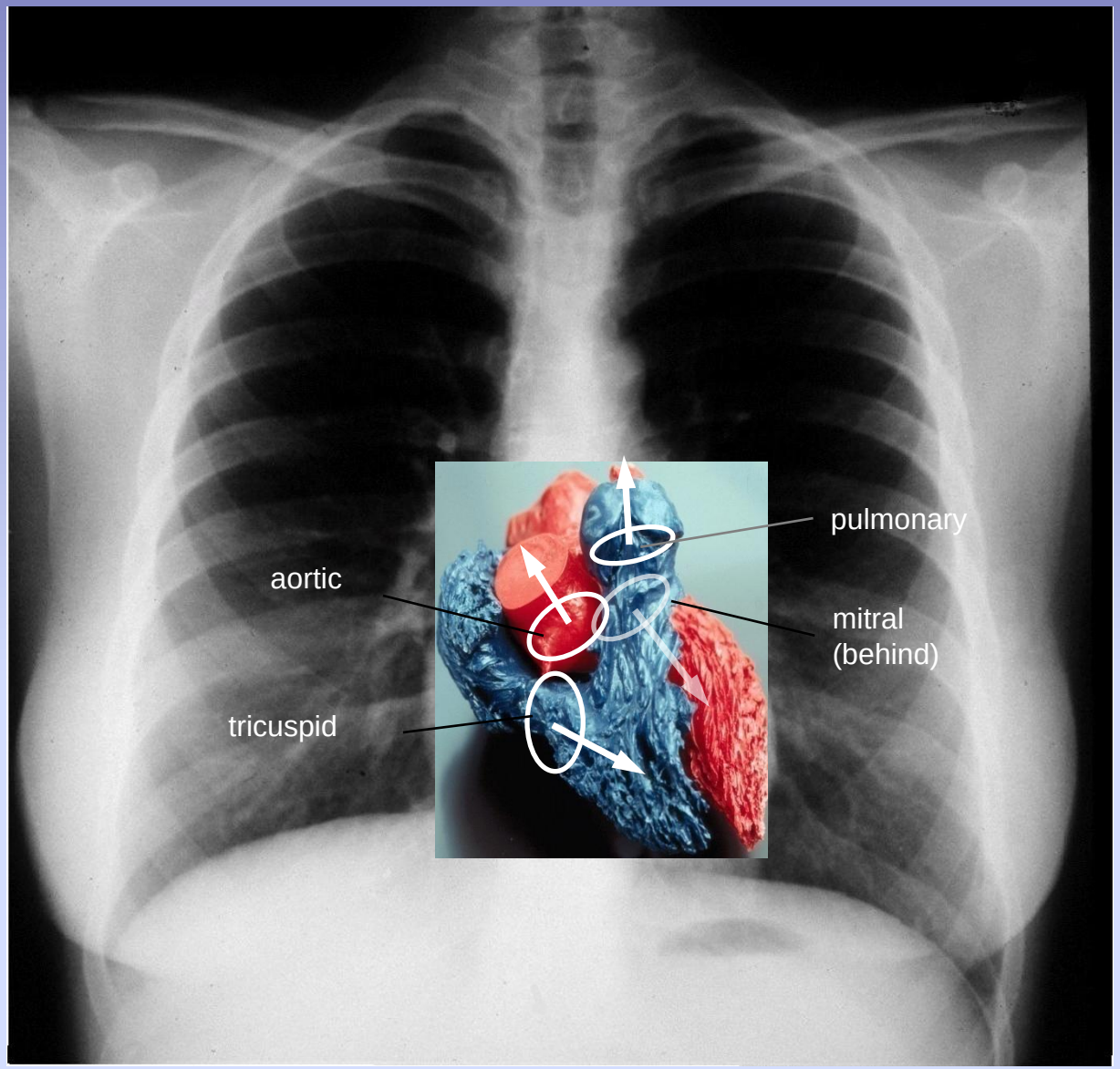
Heart valves by MRI:





Coloured resin cast of the heart cavities.

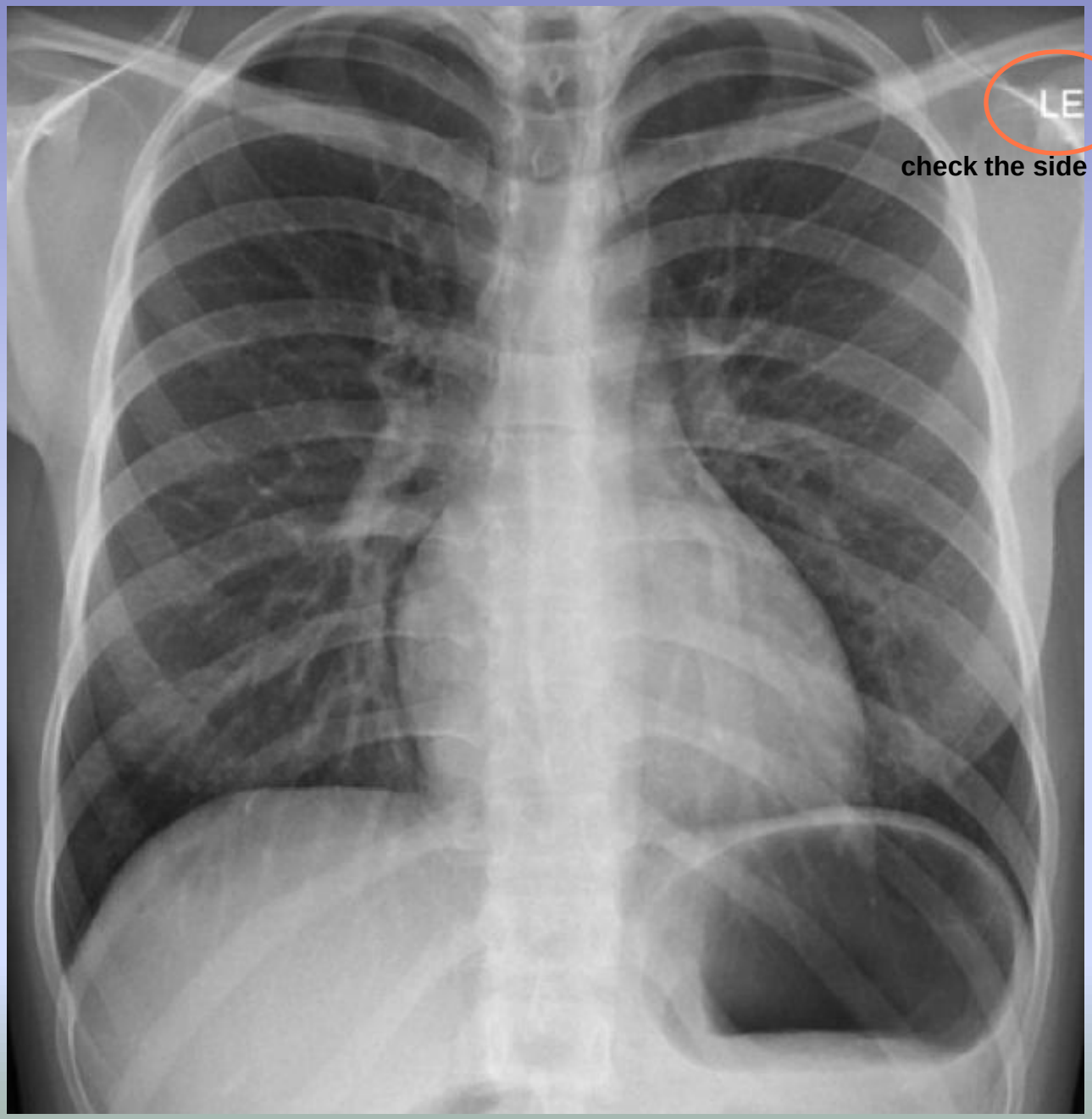
Consider the locations of the tricuspid, mitral, aortic and pulmonary valves.....


pulmonary
aortic
mitral
(behind)
tricuspid

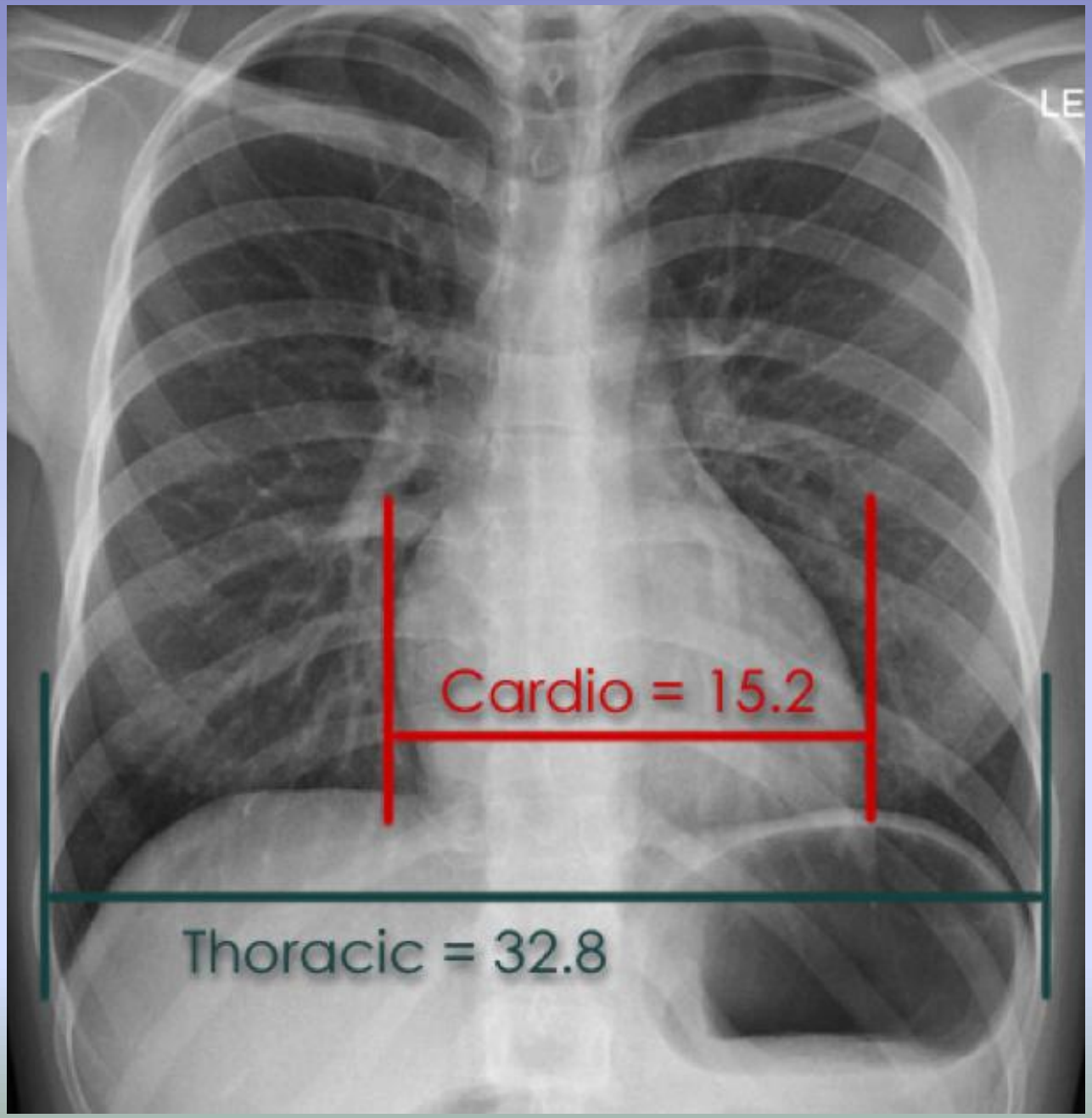
Imaging:

Energy source > interaction with tissues > receiver > image

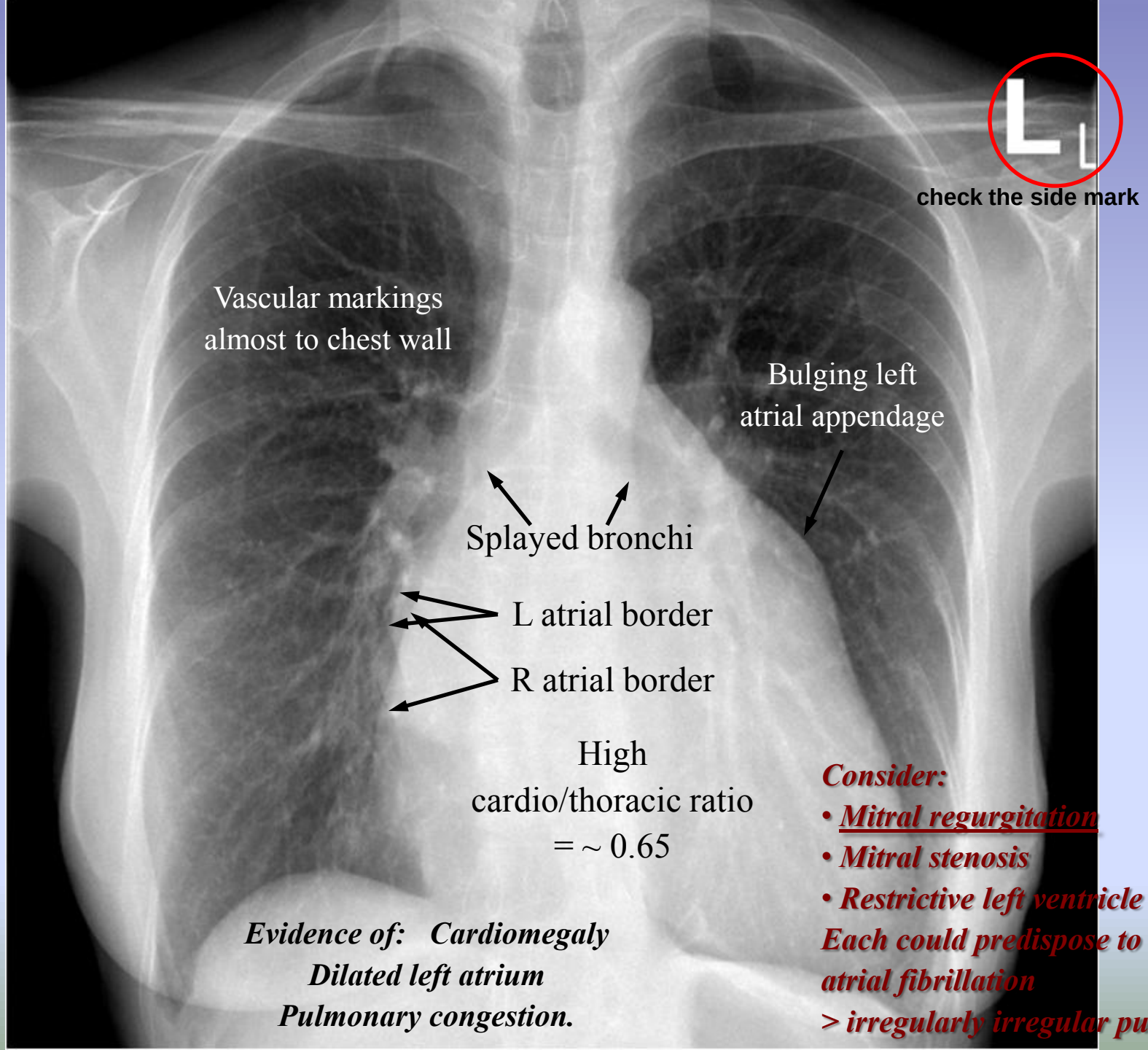
Chest X-ray (postero-anterior)

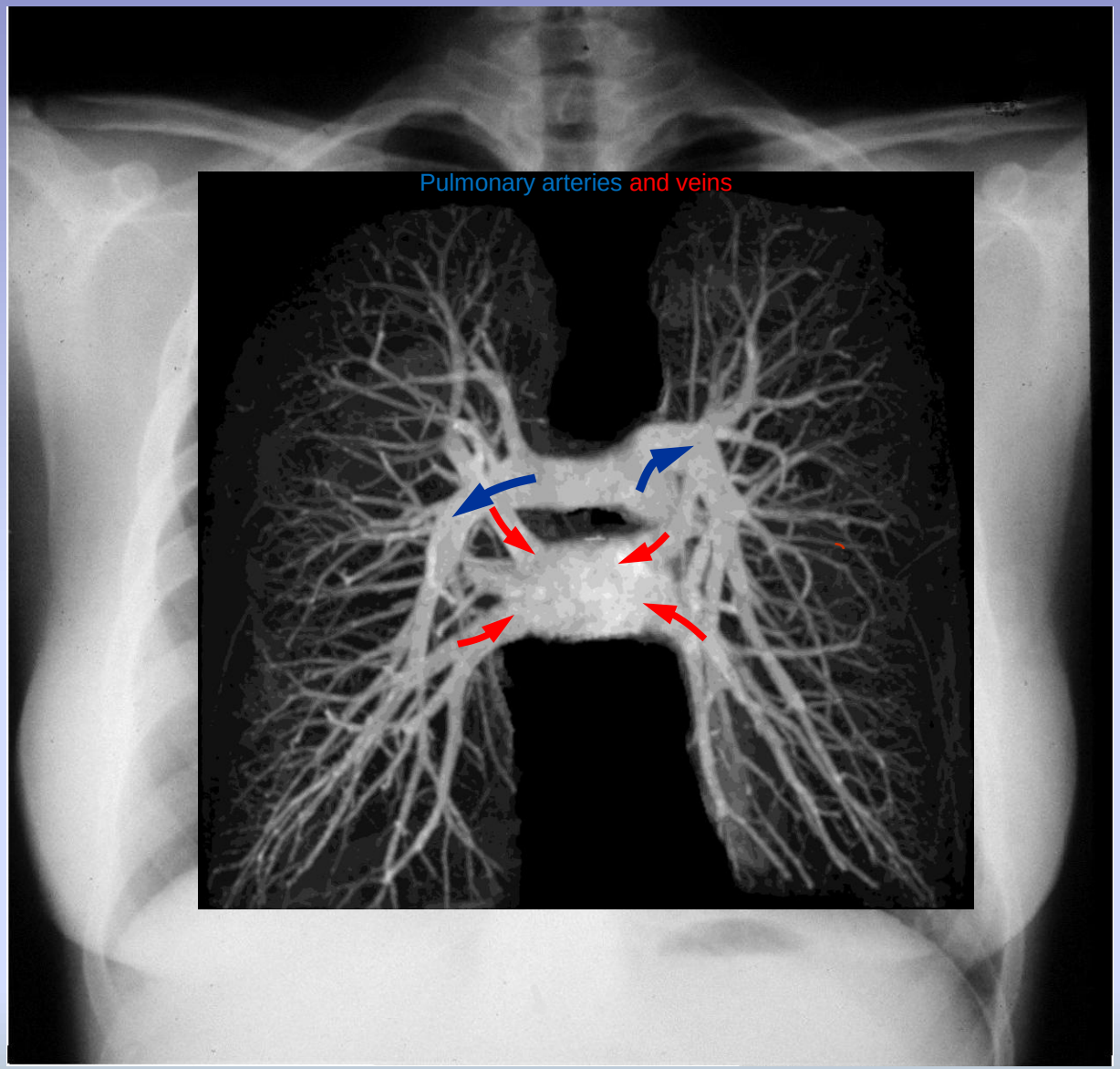


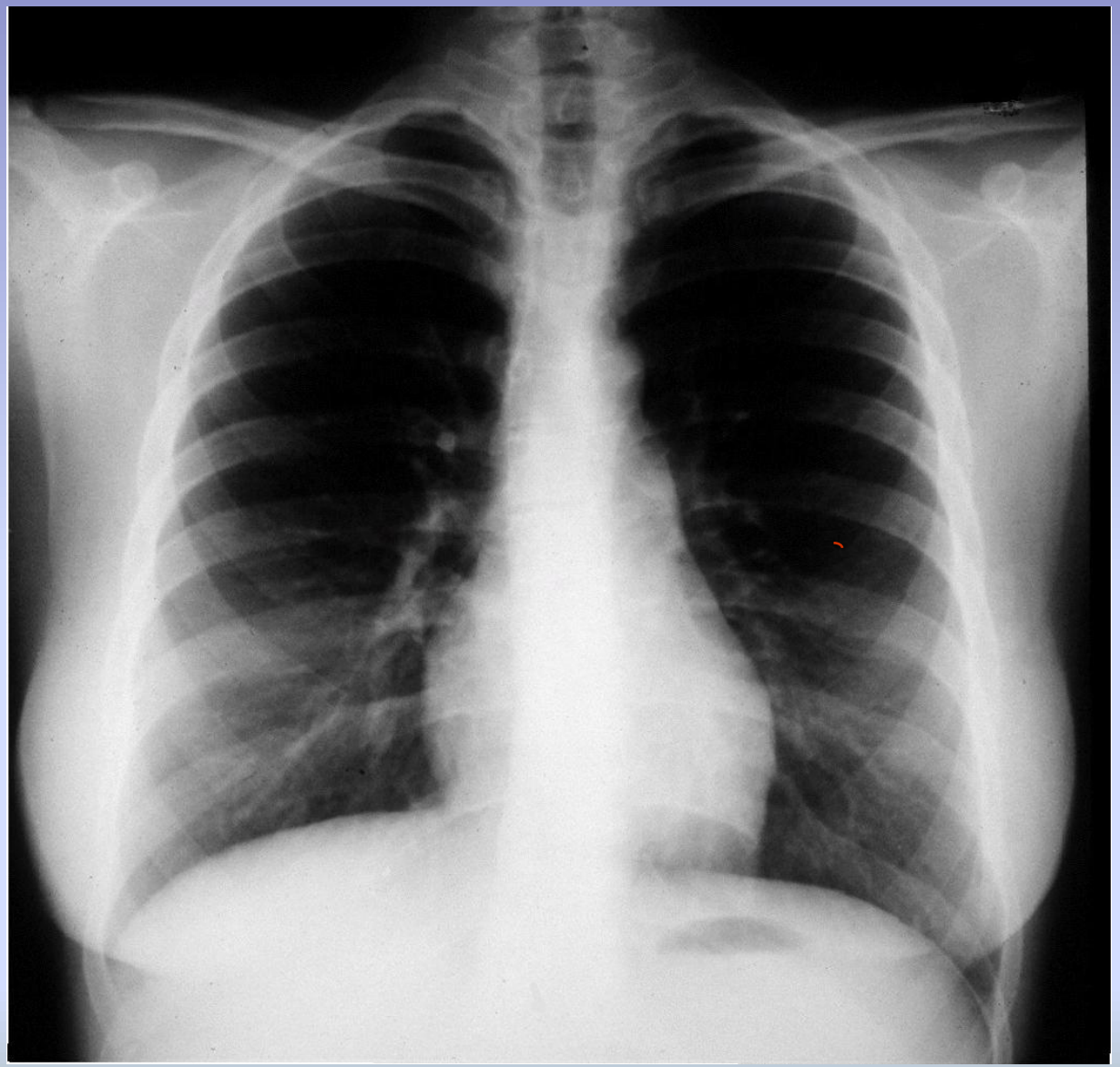
Chest x-ray
(normal)



Chest x-ray - Normal cardio/thoracic ratio = < 0.5


check the side mark
Vascular markings
almost to chest wall
Bulging left
atrial appendage
Splayed bronchi
L atrial border
R atrial border
High
cardio/thoracic ratio
= ~ 0.65
Evidence of: Cardiomegaly
Dilated left atrium
Pulmonary congestion.
Consider:
• Mitral regurgitation
• Mitral stenosis
• Restrictive left ventricle
Each could predispose to
atrial fibrillation
> irregularly irregular pulse


Pulmonary arteries and veins



Chest x-ray

Advantages:

Quick,

Inexpensive,

Overview of whole chest…

good for serial comparison

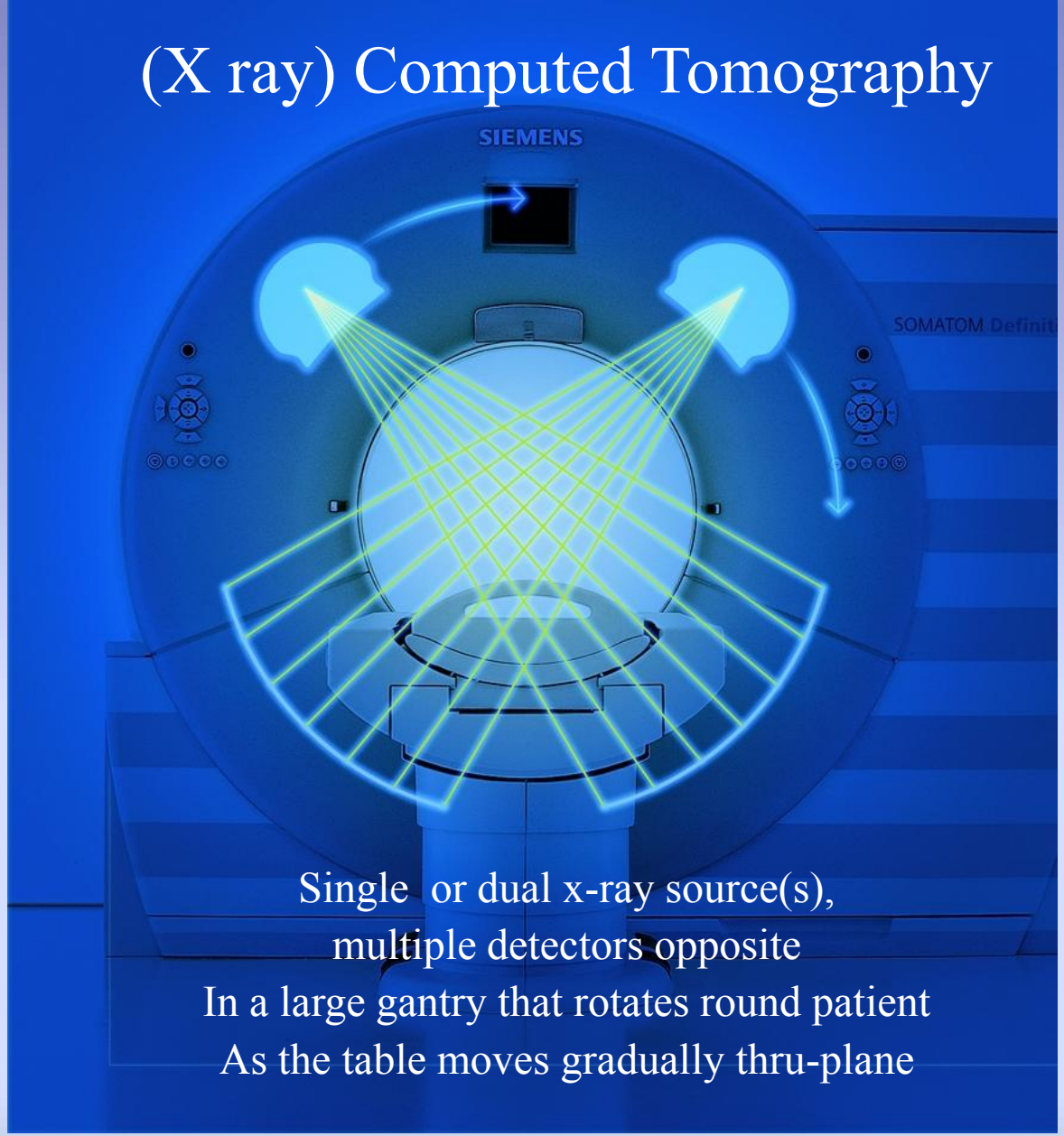
Disadvantages:

Only a static snapshot

Structures super-imposed

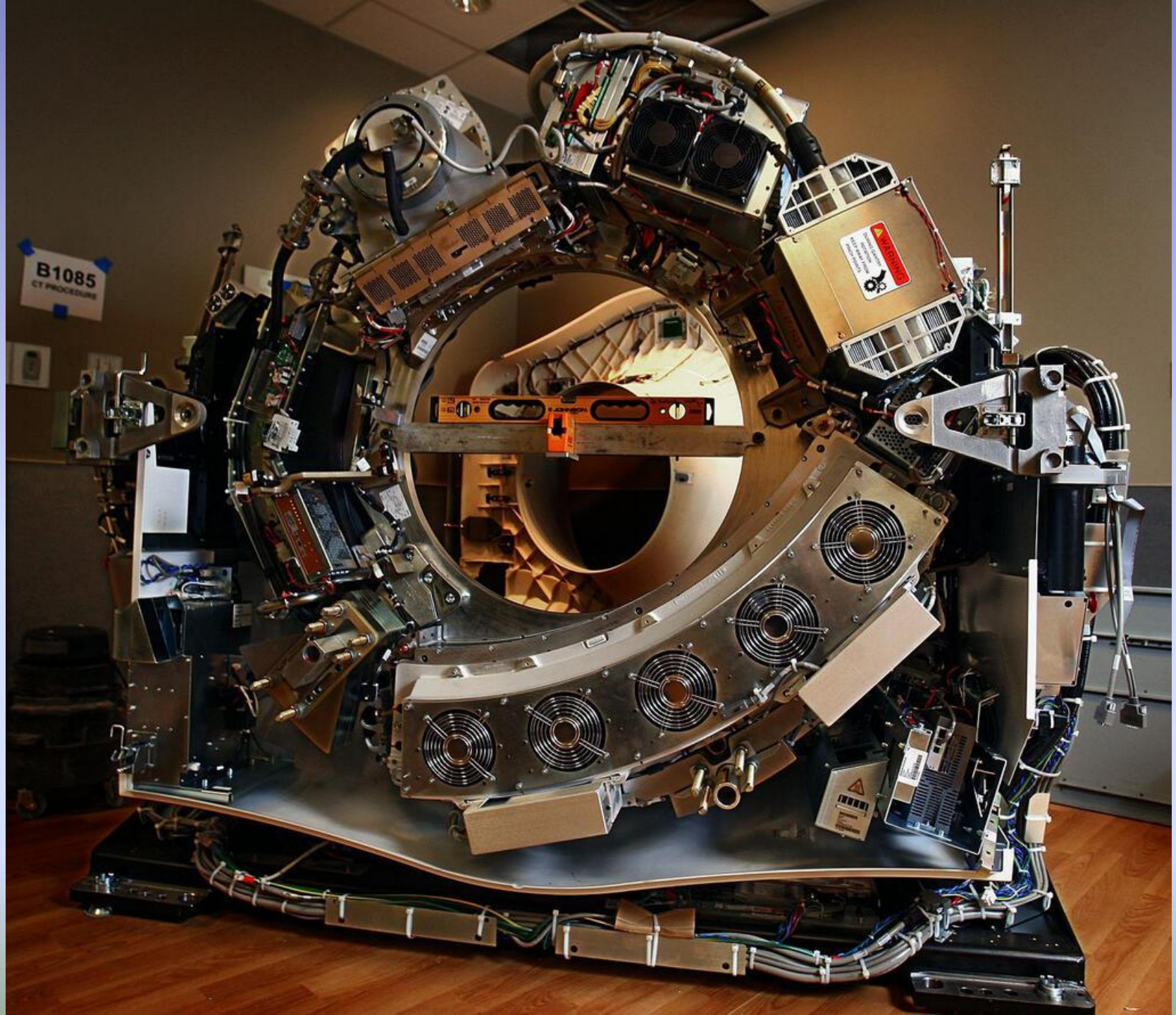
No imaging of movement, flow, etc.

(X ray) Computed Tomography

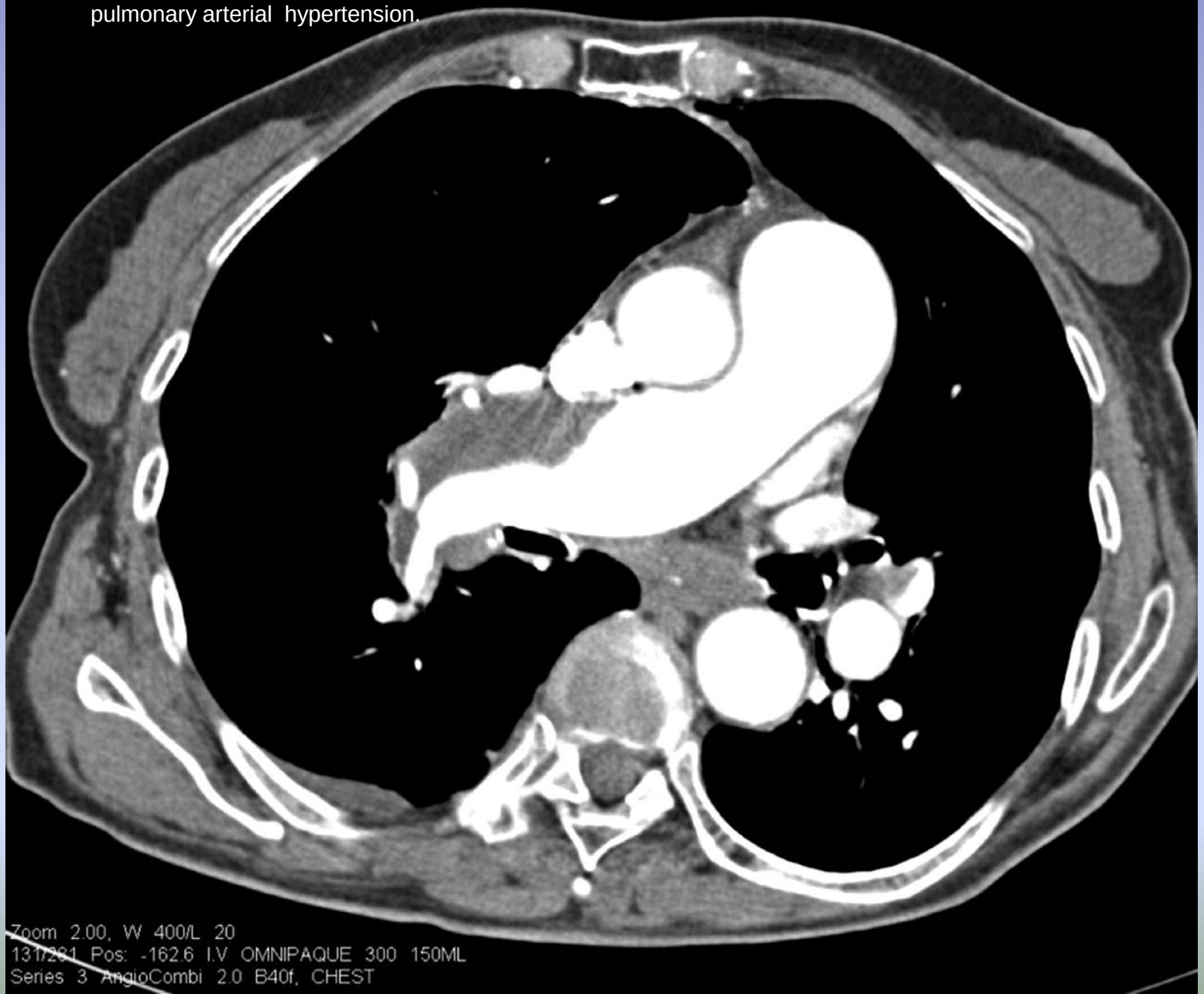


Single or dual x-ray source(s),
multiple detectors opposite
In a large gantry that rotates round patient
As the table moves gradually thru-plane

tomographic images computed by ‘back projection’

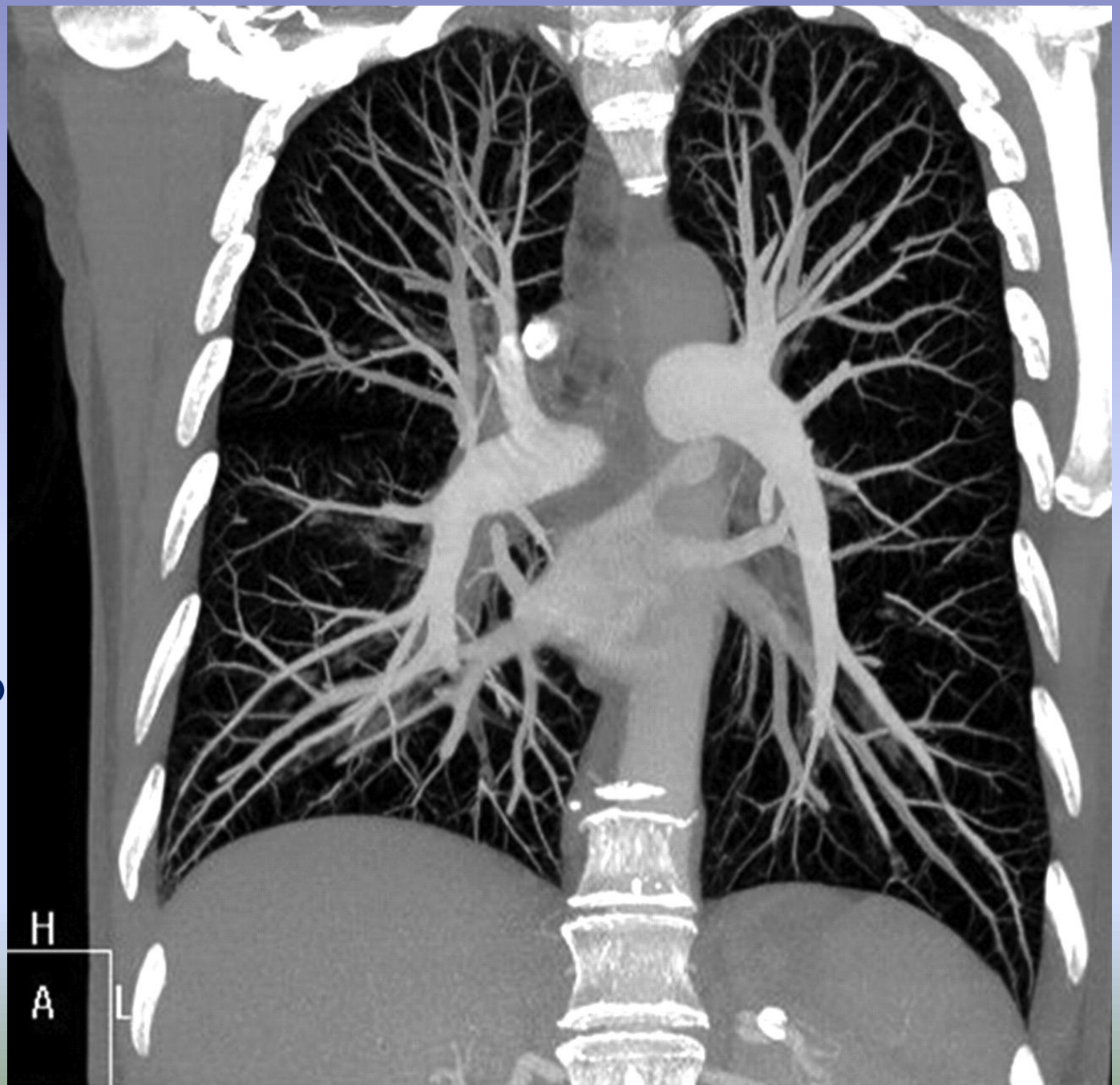

B1085
CT PROCEDURE
WARNING

CT with intravascular contrast (transaxial thoracic image – viewed towards head).
PA dilatation.
Thrombus in RPA in
pulmonary arterial hypertension.



CT with intravascular contrast

coronal Reformat from the 3D dataset



CT with contrast data ‘surface rendered’ to show L heart and vessel cavities

(processed by
Petter Quick
CMIV
Linköping University
Sweden

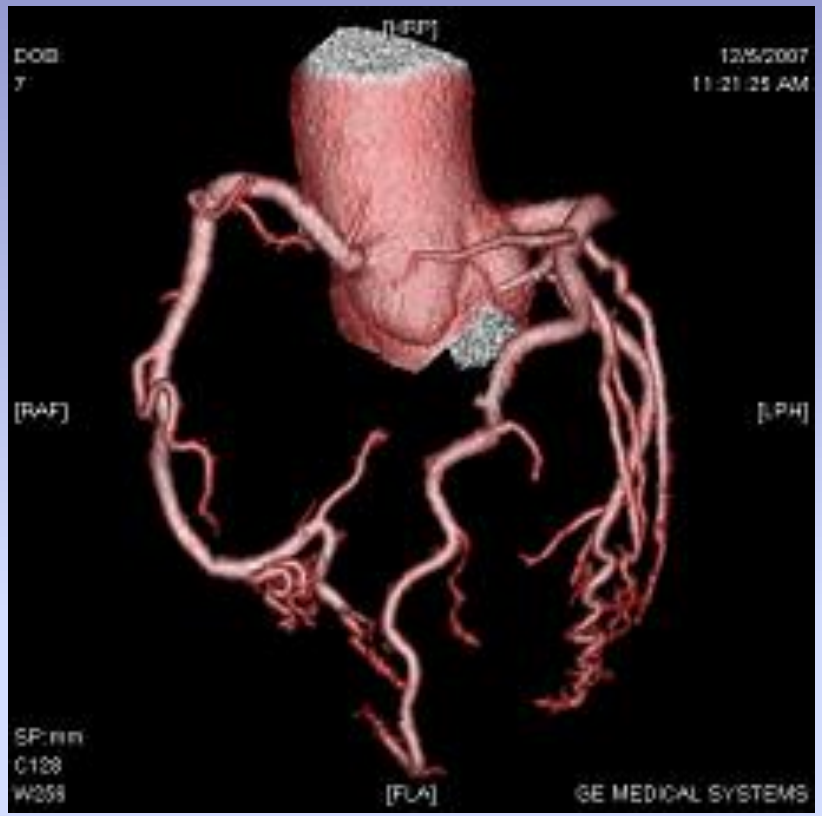
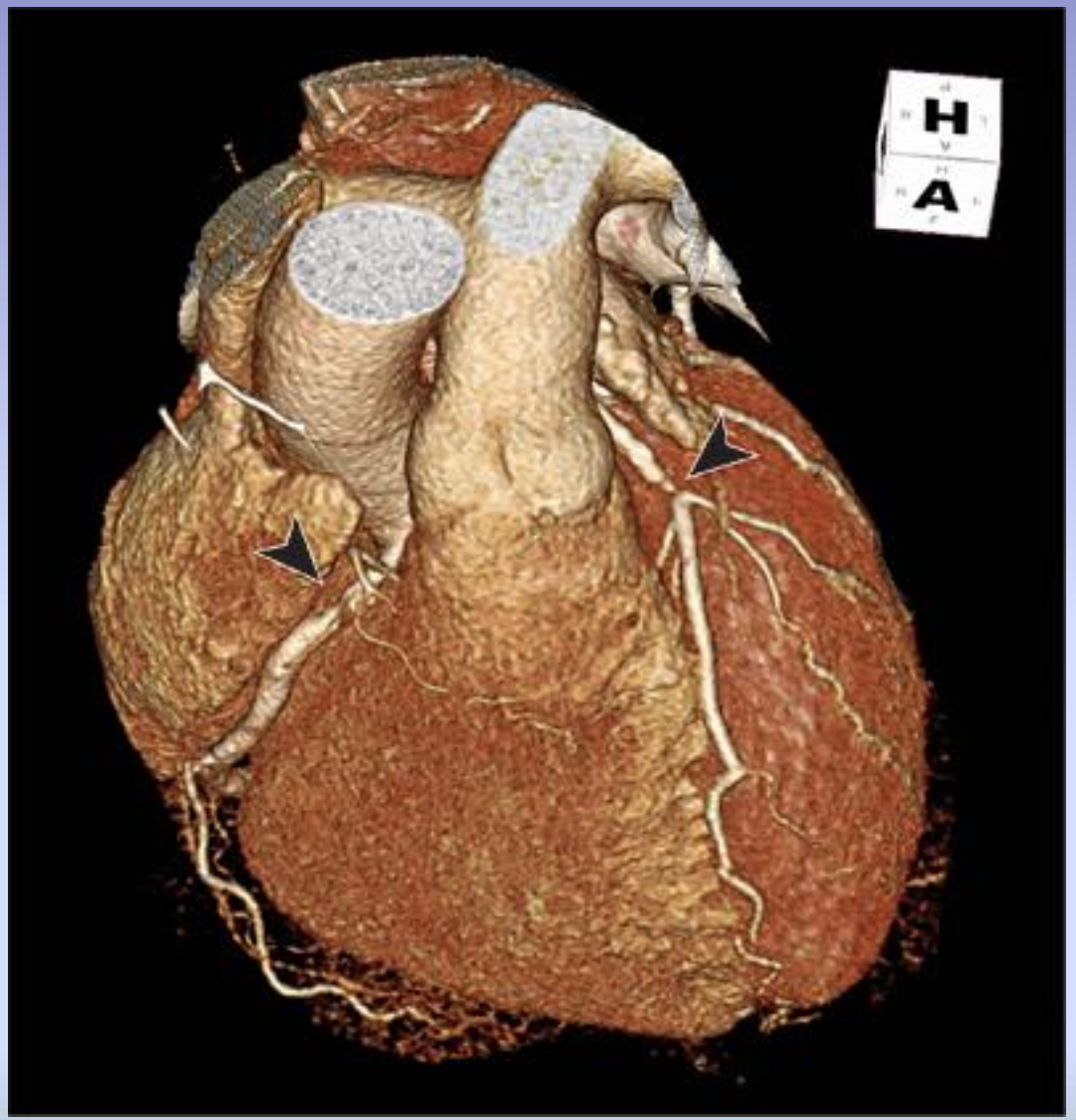


Figure 2. Non-invasive coronary angiogram performed by coronary 64-row multidetector computed tomography.



CT with contrast
surface rendered 3D display
Showing coronary stenoses

(x-ray) Computed Tomography

Advantages:

Relatively quick

3D volume coverage

Good spatial resolution

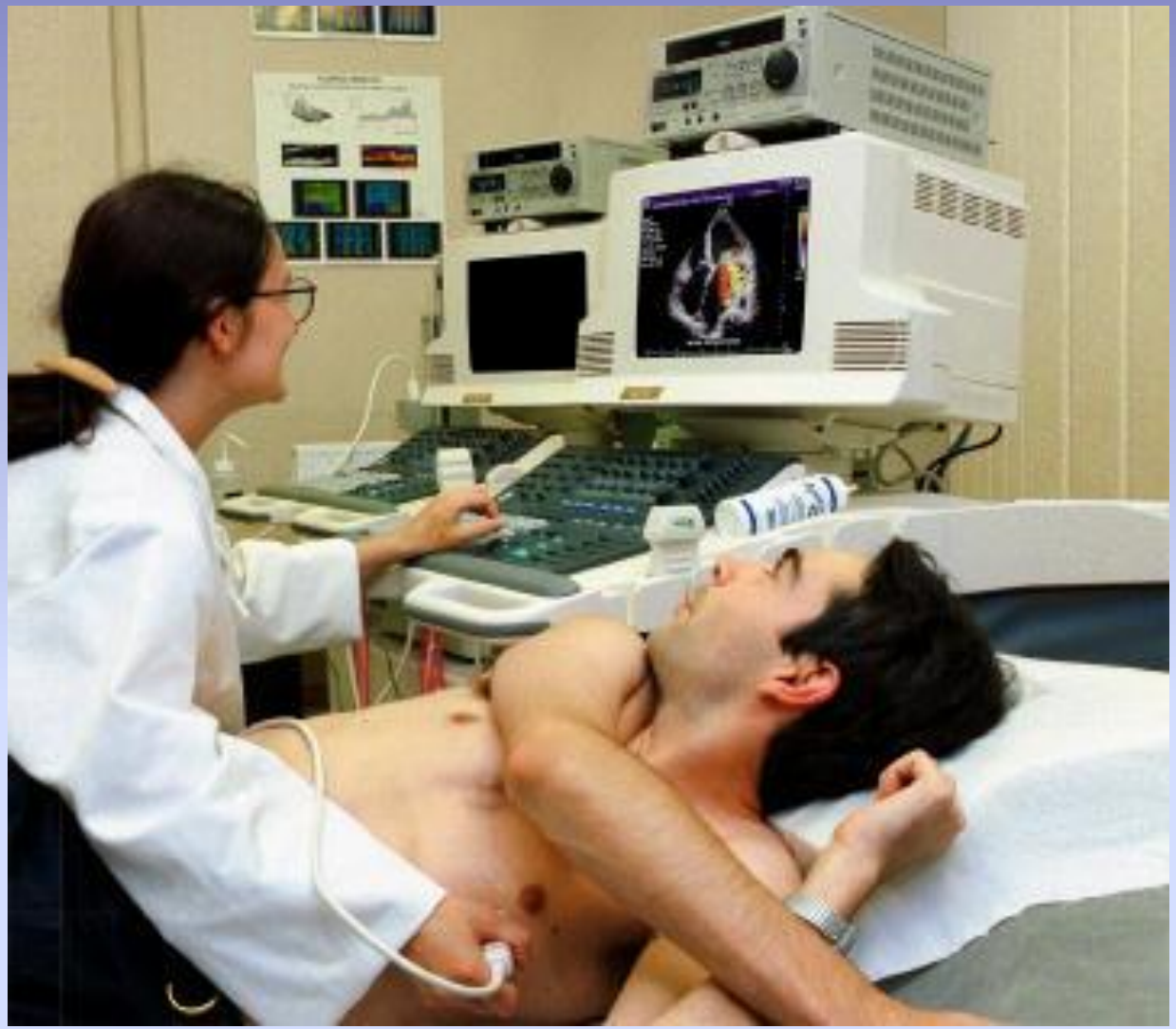
Good, with contrast, for small vessels

Disadvantages:

Ionising radiation

Movement and flow not usually well shown

Coronary artery lumen can be obscured by calcium

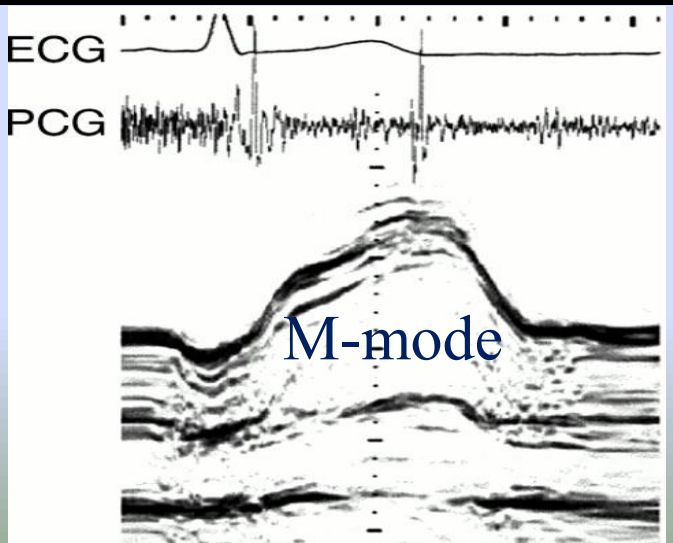


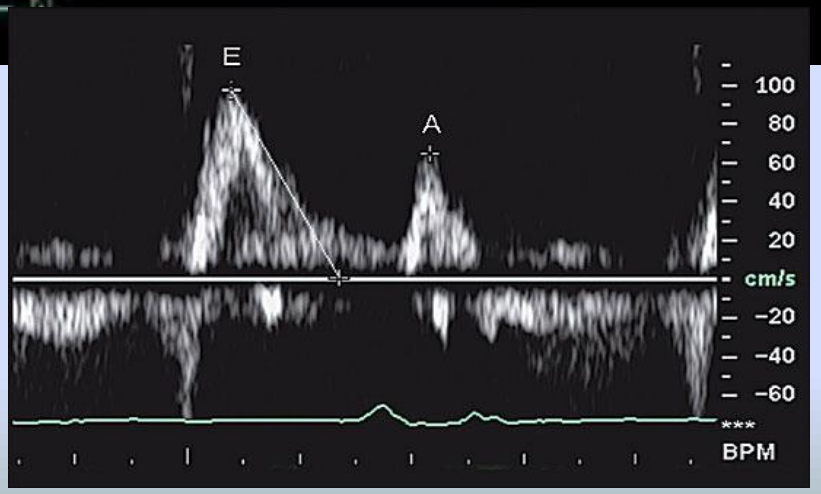
Cardiac ultrasound / echocardiography

High frequency ‘sound’waves are emitted through tissue. ‘Echos’ from structural discontinuities are re-detected by the transducer array > image reconstructed

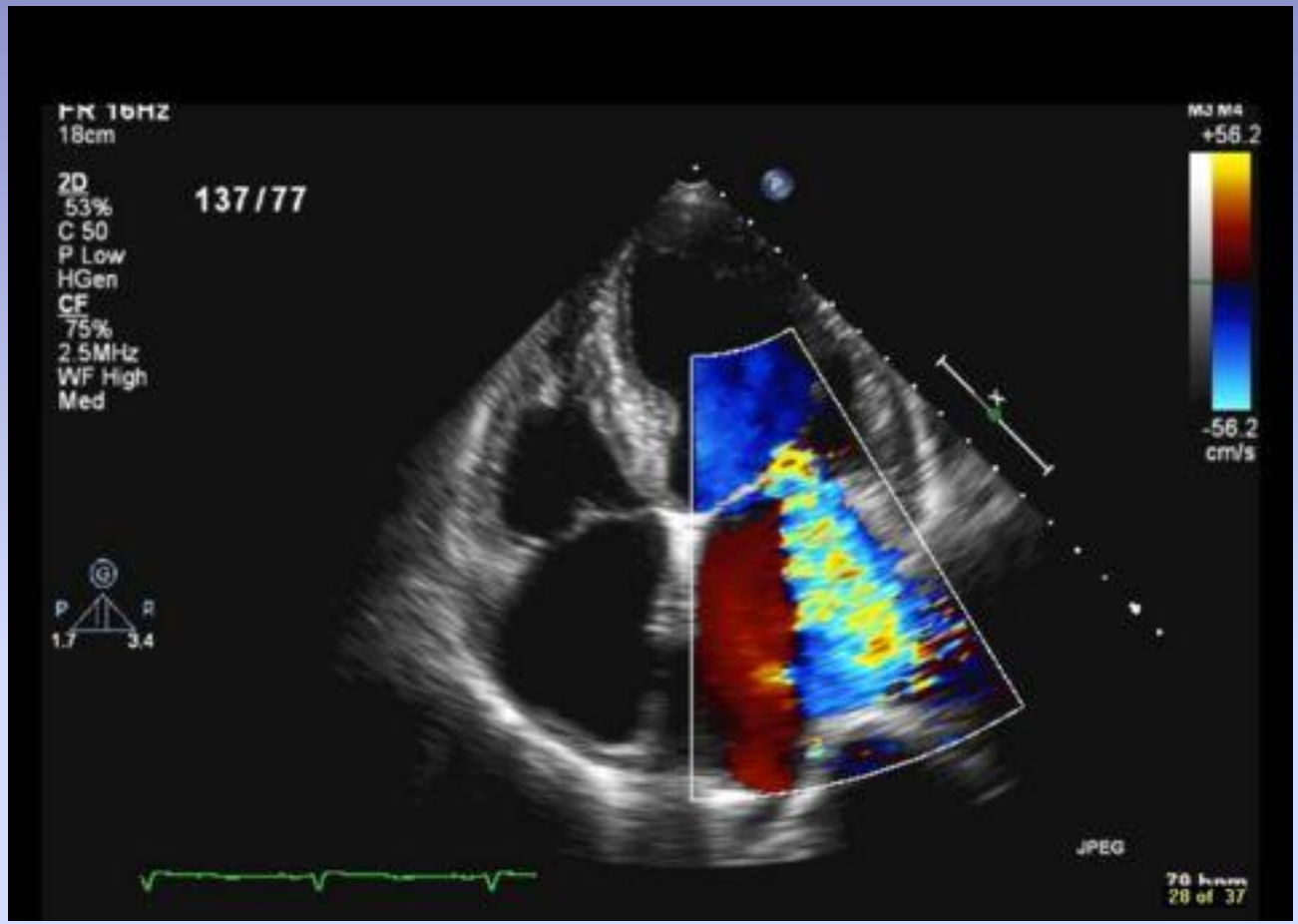
2D echo
4 chamber

Colour
Doppler

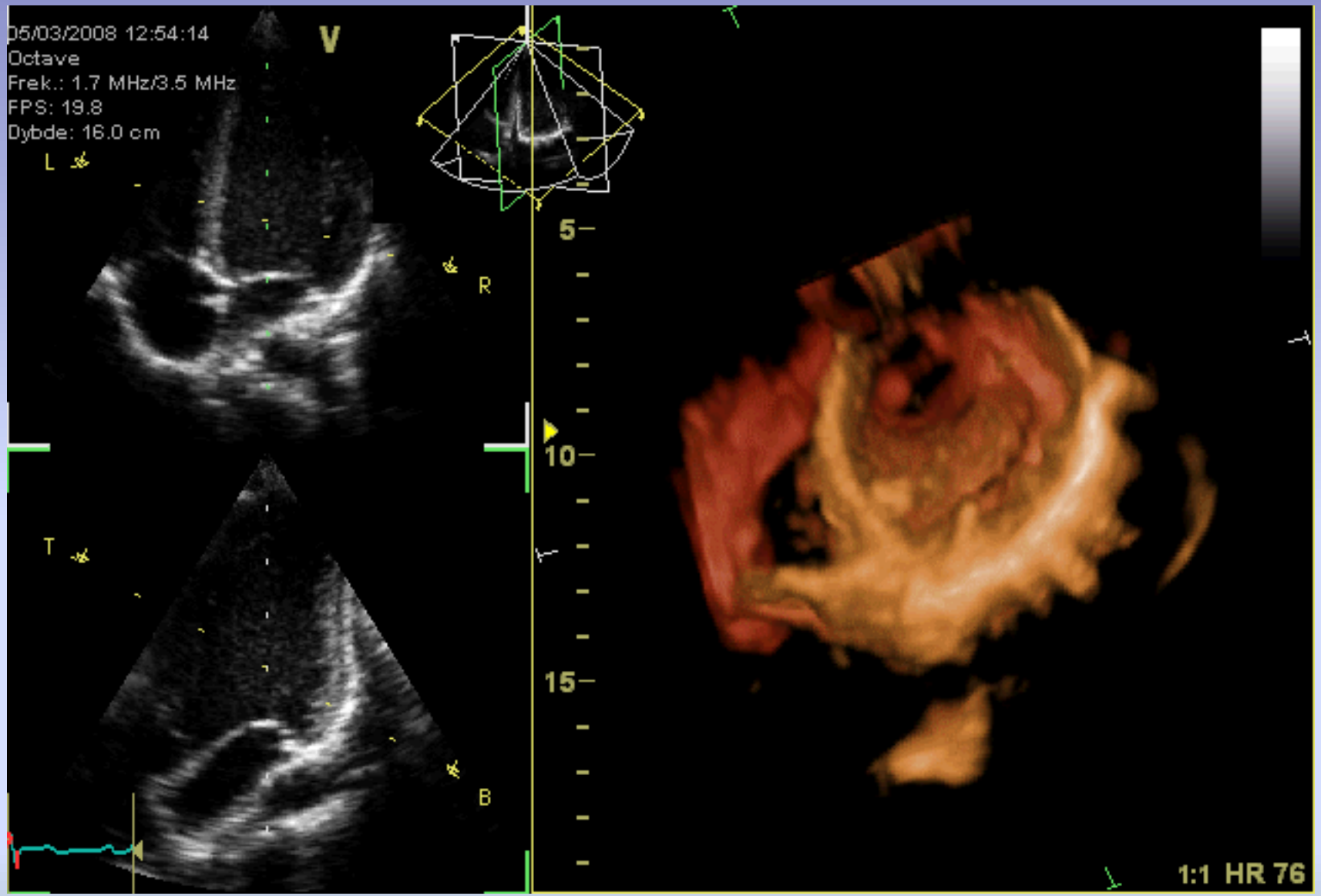




Doppler M-mode (normal mitral inflow)



Mitral regurgitation by colour Doppler echocardiography



2D and 3D echcardiography, Kjetil Lenes, Wikimedia commons

Echocardiography

Advantages:

Portable

Reasonably quick

Versatile

Shows movements and flows well

Including thin structures (valves, septum)

Disadvantages:

Windows and depth of access limited

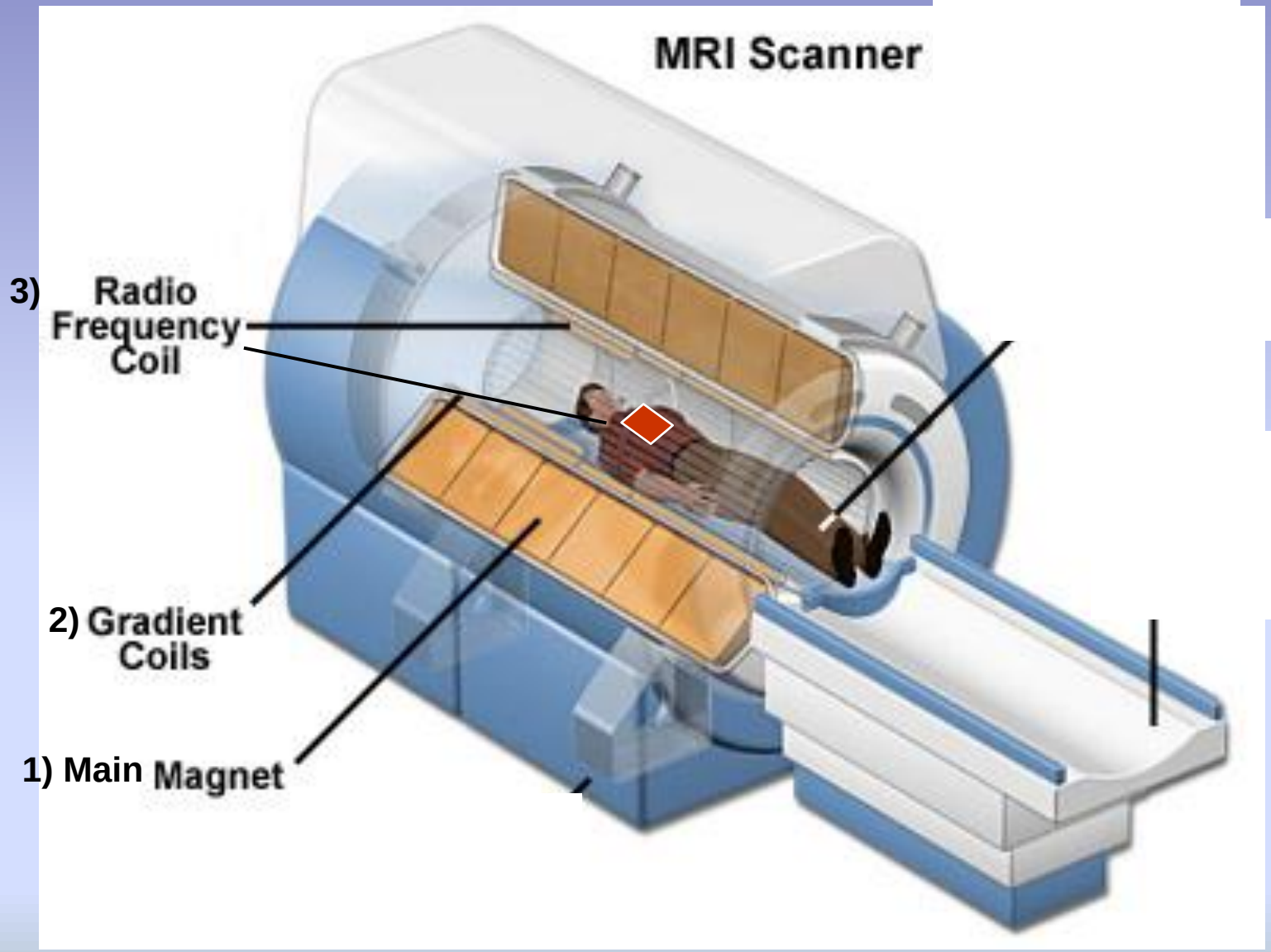
(especially by ribs and lungs)

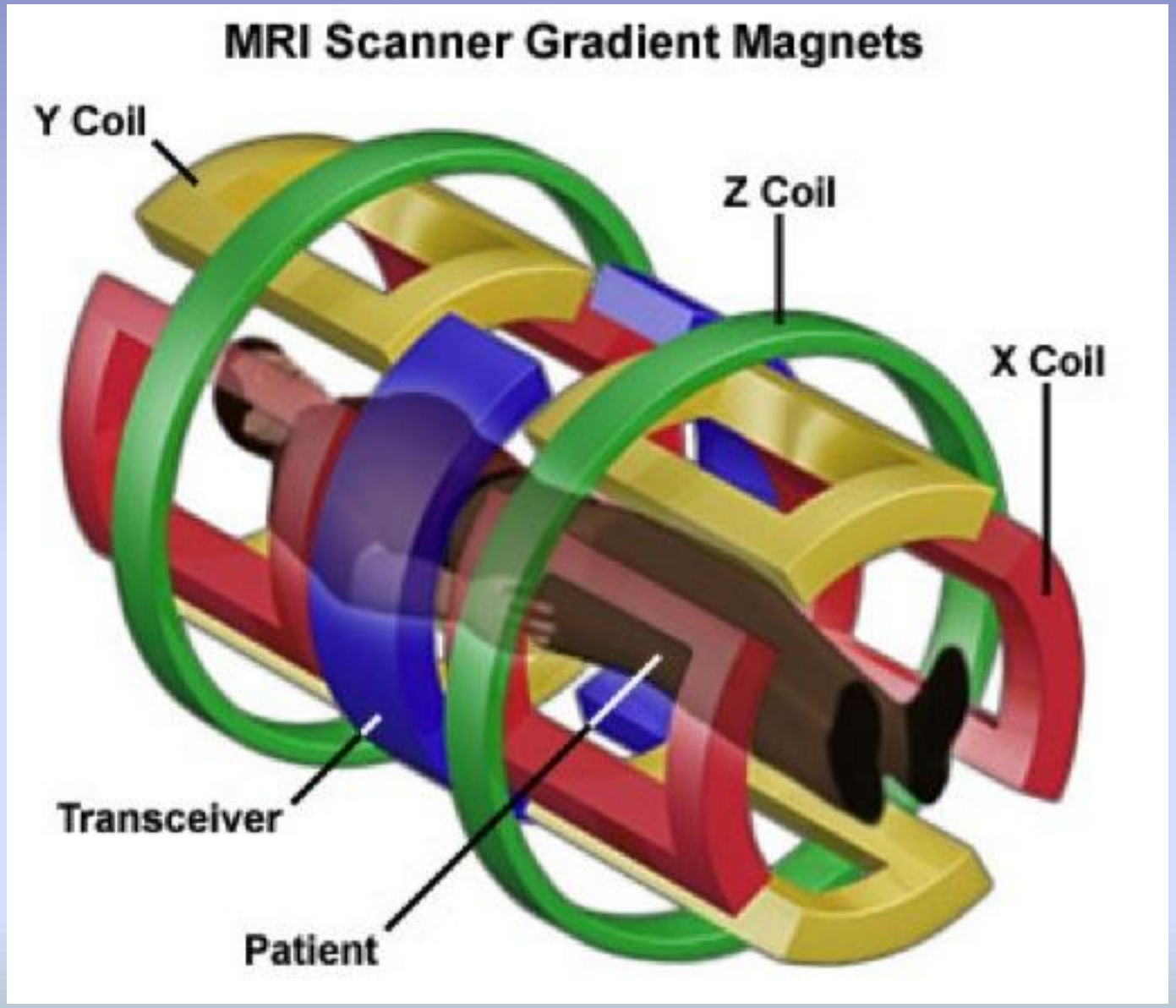
Operator dependent

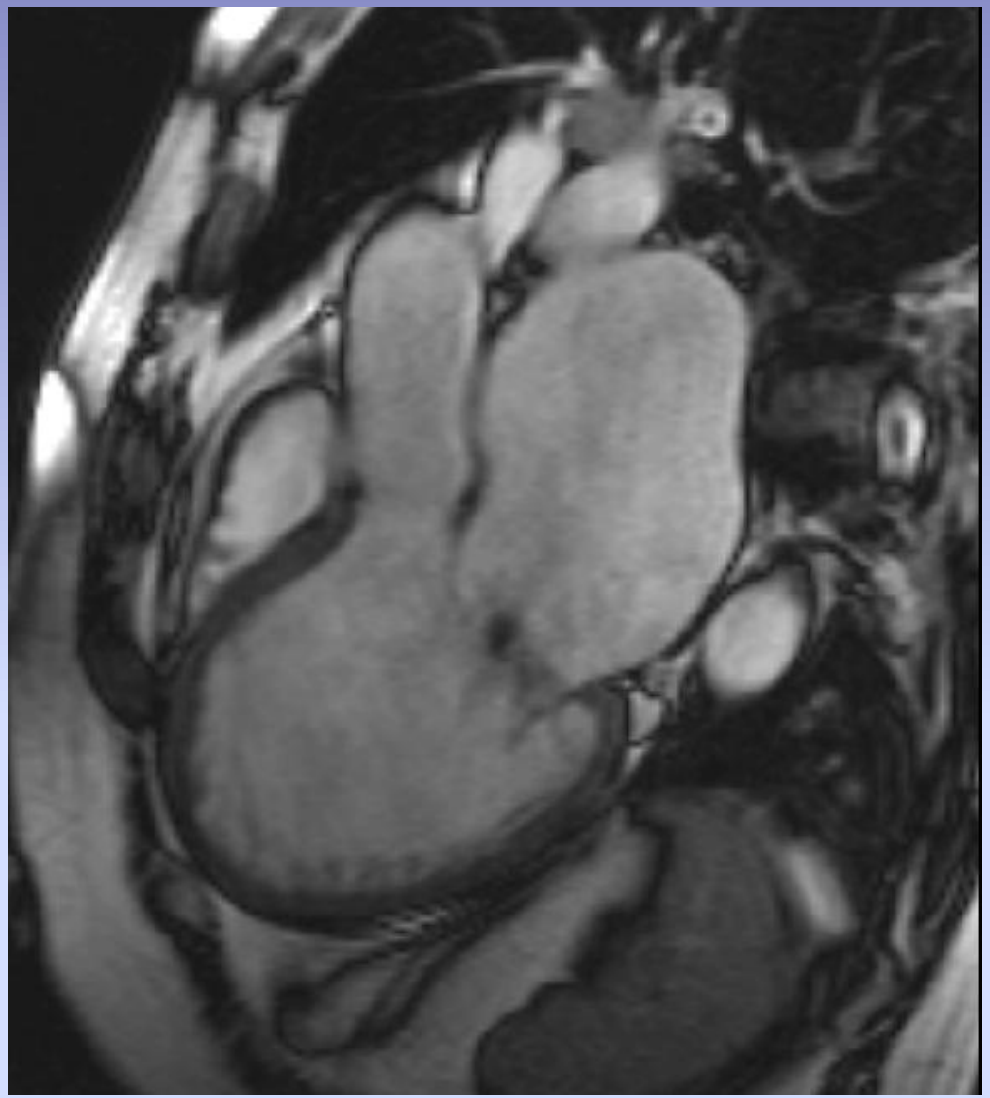
Cardiovascular

MRI

(normal)


MRI Scanner
3) Radio Frequency Coil
2) Gradient Coils
1) Main Magnet


MRI Scanner Gradient Magnets
Y Coil
Z Coil
X Coil
Transceiver
Patient



Cardiac MRI. \Mitral regurgitation

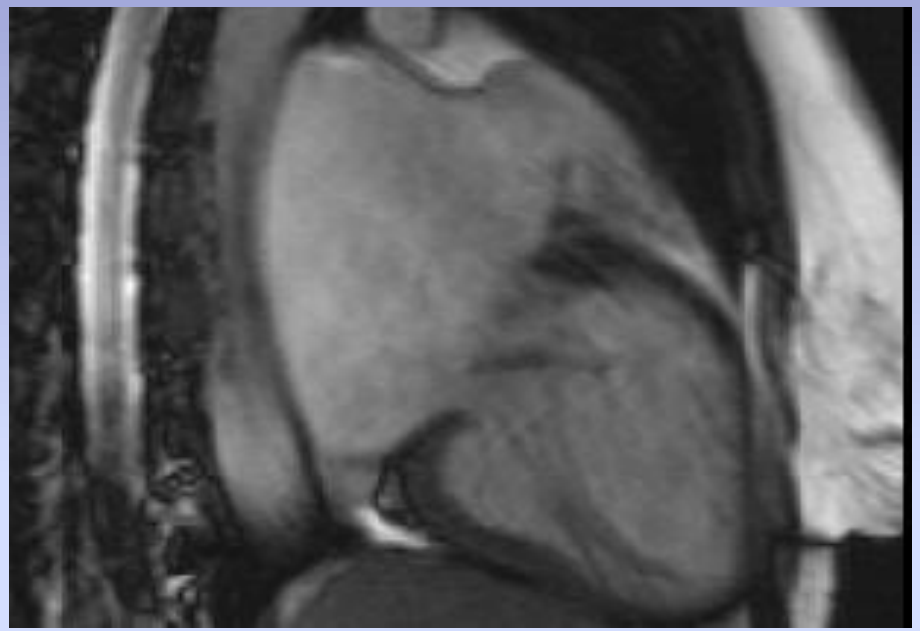
Cardiac MRI

Advantages:

The most versatile imaging modality
Quantifies movements and flows well
Allows tissue characterisation
Versatility > a great research tool

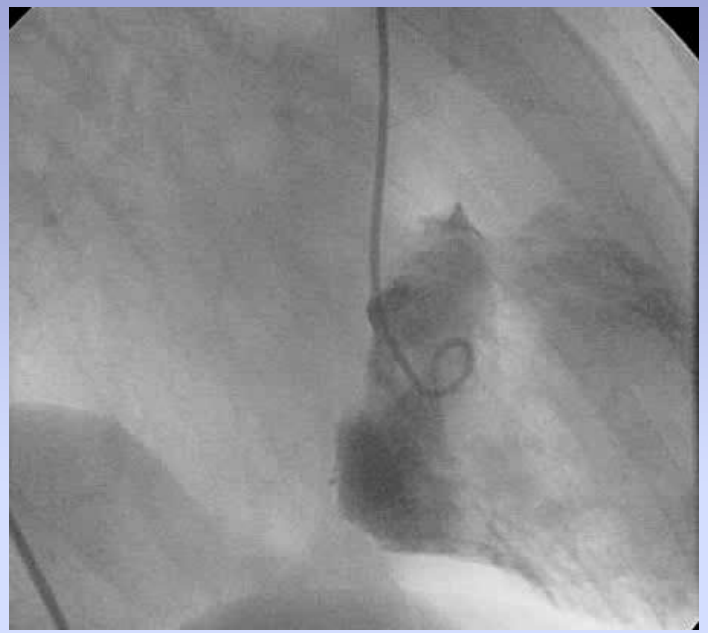
Disadvantages:

Expensive. Time consuming.
Versatility can result in lack of consistency
Aspects are operator dependent
Cardiac arrythmias may degrade images
Occasional specific risks: pacemakers, ferromagnetic clips or inadvertent metal ‘missiles’



Cardiac MRI.

Mitral prolapse and regurgitation



Invasive (catheter) X-ray ventriculography

Mitral prolapse and regurgitation

Conclusions

- **x-ray, computed tomography, ultrasound and MRI approaches to cardiac imaging are based on different principles, with different strengths and limitations**

- **Cases with mitral regurgitation were shown for illustration. Regurgitation of the mitral valve causes dilatation of the left atrium (often leading to atrial fibrillation) and pulmonary vascular congestion. Also volume loading of the left ventricle,**

- **Make friends with images and traces of different types! Take an interest: 'what *can* I see there?', 'what *can't* I access through this approach?', 'why?'….**

- **As with numerical models of biological systems, images only ever represent aspects of what's really there. They always select and simplify. However, different approaches tend to be complementary….**